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Energy and Climate Change Committee

A Severn Barrage?

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Additional written evidence

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The Energy and Climate Change Committee

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The Reports and evidence of the Committee are published by The Stationery Office by Order of the House. All publications of the Committee (including press notices) are on the internet at www.parliament.uk/ecc.

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The current staff of the Committee are Sarah Hartwell-Naguib (Clerk), Liz Bolton (Second Clerk), Jenny Bird (Senior Committee Specialist), Tom Leveridge (Committee Specialist), Luanne Middleton (Inquiry Manager), Shane Pathmanathan (Senior Committee Assistant), Jonathan Olivier Wright (Committee Assistant), Joe Strawson (Committee Support Assistant), and Nick Davies (Media Officer).

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List of additional written evidence

Written evidence

Written evidence submitted by Richard Phillips (SEV02)

The concept of a tidal barrage running across the Severn Estuary from Cardiff-to Weston has a long history. The last proposition was put forward in the first decade of the 21st century, but was put to one side.

At that time a 70 page document was produced, purporting to examine all aspects of the project.

I searched the whole of this work, seeking the results of any technical assessment of the impact of sedimentation, induced by flow restrictions, inevitable in such an undertaking.

I found none.

As a scientist, this aspect of the physics of the undertaking was of primary importance, since silting, on the scale which I would consider inevitable would rapidly take place. A reference on the Web states that "However, the barrage has caused progressive silting of the Rance ecosystem".

Though operating under a different regime, the Aswan Dam suffers immense silting problems, both in loading the dam itself to the point where flow into the turbines is in danger of being affected, and of denying the rich silt to Egyptian agriculture.

The physics of sedimentation is well known. Whenever a solids laden fluid stream with a stable suspended burden of solids suffers a reduction in its velocity, the solid particles fall under gravity. This is absolutely inevitable.

Inhibition of the flow of the Severn Estuary will inevitably take place, in total disregard of the manner in which the generation pattern is operated.

The experience of the construction of a "causeway", essentially a dam-like structure, on the Petitcodiac River in Canada, illustrates the havoc that the impedance of a muddy river create.

Another matter to be addressed is the pattern of generation. Tidal cycles are completed in approximately one terrestrial day; but not quite. The cycle is in time with the lunar day, and thus tidal movements occur at different times every day, at precisely known times. Generation is in time with this shifting pattern.

The average output from the turbine installation is not the headline turbine output, but approximately 50% of this value. This is due to the ever-changing driving force on the turbine, a reflection of ever-changing water level differences.

I am a retired research scientist, having spent the last 35 years of my professional career at the Atomic Energy Research Establishment at Harwell in Oxfordshire. Since retirement I have continued to take a keen interest in all energy matters, and have a wide circle of very experienced contacts in all aspects of the industry. I have thus acquired a wide knowledge of the spectrum of energy matters from nuclear generation to renewables. I became, by examination, an Associate of the Royal Institute of Chemistry in 1954, and was elected a Fellow in 1971.

October 2012

Written evidence submitted by the Stroud Green Party (SEV 03)

The issue of obtaining renewable energy from the tide in the Severn has been discussed at various levels in the Green Party, including Stroud, the South West, Wales and at the National policy making conference. This has resulted in the following adopted policy:

> "The Green Party believe it is appropriate to use the tidal energy potential from estuaries such as the Severn estuary, subject to satisfactory sustainability and environmental impact assessments. In particular we support the development of tidal lagoons and tidal stream turbines as a means of generating clean renewable energy, but reject any proposal for a single continuous barrage across the Severn estuary."

With the recent renewed proposals for a Severn Barrage this was discussed again by the Green Party in Stroud in November 2012. It was agreed again that the Severn is a unique and important ecosystem with significant biodiversity value. A barrage would have significant adverse impacts and is not supported. However other less damaging and newer technologies should be investigated to make use of the renewable energy potential of the Severn tides such as lagoons and tidal stream turbines.

Furthermore we would like complain that the time given for this consultation is insufficient and means many groups have been unable to respond.

November 2012

Written evidence submitted by Brian Webber (SEV 04)

In the event of conflict or terrorist attack, would the Severn Barrage project be to big a target to defend?, bearing in mind its cost £34 billion, its potential power output quoted at 5% of the countries needs, and the possible significant flooding that would be caused, if it was destroyed. Couple that with rising sea levels, within its life time of 100 years, because of global warming and the potential devastation appears self evident.

All the above being satisfied, how much will its "Individual Defence Budget" be.

November 2012

Written evidence submitted by Derek G Birkett (ISG 05)

Introduction

My name is Derek George Birkett resident in Highland Perthshire. I am a chartered electrical engineer having had extensive experience in the Electricity Supply Industry on installation, commissioning and operation, initially with the now defunct CEGB. For twenty years before retirement my employment was as a grid control engineer on shift with the North of Scotland Hydro Electric Board, becoming Scottish Hydro Electric on privatisation, subsequently Scottish and Southern and now SSE. This experience was preceded by control of hydro-electric plant over a four year period.

Since retirement at the millenium I have made a number of submissions to official bodies relating to renewable energy, acted as a witness at three public inquiries, two for wind farm applications and for the Beauly/Denny Transmission line application where I was an independent witness against the proposal. In July 2010 I had a book published by Stacey International titled "When will the lights go out?" warning of the risks being taken with energy supply by UK government policy on renewable energy.

This year I have given three public lectures, two of which were to engineering institutions.

Observations

My working experience has been entirely "hands on". I have been dismayed by the absence of technical consultation over Government policy and where sought has been given by commercial organisations. Expertise with grid operation rests with a few score of individuals who are constrained to speak out unless retired. Policy has been politically driven, expropriating the time honoured practice of economic viability. Sufficient information has been made available from reports in the public domain, the problem rests with comprehension within the structures of government to implement sound policy.

Executive Summary

The approach taken in presenting this submission is to impress the long term need for secure, reliable and predictable energy supplies where tidal technology has an advantage of coming from an indigenous resource. Accommodation of any power source should relate to proximity of demand and long term economic viability with existing and prospective alternative generation sources. Current policy with wind resource is unaffordable, leading towards instability and reliance upon instantaneous imported supplies from distinct adjacent grid systems through subsea cable interconnections.

Evidence

1. *Hydroelectric Generation*. The characteristics of this technology surpass all other technologies. Long lasting, reliable, with rapid response and start up, such advantages are used to provide the dominant means for storing electrical energy by pumped storage, albeit at considerable capital cost and conversion loss. More conventional means have already been exploited, mainly in the Scottish Highlands and although some potential remains, further limited capacity is expected to come from "run-of-river" embedded sources. Where storage can be made available, significant increase of output becomes possible. There is considerable resource available from tidal barrages that if selectively developed in combination with promising tidal flow technology across the network, could yield consistent generation output over the twenty-four hour period. Such investment presents a significant opportunity by avoiding the lunar cycle and alleviating the instability problem from intermittence across the Grid system. Hydroelectric investment requires long term perspective that is not encouraged by restricted conditions of access to long-term finance.

2. *Tidal Resource*. The Severn estuary has the principal source of tidal energy available in the UK with a degree of output flexibility from a barrage having several lagoons. Other estuaries also have barrage potential with a tidal regime out of step with the Severn and further tidal resource could come from developing pockets of alternative tidal flow technology along the coastline. The effective exploitation of all these resources would require in depth studies to determine a coherent scheme of development enabling consistent and flexible power output for meeting the demands of the UK grid system.

3. *Severn Estuary*. The location of this tidal source is in proximity to the main transmission grid and demand centre of the GB Grid System in the South-East. There is limited grid generation capacity in the South-West

to support the scale of consumer demand in that area. Current development of renewable wind resource, largely from Scotland and offshore, has to be transmitted over large distances and whose accommodation demands considerable transmission investment. This includes two "bootstrap" HVDC cables bypassing the Scottish border at considerable expense.

4. *Security of Supply.* This term covers a whole range of technical scenarios from sufficient controllable generation capacity to maintaining the stability of the Grid network. The Grid system is a dynamic entity, inherently unstable being profoundly different from the distribution network. Not only must generation be finely balanced with demand, reactive conditions must be continually adjusted to secure power flows. The rising proportion of wind resource on the GB Grid system presents a serious problem of managing intermittence that soon will become dependant upon imported power from continental sources through undersea cables (in addition the recent commissioning of an Irish connection would import their intermittency). Such interconnection would create a dependency upon our Euro neighbours that is essentially one way, given the much larger scale of the integrated continental grid.

5. *Intermittence*. The scale of planned wind resource to be installed is considered to be technically and economically unsustainable. Whilst a degree of mitigation can be introduced this comes at increasing cost at a time when most thermal generation capacity is rapidly ageing and experience has shown the dearth of availability with wind generation during times of freezing weather conditions. Wind resource is uncontrollable, not securely predictable, demands excessive transmission investment and has seriously underperformed on its promoted energy output. Crucially such capacity would never have been built without an excessive opaque levy on the electricity consumer, forced by parliamentary legislation.

6. *Instability.* The impact of a problem with instability would arise suddenly. Given the background circumstance of market imperatives, developing scenarios often over-ride technical good sense. In the middle of the last decade a moratorium on further wind installation was imposed in Ireland and overnight in Germany standby generation for operating wind capacity was raised from 60% to 90%. Fossil-fired thermal generation is an essential requirement for standby supplies and National Grid expect by the end of the decade an operating margin equivalent to a fifth of maximum demand will be needed to be available at all times to cope with the anticipated level of wind capacity.

7. *Generation Mix*. Renewable resources being developed are invariably intermittent except for biomass which has the problem of fuel supply. Conventional hydro is limited in scope for the GB Grid system, unlike continental circumstance where substantial capacity is available. The characteristics of nuclear power do not lend its use for variable output leaving the only available option for meeting fluctuating demand having to come from fossil-fired thermal sources given the scale required. Embedded generation from distribution networks and fluctuating wind and solar resource must also be accommodated. Any contribution from interconnection can only be marginal as costs rise exponentially and security of supply becomes an increasing issue. Undue reliance on any one technology has to be avoided. Currently there is a serious imbalance with age of the various technologies.

8. *Fossil-fired Generation*. There are three broad categories; oil, coal and gas. The first has become too expensive. Currently coal provides a third of power supply and where a third of this capacity is soon to be taken out of service by EU environmental regulation. Most coal capacity is from forty to fifty years of age but has a significant advantage of having coal capable of being stockpiled at site. Since privatisation only gas turbines have been introduced within these three categories and where its fuel supply has to be shared with industrial and domestic heating. Only 5% of annual gas use can be stored with limited expansion in prospect. The development of shale gas becomes an imperative to reduce imported supplies although its use for electricity generation dissipates half its heat value in conversion.

9. *Contribution of Tidal Resource*. Given the above constraints tidal power as part of a balanced strategy of generation provision would provide:

A. Significant, reliable, predictable power supply for over a century.
B. Secure power output, multi-sourced from many generation units.
C. Indigenous, non-carbon energy adjacent to demand.
D. An alleviation of intermittence thereby reducing standby provision.
E. Overall reduction of start ups with all plant reducing wear and extending life.
F. Limited capability for standby operation.
G. Controllable generation to absorb intermittence from renewable sources.
H. Reduction overall of transmission reinforcement expense and line losses.
I. Limited reliance upon imported energy sources.
J. Diversity for an inadequate generation mix.
K. Absence of any consideration for future fuel charges.

As this list reveals, significant economic savings are made when viewed in wider perspective than a study for a single Severn project would indicate. Development of other tidal barrages would impact on any design for a Severn Barrage

Given the long term nature of exploiting such resource, reliance upon private initiative would be hazardous and some state organisation would be needed to assess all the implications. Starting with overall studies such a body could develop into a project organisation and operating concern well placed to influence, if not control other renewable development. The accumulated practical experience from this body would provide a source of advice and knowledge to government in formulating energy policy that has become so distorted since privatisation of the industry. Hindsight suggests the separation of generation and transmission at that time has led to the serious situation with electrical supply the nation now finds itself having to confront.

November 2012

Written evidence submitted by the Rail Freight Group (SEV 06)

1. Rail Freight Group (RFG) is pleased to provide evidence to the Energy and Climate Change Committee Inquiry into a potential Severn Barrage. No part of this evidence is confidential.

2. RFG is the representative body for rail freight in the UK. We campaign for a greater use of rail freight, to deliver economic and environmental benefits for the UK, in particular by ensuring that Government and rail industry policy supports growth. We represent over 120 member companies active across rail freight including train operators, customers, suppliers, and port and terminal operators. Relevant to this Inquiry, The Bristol Port Company, and Associated British Ports are members of RFG.

3. The majority of this Inquiry is not pertinent to RFG. However we do have some concerns relating to the question "*What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?*"

4. Bristol Port is well connected by rail, and sees regular services in a range of commodities. It benefits from investment in its rail infrastructure, having two high quality rail terminals including the Government grant aided track to Portbury. It also has land for future development, and is well connected to the rail and motorway network.

5. The port already has a range of rail services including coal, biomass and automotives. Although the long term prospects for coal on rail show some decline, biomass is expected to grow strongly now that the regulatory framework is progressing. There is also strong scope for a growth in automotive traffic on rail.

6. Bristol Port also has consented development for a Deep Sea Container Terminal, which once operational is expected to be rail served. To support this, and other traffic, Network Rail are currently progressing feasibility work to allow larger containers to be moved on the Great Western Main Line, alongside the committed electrification scheme, and we expect this work to progress shortly.

7. There is also growing interest in the retail sector in rail services for the South West, which could in the future make use of the container services, and available land at Bristol Port, or other land sites local to the port where logistics activities are based. The development of logistics activities around Teesport, and the emergence of new rail services provides a similar example.

8. Closure of these facilities would therefore be severely detrimental both to existing rail freight traffic, and to the future growth of new services, including from already consented facilities and for the south west hinterland.

9. We understand that the proposals include development of "replacement" port facilities at Port Talbot. It should not however be assumed that rail services from one location can simply be substituted elsewhere. For example, distance and journey time would not be equivalent, and may prove unattractive for some flows. Rail services may therefore move, or indeed revert to road from alternative locations elsewhere in the country (for example East Coast ports). Also, the clustering of logistics activities can be a key factor in attracting business to rail—and whilst Bristol is in a strong position to serve the south west, Port Talbot is not.

10. Of course there are good opportunities to grow rail freight along the South Wales corridor including better use of existing facilities and the potential for new development. This could include a growth in rail traffic from South Wales ports. However, it cannot be assumed that the market is identical or transferable, both from a shipping or rail perspective. It also does not follow that this is an either/or situation—we would consider there is scope for growth from both South Wales and Bristol.

11. Closure of the rail facilities at Bristol would also represent considerable written off investment, both at the port and potentially in the rail network. It should not be assumed that the Strategic Freight Network Fund, which is considering enhancements on the Great Western Main Line would be in a position in the future to contribute to further enhancements necessary should this scheme proceed (not least as its funding of £200 million between 2014 and 2019 is already broadly committed). In any event, uncertainty over future proposals will damage investor confidence in the existing port which is unhelpful today to growing rail freight volumes.

12. In summary therefore, we are concerned that these proposals could be severely damaging to existing rail freight and to the prospects for growth from the Bristol area and hinterland.

November 2012

Written evidence submitted by Parsons Brinckerhoff (SEV 07)

INTRODUCTION

1. Parsons Brinckerhoff led the consortium of consultants employed by DECC to assist them on the Severn Tidal Power Feasibility Study (STPFS) between 2008 and 2010 and also acted as technical advisor to DECC for the Severn Embryonic Technologies Scheme (SETS) in 2009–10.

2. Since then, a combined team from Parsons Brinckerhoff and Black & Veatch (our main partner for the STPFS) has reviewed, on a pro-bono basis, the outcomes of those studies to establish how they should be used to inform future energy development policy from the large energy resource of the Severn Estuary.

3. Our motivation is to ensure that the knowledge we gained from the Feasibility Study was translated into a tangible set of outline proposals that could help potential project developers and policy makers consider tidal power generation in the Severn in a form that was acceptable to stakeholders.

4. Our conclusions were that the uncertainties associated with the impacts of large tidal range projects need resolution and that an appropriate means of achieving this would be best achieved by taking a step by step approach in the development of the tidal power resource in the Severn Estuary. This would allow smaller and lower risk options to be developed initially and used to inform knowledge gaps during planning, construction and operation. Jobs could be created more quickly and a better evidence base for decisions on larger schemes could be established.

5. As Hafren Power have not published any details of their proposals, we have responded to the questions on the basis of the generic issues raised and our recommended approach.

KEY POINTS

- Tidal energy from the Severn estuary is a valuable, reliable and significant low carbon energy resource that should be utilized for the benefit of UK plc.
- Abstracting energy from the Severn has environmental impacts whichever projects are deployed and whilst these can be mitigated, some forms of mitigation can create further issues (for example using ebb and flood generation on a Severn Barrage to reduce the loss of inter-tidal habitats will have adverse impacts on upstream ports, particularly Bristol, due to the reduction in high tide level).
- Land connected lagoons and tidal arrays located away from navigation channels do not impact the current or proposed operations on the Severnside ports.
- Rather than considering development of one of the largest tidal power schemes in the UK as the first step, we believe a more incremental approach would be more attractive to investors, reduce the blight effect on ports, create and sustain construction and operational jobs in the UK tidal power sector as well as allowing valuable operational evidence to inform development of subsequent larger tidal power projects.
- Land connected tidal lagoons use existing technology and, in a suitable site, would be an effective first step in a tidal power development plan for the Severn. We have modelled such an option on one site in South Wales to assess feasibility, costs and gauge stakeholder perspectives. This is described in the appendix. Such an approach is also compatible with the Severn Estuary marine energy vision published in November 2012 by RegenSW.[1]

RESPONSES TO INQUIRY QUESTIONS

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

6. Tidal power projects have predictable energy outputs and do not require the same extent of system support as less predictable forms of supply such as wind or solar. This predictability can therefore contribute to security of supply providing it is used smartly within the overall system. It also requires less system reinforcement than equivalent wind generation[2].

7. A Cardiff-Weston Barrage would generate of the order of 16TWh/year. This is the equivalent of 73 million tonnes of carbon dioxide emissions saved over its lifetime, although much of this will be post 2050. This figure also takes account of the carbon used during construction and operation—our analysis[3] showed that the carbon emissions during construction and operation are equivalent to 2.6 years of the 120 year operating period. Tidal power is an effective means of reducing carbon emissions.

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[1] Bristol Channel Energy—a Balanced Technology Approach, Discussion document, November 2012.
[2] Severn Tidal Power Consultation, Phase One, January 2009, paragraph 152.
[3] Severn Tidal Power Final Report, Executive Summary, October 2010.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

8. A barrage or lagoon structure offers an enhanced level of protection from long term sea level rise or storm surge effects to the areas adjacent to the impounded estuary. In the case of the Cardiff-Weston Barrage, the reduction in tidal flood risk in the tidal floodplain adjacent to the impounded estuary would negate the effects of sea level rise over 55 to 75 years. All recent studies have shown a rise in downstream water levels, although different computer models show different extents in terms of area and level. The most recent studies by University of Cardiff[4] show that the Hafren power proposal would raise water levels within the confines of the Bristol Channel whilst an earlier study by the University of Liverpool and the Proudman Institute[5] showed a small rise in the Irish Sea. The Government's feasibility study also showed rises in the Estuary and Irish Sea. Mitigation consists of raising sea defences along the affected coastlines but more definitive hydrodynamic modelling with appropriate peer review is required to confirm the extent and nature of any far-field effects.

9. The change in the tidal regime in the impounded estuary has an adverse effect on evacuation of flood water and drainage systems during "tide lock" conditions. For the Cardiff-Weston Barrage, specialists at Black & Veatch concluded[6] that there would be an increased flood risk and/or impeded drainage affecting up to 372 km^2 of land, over 50,000 properties and 28 critical infrastructure assets. Whilst most of those adversely affected in this way would also benefit from the reduction in flood risk from extreme tide levels, the impeded drainage issue would occur many times a year, whereas the additional protection against extreme high tides would be beneficial on rare occasions, greater than 10 years but this would increase with sea level rise. A range of mitigation measures would be required to achieve current standards of drainage and flood evacuation, including providing flood storage facilities during tide lock, increasing the size of outfalls and new pumping stations. A diversion of the River Axe in Somerset could also be required.

10. Our investigations and modelling showed that the change in tidal levels and tidal flows were likely to result in erosion of banks in some locations both upstream and downstream of a Cardiff-Weston barrage in particular. Protection in the form of heavy revetment or rock armour would be required, potentially repeated at intervals during the life of the scheme. Further detailed modelling would be required to confirm the extents, but we concluded that a length of coastline ranging between 67 and 201 km could be adversely affected.

11. In opportunity terms, the onset of sea-level rise and more severe/frequent storm surges arising from the effects of climate change provides a challenge to all low lying areas, not least the Severn Estuary in the coming years. If a decision to construct a barrage was taken on energy grounds, it would provide an opportunity to protect additional areas that may not be otherwise justified in purely flood defence economic benefit terms.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

12. Specialist studies commissioned during the Feasibility Study showed that wildlife and habitat impacts were significant and that continued uncertainties existed both in the extent of impact and the means by which they could be mitigated. For example, in a time limited two year study, it was not possible to scope, collect and analyse sufficient data to be able to definitively understand fish movements and the extent to which they would be exposed to danger by their proximity to a barrage and the changes in water level. Similarly, there is little evidence available to confirm mitigation measures for such impacts in tidal (saline) waters or the cumulative effects of repeated passage of fish through turbines.

13. It is likely that the field studies necessary to understand the extent of localised fish movements and the associated modeling and mitigation studies would be on the critical path for any consenting studies. In addition, a greater understanding of the risks different turbines pose to fish passing through them is needed to adequately understand the potential impacts passage through turbines may have on fish species and their populations.

14. All tidal power development of any significance will involve the loss of habitats as energy is abstracted from the system and hydrodynamic levels are modified as a consequence. Lost Inter-tidal habitats can be replaced by newly constructed habitats elsewhere although they will not perform in the same way—as a consequence "like for like" compensatory habitat will generally need to be greater in area than the habitat it replaces. Technically, compensatory habitats can be constructed and are low risk as a construction activity. An operational example is the RSPB wetland nature reserve at Newport[7] which was constructed as compensatory habitat for the Cardiff Bay Barrage in the 1990's.

15. The loss of habitat can be reduced by changing the mode of operation from ebb only (generation on the ebb tide twice a day) to "ebb and flood" (generating on both ebb and flood tides). Energy outputs are similar for both modes in a Cardiff—Weston barrage (both were studied in the Government's Feasibility Study) but the impact on the upstream water levels is different. With ebb only generation, the lower half of the tidal range is truncated with associated loss of inter-tidal habitats whilst with ebb and flood, both the high and water levels are truncated but to a lesser extent. Whilst ebb and flood generation is a comparatively better alternative for

[4] http://www.Cardiff.ac.uk/cplan/events/105

[5] Tapping the Tidal Power Potential of the Eastern Irish Sea, Final Report, March 2009, University of Liverpool and Proudman Oceanographic Institute.

[6] Severn Tidal Power Final Report, Flood Risk and Land Drainage, April 2010.

[7] http://www.rspb.org.uk/reserves/guide/n/newportwetlands/about.aspx

habitats, the loss of high water level is problematic for upstream ports who require certain clearances to allow shipping to pass over the port lock cills and there is also a possible impact on fish mortality as fish passage through operational turbines over a daily cycle is potentially doubled.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

16. La Rance uses conventional bulb turbine technology and the original turbines are still in operation. Although expensive to finance, since its construction debt has been repaid, La Rance represents one of the cheapest forms of energy on the French generation system. The lessons that La Rance provides for future tidal range power generation are:

- Long term reduction in cost of generation is achieved in practice.
- Use of conventional bulb turbines in tidal power is tried and tested.
- Flexibility in operation has proved beneficial with the plant able to operate in both "ebb" and "ebb and flood" modes as well as being able to pump to increase storage; ebb generation is used for 60% of the time, pumping for 15–20% whilst flood generation accounts for only two to 6% of the time.[8]
- Natural environments will adapt to significant change but the new ecological balance is delicate and requires regularity of the operating modes.[9]

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

17. The key risk arising from the development of a Severn Barrage is the potential blight and disruption to the ports upstream of the barrage. For example, the Port of Bristol has growth plans for a new deep water container quay. The need to lock container ships as they passed through the barrage would affect the attraction of the Port to container shipping.

18. The construction of a large barrage, or any tidal power project on the Severn, brings with it significant local employment opportunities. The majority of these would be sustained only over the construction period. Nonetheless, a seven year construction period could see as many as 18,000 direct jobs created, of which some 40% could be locally based, more if the turbines were manufactured locally. However, there would also be job losses from a large barrage. The 2010 DECC Feasibility Study[10] identified that a central estimate for net local jobs was only 840 during construction reducing to 120 once operating. The increase in net local employment for the Bridgwater Bay lagoon was significantly higher (3,240 and 290 respectively) and a smaller initial scheme, such as the Stepping Stones Lagoon (see appendix), would also offer significant employment opportunities with the potential for 4,000 direct jobs, of which 50% or more could be local.

19. Risks could be mitigated by developing alternate tidal range power projects that did not require the estuary to be barraged, thereby enabling unimpeded passage for shipping, and reduced effects on fishing and other sea bed users. The Bridgwater Bay lagoon concept demonstrated that tidal lagoons could generate significant energy. No specific study has yet been undertaken of the potential for multiple tidal lagoons or other non barrage technologies within the Severn Estuary although various single and combination options were studied as part of the Government's Feasibility Study.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

20. Yes. Using a 10% private sector investor rate, and excluding optimism bias, a Cardiff Weston Barrage costing £23 billion would give a levelised cost of energy of more than £200/MWh[11]. This gives an indication of the strike price required over the financing period. After the financing period, the cost of energy drops significantly to less than the current wholesale price. That characteristic is true for most tidal range projects, with their long asset lives. Inflation also has to be considered. Tidal range projects are capital intensive with low operating costs and therefore negative inflation impacts are concentrated in the construction phase. Energy inflation will boost the value of revenues from tidal range projects and the required strike price will consequently be reduced.

[8] La Rance Tidal Power Plant—Lessons Learnt, BHA Annual Conference 2009, Vincent de Laleu (eDF)
[9] Severn Tidal Power Final Report, Flood Risk and Land Drainage, April 2010.
[10] Severn Tidal Power Final Report, Executive Summary, October 2010.
[11] Severn Tidal Power Options Definition Report, April 2010.

How does the company plan to engage and consult the community in the development of the project?

21. This is a question for the developer to respond to.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

22. This is a question for legal experts to respond to.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

23. The Feasibility Study considered a large number of "significant" options—typically schemes with installed capacities greater than 1,000MW. Three were identified as technically feasible:

- Cardiff Weston Barrage (8..64GW).
- Bridgwater Bay Lagoon (3.6GW).
- Shoots Barrage (1.05GW but its development would compromise the development of a future larger barrage).

24. In addition, the SETS projects identified three options of which one proposed Very Low Head turbines on a Cardiff Weston alignment. None of these options is bankable today, either because the turbines have not yet been prototyped or because they still require further development and testing to achieve commercialization.

25. We have, as stated in the introduction, developed a further option (the Stepping Stones Tidal Lagoon) which is smaller than most of those referenced above. However, at 600MW, an energy output of 1.2TWh/year and a capital cost of £1.7 billion it is nonetheless a major civil engineering project. We have briefly described this option in the Appendix. The levelised cost of energy is similar to the Cardiff-Weston barrage option.

26. We are also aware of a smaller option in Swansea Bay and note that a scoping report has been recently (October 2012) published[12]. This is for a 250 to 350MW project but is located in an area with a lower tidal range and has a relatively low energy output (0.4TWh/yr) by comparison with other options referenced above.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

27. For this question, we have interpreted the "scheme" as a credible development plan for energy abstraction from the Severn, regardless of specific scheme characteristics. We believe that tidal power development from the Severn would be better served by directing whatever funding, financing and developer appetite is available to a smaller initial scheme before then considering, using this experience, what options should be pursued for further electricity generation from the Severn.

28. A "first step" Severn based tidal power scheme (a hybrid commercial/research proposition) would be required to achieve this ahead of subsequent development of one or more larger options. We have described a possible "first step" in the Appendix, the Stepping Stones Tidal Lagoon. It does not impede access to the economically important Severnside Ports and at 600MW, would represent the largest tidal power development in the world, show-casing the UK's world leading credentials in this area. It would not prejudice the subsequent construction of other larger tidal energy projects in the Severn.

29. Such an approach provides a sustainable pathway to development of significant energy from the Severn and creates jobs both in the short (initial option) and long term (subsequent larger options). It would help resolve environmental issues where large scale field studies and practical experience are required to inform future development, particularly related to fish for example. This is one of the most significant unresolved areas of tidal power development in the Severn, irrespective of turbine type. It would also establish the UK as a leader in knowledge, engineering and science relating to tidal power and associated environment effects.

30. In summary, the UK engineering and low carbon industry sector will be best served if a phased and sustained approach to the development of tidal power from the Severn is taken, starting with a less controversial option where the interests of stakeholders and Government are aligned. Subsequent options can then be developed and appropriately finessed from this initial experience.

Appendix

Stepping Stones Tidal Power Lagoon

1. As stated in paragraph 2 of our written evidence, Parsons Brinckerhoff in association with Black & Veatch, has been studying how an interim option could be developed to address many of the uncertainties that were identified during the course of the Government's Feasibility Study.

2. Our work on developing an interim option was guided by four principles. These were:

- It should be underpinned by the evidence available, or recognition of knowledge gaps where these occurred;

[12] http://infrastructure.planningportal.gov.uk/projects/wales/tidal-lagoon-swansea-bay/

— Any proposals developed as a consequence of our work should not undermine the business case for future development of larger options but should instead support the development of future options by improving the available evidence base;

— Adverse impacts from any proposals should be manageable and proportionate whilst recognising that any energy removed from the tidal system would have some impact on the environment;

— Proposals achieve a long term reduction in energy cost after the financing period, but will require support in the form of a tidal range CfD in the financing phase.

— Proposals should create a significantly greater level of cost and impact certainty; in order to increase the probability of advancement of the Severn tidal power proposition for UK plc

3. A smaller option would still need to be relatively large—of the order of 600MW to be economic—but considerably less than a large barrage (at 8,640MW). The knowledge gained by a smaller option should prove of subsequent value to developers of subsequent tidal power projects in the Severn, whether a larger lagoon or a barrage.

4. Taking an incremental approach also enables a more diversified approach to be taken so that the success or failure of tidal power generation in the Severn isn't dependent upon a single large option. For example, a mix of two or three suitably located tidal lagoons and tidal stream devices (configured in a fence or array) maybe as, or more effective, than a large barrage in balancing the different perspectives of stakeholders whilst still generating significant energy from the Severn.

5. The site for the initial small option should be selected to minimise risks—for example in terms of ground conditions, compliance with environmental legislation, close to the existing electricity network and ability to achieve consent. In practice this means selecting a site which is outside of the Severn SAC and SPA designations and which has an exposed rock formation. Such a site exists at Rhoose Point between Aberthaw and Barry on the South Wales coast. This site was then selected by our team as the basis for a new tidal power lagoon which we have referred to as the Stepping Stones Lagoon. A powerpoint presentation given to the Bristol Tidal Forum is available on RegenSW's web site[13].

6. The key characteristics of our proposal are as follows (figures are at the end of the appendix):

— A new land connected lagoon located on the rock formation between Aberthaw Power Station and Barry Docks (see Figure 1).

— The lagoon would comprise a 10.6km semi circular impoundment with a surface are of 18sq km. The impoundment itself would be built using conventional construction techniques of rockfill embankments where depths are relatively shallow and concrete caissons for the majority of the structure which is located in water depths of between 15 and 20m (see Figure 2).

— The turbines would be based on traditional run-of-river low head Bulb turbines in use throughout the world (including La Rance in France). Total capacity is nominally 600MW operating in "ebb and flood" mode. Pumping could also be used to enhance output or provide some degree of energy storage at certain tide states. There is also an opportunity for the lagoon to act as a research centre for turbine performance with the potential for one or two additional turbine bays to be provided for testing of new turbine types.

— Energy output is estimated at 1.2TWh/year or 0.35% of the UK's annual electricity consumption. This is about 7.5% of the energy output from a Cardiff to Weston Barrage. However, it would be larger than the UK's biggest onshore wind farm (Pen Y Cymoedd, also in South Wales—which will generate 0.75TWh/year from 84 wind turbines with an installed capacity of 299MW).

— Lagoons have traditionally been more expensive than barrages because of their longer impoundment structure requirements. We have therefore looked hard at the design of the impounding structure and developed a modular caisson design that can be economically constructed and transported into position. Its design and configuration reduces costs and risk, and allows the majority of the structure to be over-topped by waves and storm surges without compromising its purpose (see Figure 3).

— We have estimated the construction cost at £1.7 billion using the same cost parameters as used in the Severn Tidal Feasibility Study. This equates to a cost of energy at the 10% investor rate of £190/MWh, similar to current cost estimates for Round 3 offshore wind (c£180/MWh)[14] and less than the £211/MWh for a Cardiff Weston Barrage[15] on a similar basis[16].

— A concern of smaller impounding structures in the Severn is that they will be prone to siltation over time given the Estuary's relatively high silt load. The depth of the Stepping Stones lagoon, coupled with its location on the rocky northern shore of the Estuary, reduces this risk substantially compared with other locations.

[13] http://regensw.s3.amazonaws.com/120831_stepping_stones_tidal_lagoon_presentation_for_bristol_tidal_forum_ead4881f6fce116d.pdf

[14] 4467—Offshore Wind TINA p5 and footnote 1 of p6—baseline cost of £140 used for Round 2 projects, but current costs are higher and Round 3 costs will be higher still.

[15] 624—Severn Tidal Power Feasibility Study Options Definition Report, Volume 1, p13.

[16] Basis used is 10% discount rate over financing period with no optimism bias. Equivalent costs if publicly procured, with optimism bias added and evaluated at 3.5% discount rate over full project life are: £94 for Stepping Stones, £102 for offshore wind, £108/MWh for Cardiff-Weston Barrage (source: 625—Severn Tidal Power Impact Assessment p65).

— Adverse impacts occur from any project that seeks to alter the energy balance of the estuary. The relative size of the Stepping Stones project vis-a-vis the estuary itself reduces this impact and the most significant impact is considered to be fish, an issue shared with all other tidal range proposals in the Severn. However, its location and size again help reduce the impact; the lagoon will not significantly impede fish movement in the Severn Estuary, whilst fewer turbines located away from the entrances to key migratory rivers will reduce the likelihood that fish will pass through the turbines. In addition, the project could provide a valuable opportunity to monitor and mitigate for adverse fish impacts for the benefit of the tidal power sector as a whole. The Stepping Stones project would not deliver the flood risk benefits associated with the peak tide level reduction of a Cardiff-Weston barrage. However, it would not create the adverse land drainage and flood evacuation impacts associated with the Cardiff-Weston barrage. This will be a major issue to be overcome for the large barrage option as it will affect large areas of land and many thousands of stakeholders.

7. We have called our proposal "Stepping Stones" reflecting its location which resembles a large number of stepping stones on the foreshore and as a descriptor to reflect its role in the journey for the development of tidal power in the Severn. The experience gained from initial smaller schemes will be used to inform the development of subsequent schemes—whether they be a combination of small and medium sized projects or a larger single scheme.

8. Our proposals are designed to inform policy making at this stage. The conceptual design for the lagoon and estimation of quantities, construction costs and energy outputs has been completed in sufficient detail to inform policy decisions. We have also given consideration of different commercial models that would allow the lagoon to be financed, constructed and operated by the private sector but long term benefits to be retained by the public sector

9. We have also started a process of engagement with a wide range of stakeholders to ascertain their views and feedback on the merits of such a proposal in policy terms. These are still at an early stage and further engagement meetings continue to be planned with relevant organisations. Those organisations contacted to date include:

— Department of Energy and Climate Change (from initiation of the proposals in 2010 through to sharing details of the proposals and responding to questions in 2012)

— Welsh Assembly Government.

— The Crown Estate.

— Bristol City Council.

— RegenSW.

— Bristol Tidal Forum.

— RSPB.

— Friends of the Earth.

— Bristol Port Company.

— Countryside Commission for Wales.

— Environment Agency.

— Marine Management Organisation.

10. Feedback from these engagement meetings has been used to refine the proposals, a process we envisage continuing given the positive feedback for inclusion of an interim option such as the Stepping Stones Tidal Lagoon in the development of Severn Tidal Power policy.

Figures

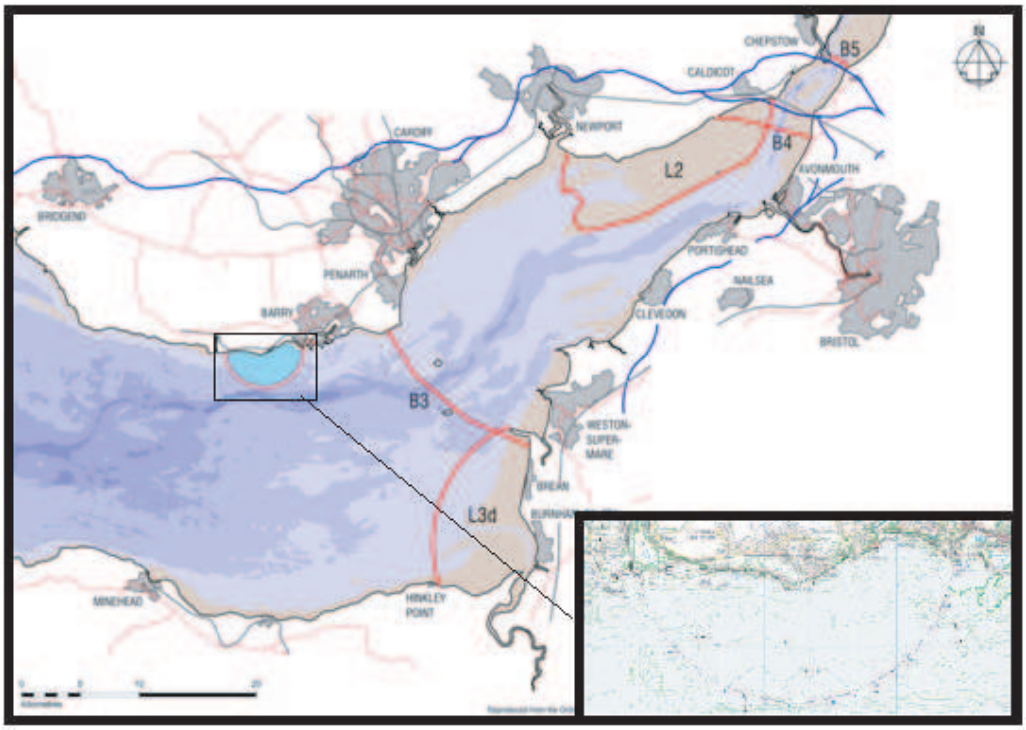

Figure 1—Location of Stepping Stones Lagoon in relation to other Severn Tidal Power shortlisted projects.

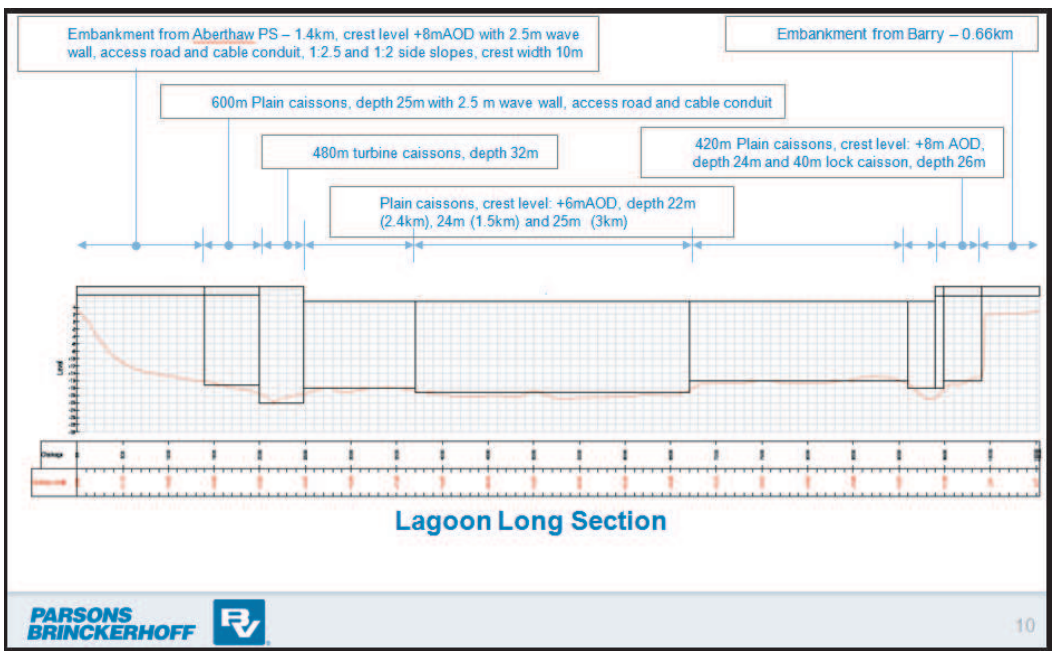

Figure 2—Long Section through impoundment structures showing construction elements.

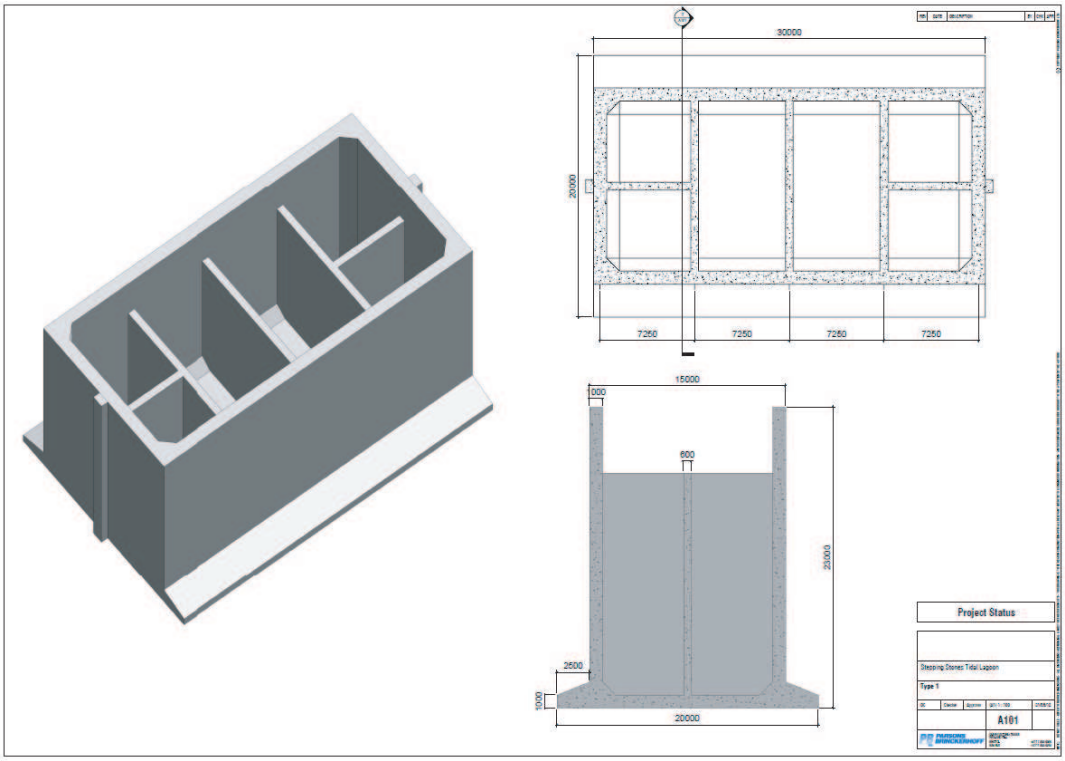

Figure 3—Typical form of concrete caisson construction used to form impounding wall.

November 2012

Written evidence submitted by Freight on Rail (SEV 08)

Rail freight is a crucial driver of green economic growth which reduces long distance road congestion, pollution and road accidents. Therefore, it is crucial that any Severn Barrage construction design keeps the Bristol Ports open to freight shipping both throughout the construction phase and long term once it is in place as there are a considerable number of rail freight flows to and from the ports.

Trends in rail freight show how important it is as part of the intermodal solutions which is what customers want using rail, sea and road via the Bristol Ports in this case.

A. *Rail freight has been a success story*

- Rail freight overall grew 60% in past 10 years.
- Latest annual ORR figures for the year 2011–12 show total tonne kms up 10% and intermodal freight up 11% on previous year, the 9th consecutive year of growth for consumer rail freight, despite the recession.
- Overall volume of containers at ports in 2010 was the same as 2005 but rail volumes 29% up.
- Actual tonne kms figures for the years 2009–11 higher than previously forecasted which demonstrates that industry forecasts are conservative.
- Potential from Felixstowe to increase long distance traffic from 25% to up to 40% when HLOS capacity schemes completed which will also remove 40 million long distance lorry miles for annum off the A14 corridor.

FORECASTED GROWTH

- MDS forecasts rail tonne-km doubling 2010–30 with Intermodal quadrupling and infact with investment intermodal could grow five fold
- MDS forecasts rail tonne-Km doubling 2010–30 with intermodal quadrupling or even fivefold if the existing market conditions are retained.

See detailed forecasts http://www.rfg.org.uk/updated-2011-forecasts-show-strong-prospects-growth.

B. *Value of Rail Freight to GB PLC*

The rail freight sector directly contributes £870 million to the UK economy and supports output of £5.9 billion according to Network Rail's Value of Freight report July 2010.

- The rail freight industry has achieved a 48% growth in tonne kilometres since 1994–95 with half the number of locomotives and two thirds of the wagons employed at that time.
- The benefits of rail freight fall outside the railway balance sheet but benefit the road network and the economy by removing or reducing;
  - £772 million per annum in congestion costs.
  - £133 million per annum in road infrastructure costs .
  - £68 million per annum in CO_2 costs.
  - Pro-rata 42 road deaths at a value of £78.8 million.
- There has been over £1.5 billion of private sector investment since 1996.

C. *Sustainable distribution and its role in helping the Government meet its CO_2 targets*

Freight is a big CO_2 emitter; HGVs are responsible for 20% of carbon dioxide emissions from all domestic transport and road freight now account for 8% of UK carbon dioxide emissions. Rail produces 70% less carbon dioxide than road per tonne carried for the equivalent journey so it has a crucial role in reducing freight's overall carbon footprint.

Energy efficiency of rail—A gallon of diesel will carry a tonne of freight 246 miles by rail as opposed to 88 miles Network Rail July 2010.

D. *Safety benefits of rail freight*

Rail is the safest form of surface transport.

Rail freight is safer than long-distance road freight using major roads, as HGVs are over three times more likely to be involved in fatal accidents than cars on major roads due to a combination of size, lack of proper enforcement of drivers hours, vehicle overloading and differing foreign operating standards. *Source: Traffic statistics table 2010 TRA0104, Accident statistics Table RAS 30017, both DfT.*

November 2012

Written evidence submitted by Archie D. Speirs (SEV 09)

1.0 Information on Submission

This submission is made on a personal basis by a retired chartered electrical and mechanical engineer, whose lifetime professional experience was gained in the electricity supply industry in the employ of engineering consultants, manufacturers and contractors. This included a heavy involvement in major hydro-electric projects, particularly from the points of view of design and project management of some of the largest export contracts placed with UK contractors in this field, particularly in the USA and New Zealand.

2.0 Submission Content

I wish to restrict my comments in this submission to the following aspects connected with the construction and management of the proposed Cardiff-Weston barrage project:

- Management & Ownership of the Project.
- Future Advantage to UK Enterprise.

3.0 Management & Ownership of the Project

I feel very strongly that this project should proceed at this time. It has been a project which has been on the drawing board for far too long and studied from every angle imaginable since the 1920's. I believe that the time has come when it is absolutely right to make the decision to proceed with its construction. It is a wonderful project in concept and I have every confidence that UK plc can and will make a first class job of its execution. The feasibility study projects its life as a nominal 120 years, but it is quite likely that it will be generating full designed output in the year 2220, 200 years after commissioning. Accordingly it is likely that it will prove to be far and away the best investment ever made in an infrastructure project in this country.

In these circumstances it is not at all surprising that private finance is likely to be available to back construction of this project. However, I believe it would be a gross error to proceed on this basis and that it is essential that the development should be carried out under the auspices of a Government Authority specially established to build, own and operate the project throughout its life. It is acknowledged in the studies undertaken that government finance will prove to be significantly cheaper than private finance. This should show up in a greatly reduced construction cost, as for a project with a useful life of up to 200 years it is to be

expected that the Exchequer should be able to make project financing available at the extreme low end of the interest scale. As a very major element of the project cost is made up of interest during construction, one would expect that this will prove to be very significantly lower if the project is developed under the auspices of a Government Agency.

In this connection it is worth recalling that in 1943, in the middle of a World War, the Government established The North of Scotland Hydro Electric Board, which went on to develop most of the major hydro-electric projects existing today in Scotland. A similar entity should be formed to build, own and operate the Severn Barrage Project and, indeed, other UK tidal range projects. It might appropriately be named UK Tidal Power. Although the generation, transmission and distribution of electric power is now in the private sector in the UK, this should not be relevant in arriving at a decision to develop major tidal schemes as public power projects. If one looks at the USA, for example, major hydro projects have been constructed and operated by Government agencies there such as the Tennessee Valley Authority, the Bureau of Reclamation, and the US Army Corps of Engineers, all of which operate alongside private power companies.

Another very cogent reason for advocating development of the Severn Barrage Project by a Government Agency is that it is well known that there are very major environmental problems associated with its construction and operation which will have to be overcome at an early stage of development. It is suggested that these will be satisfactorily dealt with much more expeditiously by a Government Agency than by a private developer. Indeed it would not be unexpected if project development was indefinitely held up on environmental grounds if project development was in the hands of a private sector developer.

4.0 Future Advantage to UK Enterprise

From the point of view of generation of renewable energy, to which the UK Government is committed under the auspices of the European Union, production from the Severn Barrage should prove to be very considerably more benign from the point of view of operation of the national grid than that generated from wind turbines. System Operation will know exactly what input to expect and when from the barrage project, as compared with the opaque variability associated with input from wind projects, which latter may prove to cause dangerous instability in national grid control. Although first power is not expected to be available from the project until the year 2020, it is suggested that the currently planned programme of off-shore wind turbine installation could be drastically cut back. This would be of considerable advantage to the national economy by elimination of this high cost and doubtful long-term reliability element of currently planned renewable energy generation. Furthermore it is expected that the barrage generating units will be designed to have the facility to operate under certain tide conditions as pumps, providing System Operation with an element of pumped storage capability which could be very useful under certain grid control circumstances.

Looking to the future, one can expect that establishment of a government agency to build, own and operate the Severn tidal power barrage will provide the impetus to precede more rapidly with development of other tidal barrages, such as those in the planning stage for the Mersey estuary, the Solway Firth, Dee, Ribble, Wye and Morecambe Bay. Studies on these potential projects are at various stages, but it is judged that the Mersey scheme, for instance, which has the potential for generation of up to 1,000 GWh/year could be operational by the year 2020.

On the international scene, successful development of the Severn Barrage Project by Tidal Power UK could put UK national enterprise in an advantageous position in the pursuit of tidal power development business, led by this specialist developer. Although subject to a similar chequered history to the Severn Barrage Tidal Power Project, the Passamaquoddy Bay Tidal Project at the mouth of the Bay of Fundy in the eastern Gulf of Maine, in the USA could, in the future present major opportunities for developed British expertise in this field, along with other tidal projects in the American and Pacific North West.

November 2012

Written evidence submitted by VerdErg Renewable Energy Ltd (SEV 10)

Executive Summary

1. VerdErg is developing "SMEC" technology for cost-effective and environmentally safe conversion into electricity of the energy in both river and tidal flows. SMEC was one of the three embryonic technologies selected by DECC for investigation under the Severn Embryonic Technology Scheme ("SETS") programme in 2009–2010. This submission gives a précis of these SETS findings and provides an update on the further development of SMEC in the three years since the SETS programme reports were prepared.

2. All candidate SETS technologies were compared using the same unit cost data base provided by DECC to ensure consistency between concepts. Several of VerdErg's SETS reports are on the DECC website, including the Final summary report: http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/severn-tp/651-severn-embryonic-technology-scheme—final-report-.pdf.

3. The SETS report established the following SMEC features:

— A SMEC barrage on the Cardiff-Weston alignment was costed at **£9.85bn** including habitat loss compensation and 15% contingency. This is somewhere between one third and one half of the capital cost of a tidal barrage fitted with conventional turbines.

— Power output was conservatively calculated to be **75%** of that potentially available from a barrage. Now that greater design experience has been gained with SMEC over the last three years, a figure closer to 80% is thought to be appropriate.

— Permanent inundation of wetlands upstream of the alignment currently forming the feeding grounds for migratory birdlife was shown to be 1,775ha with SMEC turbines fitted compared to 20,000ha for a conventional Ebb-Flow Barrage with bulb turbines. (just **8.9%** of the environmental impact of a conventional barrage.)

— SMEC would produce electrical power during the full range of the ebb and flow tides at an attractive cost of **£68/MWh**, calculated in accordance with the DECC-specified costing metric.

— A shipping lock in a conventional barrage on the Severn has to cope with an 11m water head difference across it. A lock in a SMEC barrage on the same alignment is much simpler and easier to operate as the maximum water height difference across is can never exceed 2.5m.

4. In March 2010 when the SETS programme reported, SMEC was correctly seen to still be an embryonic technology, requiring further proof of its compelling economic and environmental advantages. Its development has continued since then, however, and a prototype has now been built (November 2012) on the river Caldew in Cumbria, with funding support from the Technology Strategy Board.

— Commercial river SMEC projects are planned from Spring 2013 onwards.

— Several tidal estuary projects are under consideration. A crossing of the river Camel is thought suitable for early development.

— SMEC has been selected for the Solway Energy Gateway across the Upper Solway Firth.

— Early studies by PEEL Energy of a possible Mersey Estuary crossing found SMEC to be attractive but not sufficiently developed, at that time, for early adoption.

— The projection made in the SETS Road Map Study for SMEC to be ready for adoption in the Severn Estuary Barrage by 2020 remains valid.

— Unlike a conventional barrage, SMEC can alternatively be installed on the Minehead-Aberthaw alignment to produce considerably more power with an even lighter environmental footprint. This is because the Minehead to Aberthaw alignment lies downstream of the very large body of suspended sediment that migrates up and down the Bristol Channel with every tide. Additionally, this downstream location favours shipping access to the Port of Bristol by offering a much larger expanse of water upstream of the barrage for vessel manoeuvring.

— Further explanatory material can be found on YouTube at "VERDERGRE" and on VerdErg's website at www.VerdErg.com.

5. SMEC is not a competitor to other barrage proposals; it is a powerful potential enhancement to all of them. This is because it can simply replace the conventional turbines in any candidate barrage proposal. This will enable a better than 50% capital cost reduction to be made in any barrage scheme and deliver an order of magnitude reduction in environmental damage.

6. It is thought that one or more recent Severn Estuary barrage proposals may have been "de-rated" to extract less energy from the tidal flow in order to reduce the environmental footprint of the proposed barrage. Sketches of one such proposal recently published in the Sunday Times also appeared to show adoption of a new design of sophisticated, large-diameter, multi-blade turbine under development by a French manufacturer and said to be able to produce power at unusually low water height differences. This could be a design compromise intended to mitigate the power output having to be sacrificed to achieve less environmental damage. A radically better outcome to any such experimental "high-tech" machinery would result from simply fitting small, proven and conventional, high-speed turbines in SMEC ducting. Expected benefits would include more power at lower cost, even less permanent inundation of migratory bird habitats plus no damage to fish, as they are totally excluded from the 20% of the flow passing through the SMEC's small, high-speed turbines.

Other points

7. The current status of SMEC is:

— The essence of the patented SMEC technology is a no-moving-parts passive, low-cost duct. 80% of the flow goes straight through this duct and boosts the pressure drop in the rest of the flow by four times or more. A comparatively small, lower-cost, high speed ordinary turbine in this residual flow produces a similar amount of power to the huge, expensive, slower-moving "bulb turbines" of a comparative barrage where all the flow goes though the turbine at much lower pressure. In addition to first cost turbine savings, turbine maintenance or replacement costs through-life will be much lower for the simpler, smaller turbines in a SMEC.

— SMEC produces about one quarter of its energy output during each quarter-cycle of the tide compared to nearly all the energy from an ebb-flow barrage coming in the single quarter-cycle as the high tide falls to still water level. This even distribution of power from a SMEC barrage during each day improves Grid compatibility.

— SMEC is fish-friendly because they pass straight through unharmed, in the 80% primary flow. It is relatively easy to screen off the 20% flow through the small, high-speed turbines.

— Unlike a conventional barrage, SMEC preserves the shape of the tidal signal because it is porous and doesn't stop the flow, as does a conventional ebb-flow barrage. Upstream on the landward side of a SMEC barrage, the tide still rises and falls much as it did before installation. The entire tidal cycle in the closed upstream lagoon, however, lags behind the tide out in the open sea by a few minutes. This once-only "phase shift" of the tidal signal is irrelevant environmentally.

— Behind an ebb flow barrage, the upstream water level barely ever gets below mean water level and can permanently inundate much of the upstream wetlands, a vital habitat for migratory birds. A barrage fitted with SMEC turbines causes less than a tenth of this damage. Preserving the tidal signal also minimises disruption of the sediment transport patterns.

— With a SMEC turbine fitted, a barrage across the Severn Estuary (or any other estuary) works differently. The maximum head difference between the upstream and downstream water levels is around 2.5m. An ebb flow barrage, by contrast, has to withstand the overturning force of the full tidal range of around 11m, over five times more load. Any barrage designed to use SMEC turbines instead of conventional "bulb" turbines can therefore be significantly less massive. This is why compared to an ebb-flow barrage of the same annual energy output, a SMEC will be somewhere between **one third and one half of the capital cost**. The power it produces will be cheaper by an even greater factor because of the substantially lower maintenance costs and improved Grid compatibility.

— It would be highly advantageous economically and environmentally for any Severn Estuary Barrage consortium to install SMEC-encased turbines instead of the huge traditional "Bulb Turbines" or any complex new-technology low-head turbines. The SMEC's novelty is in the precise shape of a passive duct; the actual turbine inside the SMEC duct is absolutely conventional, as well as being very much smaller than the massive bulb turbines in a conventional barrage.

8. *Contribution to the security of the UK's energy supply*

The Cardiff—Weston scheme is expected to supply just under 5% of the UK's electrical energy demand. This is immensely valuable, and would be vital in the event of interruptions to availability of conventional fuel sources. The tidal energy "fuel" source is highly predictable; inexhaustible; not dependent on foreign oil and gas supplies, shipping routes and pipelines across potentially unfriendly states.

9. *Climate change*

Negligible quantities of carbon dioxide will be produced in the operation of the plant. Some CO_2 will be produced during construction, as with all infrastructure projects. Note however that the total material mass of a SMEC barrage is substantially less than that of a conventional barrage. CO_2 produced in decommissioning any such scheme is normally counted in the environmental assessment, but it is arguable that this is not relevant here since the lifetime is expected to be around 120 years, by which time the climate situation will undoubtedly be completely different. Tidal energy (and hydro power in general) is not subject to some of the disadvantages of well known alternatives:

— Wood as a fuel is, in the long term, carbon dioxide neutral, but only over a timescale that is much too long to affect the current problems. It takes 30 or 40 years to replace the fuel and achieve "carbon neutrality". (An exception to that argument could be the burning of wood waste.)

— Large scale bio-ethanol from plant material is now widely thought to have been a wrong turning. It occupies so much food-growing land that serious problems are already occurring with sharp price rises in poorer countries. It is likely that those concerns will halt any further expansion.

— Wind undoubtedly has a place in the energy mix, although the negative effects on people and the landscape in the crowded UK look likely to become politically troublesome in the future, at least for on-shore sites.

10. *Opportunity for UK industry*

Recent barrage proposals in the Press have indicated the very considerable positive effect on jobs and the local economy of designing, constructing and operating a Severn Estuary barrage.

The hydro-mechanical machinery and electrical plant, however, could well be sourced abroad in at least one of these proposals.

"SMEC" is a unique, patented, turbine configuration that has some UK-specific benefits:

— It is being developed by a UK company: Verderg Renewable Energy Ltd.

— The conventional higher-head and higher-speed turbines used in a SMEC can be manufactured in the UK.

— If SMEC is adopted for the Severn Estuary, the creation of a large UK manufacturing industry with great export potential would be facilitated.

Furthermore, for any barrage design, the UK Balance of Payments would be improved by a Severn Barrage because in the long-term, less fossil fuel would be purchased from overseas.

The Severn Estuary could be developed using SMEC turbines after successful development of smaller estuaries such as the Camel, Duddon, Wyre and Upper Solway. The Mersey is another potential site. Subsequently, other West Coast estuaries including the Lower Solway Firth could be developed with substantial socio-economic benefits.

11. Concluding remarks

The UK is fortunate to have arguably the world's best tidal energy site in the Severn Estuary. Access to such significant tidal power will reduce the UK's need for supply of fossil fuel from abroad and the attendant political risk and future price uncertainty. In addition, there is considerable current concern over greenhouse gasses and global warming; substantial low-carbon energy generation mitigates any such risk. The Severn Estuary is therefore a strategically vital resource to this country. By adoption of SMEC-encased turbines in any consortium's barrage design, it is possible to exploit that resource cost-competitively with future fossil fuel and without undue environmental impact.

November 2012

Written evidence submitted by the British Marine Aggregate Producers Association (SEV 11)

1. The British Marine Aggregate Producers Association (BMAPA) is the representative trade organisation for the British marine aggregate sector and a constituent body of the wider Mineral Products Association. The Mineral Products Association (MPA) is the trade association for the aggregates, asphalt, cement, concrete, dimension stone, lime, mortar and silica sand industries. With the recent addition of The British Precast Concrete Federation (BPCF) and the British Association of Reinforcement (BAR), it has a growing membership of 450 companies and is the sectoral voice for mineral products. MPA membership is made up of the vast majority of independent SME companies throughout the UK, as well as the nine major international and global companies. It covers 100% of GB cement production, 90% of aggregates production, 95% of asphalt and ready-mixed concrete production and 70% of precast concrete production. Each year the industry supplies £9 billion of materials and services to the £120 billion construction and other sectors. Industry production represents the largest materials flow in the UK economy and is also one of the largest manufacturing sectors. BMAPA represents 11 member companies of MPA who collectively produce around 90% of the 20 million tonnes (Mt) of marine sand and gravel dredged from licensed areas in the waters around England and Wales each year.

Background

2. The Marine Policy Statement 2011 (MPS 2011) recognises that the UK has some of the best marine aggregate resources in the world. Paragraph 3.5.1 states that "*Marine sand and gravel makes a crucial contribution to meeting the nation's demand for construction aggregate materials, essential for the development of our built environment. They are particularly important in England, accounting for 38% of the total regional demand for sand and gravel in the South East (80% in London), 46% in the North East and 22% in the North West. South Wales is also highly dependent on marine-dredged sand, which meets more than 80% of the demand…*". In this respect, marine aggregate supplies play a key role in supporting the delivery of various Government policies, including Sustainable Communities, the regeneration of Thames Gateway and the 2012 Olympic Games.

3. The MPS 2011 acknowledges the strategic roles played by marine dredged sand and gravel resources in supplying large scale coast defence and beach replenishment projects—over 25 Mt being used for this purpose since the mid 1990's. With the growing threats posed by sea level rise and increased storminess, the use of marine sand and gravel for coast protection purposes will become increasingly important.

4. The MPS 2011 also recognises marine sand and gravel resources can be expected to play a key role in supporting the successful delivery of major coastal infrastructure projects associated with Government policies related to energy security and climate change, such as nuclear new builds, port developments and renewable energy. The coastal location of many of these developments means that the sector is ideally placed to supply the large volumes of construction aggregate and fill material that will be required.

5. In all cases, the marine aggregate sector is dependant upon identifying and licensing economically viable sand and gravel deposits to secure sufficient reserves to maintain long term supply to existing and well established markets. The location of such deposits is extremely localised around the waters of England and Wales, restricted to their geological distribution and their geographical position related to the markets location.

6. At present 1,274km^2 of seabed is licensed for marine aggregate extraction, of which around 114km^2 is dredged in a typical year. This represents around 0.15% and 0.016% of the total UK continental shelf area (867,000km^2) respectively. A further 1,931 km^2 of seabed is currently under exclusive option agreement with The Crown Estate. In this respect, the marine aggregate sector is responsible for managing a significant area of the UK seabed.

7. This response sets out some initial views of the British marine aggregate sector on the potential impacts and implications of the proposed Cardiff-Weston Barrage tidal power development in the Severn Estuary.

Marine aggregates in the Bristol Channel

8. At present, five companies are involved in marine aggregate production operations in the Bristol Channel: British Dredging Ltd (CEMEX UK Marine Ltd), Hanson Aggregates Marine Ltd, Llanelli Sand Dredging Ltd, Severn Sands Ltd and Tarmac Marine Dredging Ltd. At any one time there can be up to five marine aggregate dredgers operating in the region.

9. Although the overall production of marine aggregates from the Bristol Channel may appear relatively small (1.232 Mt in 2011) when compared to the overall national production (19.115 Mt), the South West region is particularly dependant upon marine aggregate supplies for natural sand to support both the maintenance and development of the built environment. It should be noted that the current levels of production very much reflect the ongoing economic downturn, being reduced by over 30% from the 10 year peak production that took place in 2007 (1.769 Mt).

10. While there are extensive sources of coarse aggregate (crushed rock), supplies of natural fine aggregate (sand) from terrestrial sources are extremely limited in South Wales. As a consequence marine dredged sand fulfils a strategically important role in underpinning the construction activity taking place in this region, with around 0.6Mt being landed from Crown Estate licence areas in 2011 (1.071 Mt in 2007). The British Geological Survey report that marine dredged sand accounts for 85% of the market for concreting sand and 97% of the building sand supply with no realistic alternatives for either[17]. Landings of marine sand currently occur at Pembroke, Burry Port, Swansea, Port Talbot, Cardiff and Newport. Further landings from licence areas outside of the control of The Crown Estate occur at Newport and Chepstow, which are believed to account for a further 150,000 tonnes.

11. The strategic importance of marine aggregate supplies to South Wales are recognised in the Welsh Assembly Government's minerals policy statement (Minerals Technical Advisory Note 1, March 2004)) together with the Interim Marine Aggregates Dredging Policy (November 2004), both of which acknowledge the importance of marine supplies to the region and the need for these to be maintained.

12. Marine landings to South West England are smaller, 0.409 Mt in 2011 (0.721 Mt in 2007), but no less important at a local scale, with 0.332 Mt being landed at Avonmouth alone (0.618 Mt in 2007). Further landing points include Bridgewater and Appledore.

13. The Department for Communities and Local Government publishes National and regional guidelines for aggregates provision in England over a 20 year planning horizon. This information supports the Managed Aggregate Supply System, which sits within the National Planning Policy Framework 2012. The latest guideline figures were published by DCLG in 2009, and include an assumption that over the period 2005 to 2020, marine sand and gravel will contribute 12 Mt to the construction aggregate production of the South West region—all of which would be delivered through the Bristol Channel.

14. For the Bristol Channel region as a whole, marine aggregate supplies offer significant environmental advantages by being able to deliver large volumes of a low cost, bulk construction material very close to the point of demand. The distribution of the landing points for marine aggregates across the region reflect the location of port infrastructure, which in turn is closely associated with the major coastal urban areas. This relationship between port and urban coastal hinterland significantly reduces the distance over which the material has to be transported by road to reach its point of end-use.

15. The large tidal range of the region means that access to landing points is largely constrained to high water. The current fleet of dredgers operating in the region have therefore been specifically designed for dredging relatively shallow water in order to supply tidally restricted wharves. To maintain vessel productivity and meet market supply demands, a typical production cycle will therefore see cargoes being loaded at low water and discharged at high water, with a 12 hour turnaround between cargoes (i.e. two cargoes being dredged and landed each day).

Implications of the Cardiff-Weston Barrage

16. Marine aggregate landings in the Severn Estuary region generate turnover in excess of £10 million per annum, based on the product value at first point of landing. However, as aggregates lie at the beginning of a supply chain that supports the manufacture of a range of value-added products including concrete products and ready-mixed concrete, this baseline value considerably underplays the economic significance of the sector's

[17] Highley, DE *et al*. 2007. The strategic importance of the marine aggregate industry to the UK. British Geological Survey Research Report, OR/07/019. ISBN 978 0 85272 607 5

contribution in underpinning wider construction output across the region—particularly given the particular reliance in South Wales.

17. As far as the proposed Cardiff-Weston Barrage that is being considered, there are two main issues that need to be taken into account from a marine aggregate perspective.

Access to licence/landing port

18. The first concerns the degree to which any barrage proposal would constrain the ability of the marine aggregate industry to access licensed reserves or supply their principle markets. As outlined in paragraph 15, the cost model of the industry is based around small vessels supplying tidally constrained ports through a 12 hour cycle. As this cycle is determined by high water times, there is very little flexibility in the timing of these operations. If a vessel misses a tide, the vessels productivity is effectively halved.

19. The Cardiff-Weston Barrage proposal would separate the principle licensed reserves (including the production licence areas at Holm Sands, Culver Sands and Nobel Bank and the Outer Bristol Channel application area) from the principle landing points in the upper estuary, namely Cardiff, Newport and Avonmouth. These three ports collectively receive around two thirds of the marine sand production landed in the region. Inevitably, vessels transiting between the open sea and the waters confined by a barrage would be subject to significant delays in having to lock between the two water bodies. While there may be some mitigation derived through extended tidal windows to access ports within the confined water body in the upper estuary, the implications to the marine aggregate sector in terms of lost productivity and the impact on the current business models in place will have to be considered in detail. This is particularly important given the construction market's reliance on marine sand, and the absence of any realistic alternative products to replace it.

20. The barrage proposal could also potentially constrain access to existing marine aggregate interests, both licensed and under application, through the construction works and through alterations to the tidal range in the upper estuary which may constrain safe access to licensed areas. The precise implications of these issues remain unclear and also need to be considered.

21. Finally, the hydrodynamic implications of the barrage proposals could have a significant effect upon the various marine sand deposits that are permitted/under application for marine aggregate extraction—both offshore and in the waters confined by a barrage. Significant changes to flow rates and/or directions could see these deposits being adversely affected, either through increased flow resulting in the deposits being eroded and removed through scour or through reduced flow resulting in the deposition of fine grained sediments unsuitable for construction aggregate as over burden.

Construction aggregate supply

22. The volume of construction aggregate required to support any barrage development will be significant, but will also be subject to the same constraints over the availability of aggregate supply in the region as other construction projects. While resources of coarse marine aggregate (gravel) are limited in the Bristol Channel region, there are substantial volumes of marine sand available which could be suitable for both fill and general construction purposes. The ability to deliver large volumes of a low cost, bulk material directly to site could make marine dredged sand a potentially attractive option for the fine aggregate requirements of any construction works that take place.

23. In terms of the potential role for marine aggregate resources, there are useful parallels that can be drawn on elsewhere. As one example, the Cardiff Bay Barrage used over 2.5 Mt of marine sand, dredged from a licence area permitted specifically to support the projects construction. While in the Netherlands, three borrow pits were permitted to source marine sand to support the extension of Rotterdam harbour, Maasvlakte 2. This project, which is currently ongoing, has already seen over 200 million m^3 of sand being dredged from dedicated licence areas in the southern North Sea in order to create new land area for the port development. In one seven day period alone during 2011, over three million m^3 was dredged and relocated—equivalent to 4.5 Mt.

24. Given the significant volumes of sand likely to be required to provide both the construction aggregate and fill associated with a barrage project, the current reserve permitted within existing licensed areas would not be sufficient to supply the additional volumes required on top of the baseline market demand requirements for the region as a whole. In 2011, the maximum permitted offtake from Crown Estate licensed areas in the Bristol Channel region was 3.249 Mt, of which 1.232 Mt was actually dredged.

25. Critically, we do not consider there to be a shortage of marine sand resource within the Bristol Channel region to support such a project. However, to realise the significant volumes that are likely to be required for any major construction effort, either the permitted offtakes from existing licence areas would have to be substantially increased or new areas permitted for extraction. In both cases, new Marine Licences for the extraction of marine minerals would have to be sought. Based on recent experiences in the region, the timescale for achieving new Marine Licences can be expected to take three years as an absolute minimum. Therefore it is important that sufficient lead time is scheduled into any construction plan.

November 2012

Written evidence submitted by The TaxPayers' Alliance (SEV 12)

1. The proposed Severn Barrage does not appear to be a cost-effective means of generating energy to supply the needs of Britain's families and industry, or of increasing the amount of low carbon energy used in order to meet international commitments. While private finance may be available, that will only be on the basis of significant subsidy at the expense of taxpayers or consumers.

2. A feasibility study in 2010 by the Department of Energy and Climate Change found that a proposed Severn Barrage would only generate power at a levelised cost of over £300/MWh—"other renewables (e.g. wind) and nuclear power represent better value"—and would have a negative Net Present Value (NPV). The study found that the project most similar to the Hafren proposals—a Cardiff-Weston barrage—would have had a levelised cost of £312/MWh and an NPV of -4.6 billion.

3. The projected cost per MWh is greater than for any other source of energy which is currently expected to be deployed on a significant scale. The price and construction risk is also greater with a single project. And building a single barrage removes the possibility of technological improvements and learning reducing the costs and risk over time as the project moves to scale.

4. As a result, Contracts for Difference (CfD) are needed for energy generated by the Severn Barrage to be competitive, and would presumably need to cover the difference between the levelised cost and the energy price. That implies a very high level of subsidy. Given the scale of the project, and the amount of energy that could therefore be generated, the high cost per MWh would mean that paying for the subsidies would impose a substantial burden on consumers.

5. The difference in the DECC feasibility study between the levelised cost for the Cardiff-Weston barrage £312/MWh and the levelised cost of even extremely expensive offshore wind energy (at £160/MWh) is £152/MWh. As a result, **even if the barrage entirely displaced offshore wind energy, it would cost an additional £2.4 billion a year to generate the projected 15.6 TWh a year—equivalent to nearly £90 a household**.

6. It would be more likely that it would displace a much more affordable mix of energy sources and the cost would be even greater than that. **If the barrage displaced nuclear power (estimated in the feasibility study as costing £79/MWh) then it would increase costs by £3.6 billion a year—equivalent to nearly £135 a household.**

	Cardiff-Weston barrage	*Offshore wind*	*Nuclear*	*Difference between Cardiff-Weston and offshore wind*	*Difference between Cardiff-Weston and nuclear*
Energy generated TWh per year	15.6	15.6	15.6	-	-
Levelised cost £ per MWh	312	160	79	152	233
Total cost £ billion per year	4.87	2.50	1.23	2.37	3.63
Cost per household £ per year	180	92	46	88	135

For all projects, 10% investor discount rate assumed and optimism bias included. Number of households assumed at 27 million.

7. The contracts for difference would also transfer electricity price risk from investors to consumers. Given the lifespan of the project, those risks could lead to a substantial further subsidy bill if the energy price turns out to be lower than expected.

8. While most of the construction risk will lie with the investors, should the project go too far over budget it seems possible that the taxpayer will ultimately end up with the liability to complete the project.

9. Much more detailed technical information is needed in order for independent groups to properly assess the scale of the costs of this new project and risks which will be borne by consumers. There is no reason to think that the NPV has changed sufficiently from the DECC study to justify going ahead though.

10. Claims about significant increases in employment resulting from projects which depend upon substantial subsidies should always be viewed with scepticism. The effect on net employment after the disruption of local industries (such as Bristol Port, with reports a new deep-sea port may be jeopardised) and the cost to domestic and industrial energy consumers is likely to be negative.

11. The DECC feasibility study was highly uncertain but it suggested Regional Net Operational employment of only 120 within a range between -2000 and +800. Given that the subsidies will mostly be paid outside the region, it seems likely that the overall impact on employment across the UK would be negative. The wider benefits envisaged by Hafren are highly speculative and their estimate of 50,000 new jobs is not credible.

12. Given all of these concerns, the TaxPayers' Alliance believes that it would be reckless to go ahead with this high risk project. There is also no sense in repeating a major study on the feasibility of a Severn Barrage

when the last one was completed just two years ago. Britain should focus on other sources of energy for the foreseeable future.

November 2012

Written evidence submitted by Unite the Union SW/8071 branch (SEV 13)

1. Jobs dependent on Bristol Docks

The Port of Bristol Company directly employs about 500 people, most of whom are members of Unite, while there are between 5,000 and 7,000 jobs in the immediate area that are dependent on the port. Most of these are well organised with a high proportion of Unite membership).

2. Current position of Bristol Docks

The Port is made up of two dock complexes: Avonmouth and Portbury. The most significant trades are in the import of Cars, Jet Fuel (25% of UK imports), Animal Feed, Coal, Food and Containers.

3. Access to Bristol via the Barrage

The proposed barrage will be about 20 miles downstream of Bristol, and so access would be via locks. Locks add a lot of time to a voyage, and might double the turnaround of ships visiting the Port. This is a cost to the shipping company, and alternatives (such as Southampton, where there are no locks) become more attractive. Locks are also costly to build and operate, and though Hafren Power say there would be no charge, the costs have to be recouped somewhere.

4. Big Ship Capacity

Ships are getting bigger, and any viable port needs to maintain and increase its Big Ship Capacity. A barrage would reduce Bristol's. Because the barrage would half the tidal range, there will be less depth of water at high tide. In addition, the salinity of the estuary behind the barrage will reduce, meaning the ships will ride lower in the water, so again reducing the available depth. Increased sedimentation behind the barrage will also massively increase the need for dredging, and the costs that entails.

5. Proposed Deep Water Container Facility

The future of Bristol Docks is dependent on the new container facility, which will create a massive increase in capacity and jobs if it goes ahead. Planning permission has been granted and funding is in place for this, and construction is due to start in 2014. If the barrage goes ahead, the new facility will not be built. This will mean that the port will no longer be a viable proposition for the Bristol Port Company, and they will sell or wind up their operation, threatening the future of the whole of the Port.

6. Blight

The uncertainty over the future of Bristol is already having an effect on negotiations between the Bristol Port Company and shipping companies about long-term contracts.

7. Impact on Employment

The 2009 DTZ Report says that "at the peak of negative impact" that 60% of port activity upstream from the barrage will cease, and it will continue to diminish after that. So effectively, a barrage means the death of the Bristol docks.

8. Impact of Construction

At some point during construction of a barrage, shipping would have to cease for a period of 3 to 6 months at the final stage to allow the transformation from open sea to sea/lake. During this period Bristol ships would have to go elsewhere. It is then difficult to see why any of this trade should come back.

9. The Hafren Power Proposal

Hafren Power says that the concerns expressed about the Port of Bristol in 2008–10 have been addressed in the new proposal, but neither the Bristol Port Company nor the Unite branch have been able to identify significant differences from the old proposals.

November 2012

Written evidence submitted by Gloucestershire County Council (SEV 14)

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

We understand that the barrage is estimated to have the potential to generate approximately 5% of the UK's current electricity requirement and make a significant contribution to reducing greenhouse gas emissions. Whilst Gloucestershire County Council has not singled out the C-W Barrage as a preferred option, the Council does believe that energy should be recovered from the enormous tidal potential of the Severn Estuary, and acknowledges that this scheme is by far the most effective from an energy generation perspective.

What risks and opportunities could it pose with regard to flooding in the Severn Estuary, and how might any risks be mitigated?

This is a critical issue for Gloucestershire. The impact on flood risk and drainage that the scheme may have on the County and surrounding areas needs to be fully understood before a decision is taken. Full account needs to be taken of the potential impacts of the change in water levels and longer residence periods on saturation levels, ground water flows and increased flood-risk within the affected areas. The issue of potential tidal locking resulting from water being impounded by a barrage needs to be examined in detail. In particular, the impact of tidal locking on properties as well as agricultural land along either side of the River Severn is a key concern and needs to be fully explored. We understand this was examined in detail in the earlier studies.

However, we also recognise that in a "do nothing" scenario, rising sea levels will increasingly present a flood risk within Gloucestershire, and a C-W Barrage is likely to afford significant protection from this source of flood risk.

What risks and opportunities could it pose to wildlife and habitat in the Severn Estuary, and how might any risks be mitigated?

The Severn Estuary and its surrounds are of high value in biodiversity terms and form an important area for the delivery of international, UK, national and county-wide biodiversity objectives. Indeed, the waters of the Severn have been described as a "uniquely harsh" environment by virtue of the huge tidal movements and very high silt content—this would almost certainly change with a C-W Barrage.

The Severn Estuary is of worldwide importance for its habitats and associated species of wildlife. It is designated as a Wetland of International Importance (Ramsar), a Special Protection Area for its birds (SPA) and a Special Area of Conservation for its habitats and fish (SAC). It is also classified as a European Marine Site and is nationally important as a Site of Special Scientific Interest (SSSI). Further information on its designations and importance for biodiversity can be found on the Severn Estuary Gateway website at http://www.severnestuary.net/asera/. There is a significant challenge in relation to these designations as to what mitigation and compensation could be provided to a Cardiff to Weston Tidal Barrage to make it environmentally acceptable.

Other protected sites that are likely to be affected include the European Sites (the River Wye (SAC) & Walmore Common (SPA/Ramsar)), a number of SSSIs (e.g. Lydney Cliff, Frampton Pools) as well Local Sites (e.g. Alney Island LNR plus Nass and Garden Cliff Key Wildlife Sites). There are also many identifiable legally protected species in the Severn Estuary within Gloucestershire that may be affected by a Cardiff to Weston Severn Tidal Barrage Scheme such as otter, whimbrel and Bewick's swan. In addition priority species on the English List (S.41 NERC Act 2006) including Allis shad, Twaite shad, river lamprey, sea lamprey, Atlantic salmon, European eel, slender hare's ear and curlew.

Tidal barrages are of particular concern for the estuary's migratory fish and this issue has received detailed examination when various tidal options were considered by the government between 2007 and 2010. A Strategic Environmental Assessment topic paper on fish from this time (December 2008) raised many issues and uncertainties. It is difficult to see how an impact might be avoided by a Cardiff to Weston Tidal Barrage, particularly on migratory fish. A tidal power scheme is also likely to displace birds and change the nature and extent of intertidal habitats. This may have knock on effects upon national/international species' abundance and distribution.

It is recommended that the Devon and Severn Inshore Fisheries and Conservation Authority (IFCA) is engaged in any future discussions on this issue.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

The second largest tidal range in the world brings both potential opportunities but also greatly enhanced risks to the environment and sustainability of the scheme. In 2010 we were made aware by the Royal Society for the Protection of Birds (RSPB) of the difficulties and unexpected adverse costly effects experienced by the Eastern Scheldt (Oosterschelde) storm surge barrier scheme in the Netherlands. We would advise that the RSPB briefing report of this scheme (http://www.rspb.org.uk/Images/RSPBbriefEasterScheldtreportfinal_

tcm9–240984.pdf) is looked at very carefully and assessed to see if any lessons can be learnt before any estuary barrage scheme is progressed further.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

Gloucester Harbour Trustees will be responding separately on the potential impact of the barrage on ports within the County.

Leisure and watersport activity might arguably be enhanced by a reduced tidal range in the wider reaches of the Severn.

The effective loss of the Severn Bore would be seen as a significant issue.

[The impact of a barrage on ports along the estuary was discussed extensively in the previous studies. Concerns were raised about the possible job losses at the Port of Bristol resulting from a barrage.]

The barrage would create significant employment during its construction although a lot of the components would be manufactured elsewhere in the UK and Europe. Local skill sets may not match those required although apprenticeships and training courses could be set up to address this issue.

The impact on fishing and aggregates was extensively covered in the previous reports/studies. Clearly both sectors would be affected by a barrage between Cardiff and Weston.

The potential impacts of the scheme on the use of construction materials and any construction waste which may arise will need to be assessed.

With regards to sufficient supply for minerals—the overarching landbank in South Wales and the South West might indicate that sufficient reserves are available. However, this might be misleading and there could be significant environmental issues depending on from where aggregate supplies are sourced from. Clearly this issue requires careful consideration to ensure the most sustainable approach to supply of aggregates is indicated.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

No comments.

How does the company plan to engage and consult the community in the development of the project?

No comments.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

The proposals would be very likely to be in breach of the Habitats Directive if adequate compensation for damage to the European Marine Site could not be shown to be achievable and is then implemented successfully. It will be a significant challenge to analyse the biodiversity effects of a tidal barrage and how they could be compensated for especially with respect to migratory and estuarine fish but also the re-creation of habitats elsewhere of a type and scale for those that would be lost.

Are any other proposals for tidal power projects in the Severn Estuary currently under consideration?

None known.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

This would obviously depend on the extent to which UK firms were involved but the scheme would raise the profile of UK based companies involved in its design and construction. Given the scale of the proposed barrage it would act as a showcase for UK engineering and UK low carbon technologies. As mentioned previously, some of the components would be manufactured offsite and transported to the estuary.

Gloucestershire is a centre for a number of companies working in the nuclear industry and is well placed to become an international hub for businesses focused on low carbon generation. There is potential to develop the skills already available locally to attract firms to the county.

November 2012

Written evidence submitted by the North Somerset Flood Risk Action Group (SEV 15)

NORTH SOMERSET FLOOD RISK ACTION GROUP

Formed in 2008, the North Somerset Flood Risk Action Group is an umbrella group consisting of nine 12 town and parish councils* (all with significant amounts of land at high risk of flooding from either tidal or fluvial flooding, or both), the North Somerset Levels Internal Drainage Board, and a number of individual landowners, NFU and CLA members. Its Terms of Reference are as follows:

(i) to raise awareness of flood risk in a constructive and proportionate manner;

(ii) to work to secure improvements to North Somerset's flood defences;

(iii) to assist in the preparation of community emergency strategies;

(iv) to ensure that the views of local communities are represented in every debate involving flood risk and flood management issues.

**Councils currently represented are: Clevedon, Kenn, Kewstoke, Kingston Seymour, Puxton, Wick St Lawrence, Wrington, Yatton and Weston-super-Mare*

Adopted February 2008

Its meetings are attended by Environment Agency staff as appropriate and, on the same basis, by officers from the local authority's Emergency Management Unit. A number of district councillors also attend.

In the wake of profound academic, technical and community concerns arising from the draft Severn Estuary Flood Risk Management Strategy (SEFRMS), and the ensuing representations to ministers, MPs and MEPs, a sub-committee of NSFRAG was formed last year to negotiate with EA staff on revisions to the Strategy, which are understood to be due early in 2013.

COMMENTS ON THE PROPOSAL

The initial comments of NSFRAG are as follows:

1. *Engagement*

1.1. It is regrettable that NSFRAG was not alerted to this call for evidence until a very late stage, and only then by another action group. Engagement should begin at the outset of the process and should certainly include all those town and parish councils likely to be directly affected by any Barrage proposals, as well as action groups such as this.

1.2. Lack of meaningful engagement was one of the causes of the withdrawal of the SEFRMS and confidence in the engagement process has been slow to rebuild. The promoters of the Cardiff—Weston Barrage proposal would be advised to learn from this, along with all other interested parties, both at national and local level.

2. *Modelling*

A project such as this needs to be underpinned by robust modelling, and there should be complete transparency as to the completeness and reliability of the data on which such modelling is based.

3. *Flood Risk Impacts*

In North Somerset the interaction between tidal systems and surface water drainage via the rhynes is complex and finely balanced. It will be important to understand how this will be affected by the barrage proposal and what the implications would be for the future management of rhynes and outfalls. The Internal Drainage Boards have a particularly vital role to play in any further development of these proposals.

4. *Wildlife and Habitat*

Wildlife and habitat in the Severn Estuary would be significantly affected by the proposed Barrage, in a multitude of ways which are far from being completely understood. Lost intertidal habitat would have to be replaced on an unprecedented scale; there is no guarantee that this would be successful and it would presumably involve the loss of productive farmland and habitation.

5. *Economic Effects*

The economic effects of these proposals—ranging through impacts on agriculture, other rural enterprises, port facilities, recreational and leisure facilities and entire communities—would need very careful assessment. Our fear is that any benefits to the area are likely to be heavily outweighed by the costs. Small rural communities adjacent to the estuary are likely to be particularly badly affected. **This aspect of the proposal needs input from the whole spectrum of stakeholders, from the smallest individual landowner to the largest local authority.**

6. *Consultation*

NSFRAG wishes to be kept informed of the future development of the Cardiff-Weston Barrage Proposal, and to be included in the list of formal consultees.

November 2012

Written evidence submitted by Kingston Seymour Parish Council (SEV 16)

KINGSTON SEYMOUR PARISH COUNCIL (KSPC)

Kingston Seymour is a small rural parish (population 400) lying to the south of Clevedon, North Somerset, bounded to the west by the Severn Estuary and to the east by the M5. The entire parish is Flood Risk Zone 3 (high risk of tidal flooding), its land lying between a few feet below and a few feet above sea level. Surface water is drained by ditches and rhynes which are ably managed by the North Somerset Levels Internal Drainage Board. The village flooded in the early 17th century and then not again, as far as we know, until 1981, when an unfortunate combination of excessive rainfall, storm force westerly winds and the highest tidal levels recorded in the last century caused extensive flooding of land, houses and commercial property. It has not flooded since then.

COMMENTS ON THE PROPOSAL

The initial comments of KSPC are as follows:

1. *Engagement*

1.1. It is regrettable that the Parish Council was not alerted to this call for evidence until a very late stage, and only then by the North Somerset Flood Risk Action Group, of which it is a member. NSFRAG was similarly unaware until a few days ago.

1.2. Engagement should begin at the outset of the process and should certainly include all those town and parish councils likely to be directly affected by any Barrage proposals, as well as action groups such as this.

1.3. Our recent experience with the Severn Estuary Flood Risk Management Strategy has been salutary. The original Environment Agency proposals horrified the whole community, which could not believe that they were to lose almost 25% of the land area of the parish to "compensatory habitat", or that such habitat would necessarily be created. Confidence in the engagement process has been slow to rebuild. The promoters of the Cardiff—Weston Barrage proposal would be advised to learn from this, along with all other interested parties, both at national and local level.

2. *Modelling*

A project such as this needs to be underpinned by robust modelling, and there should be complete transparency as to the completeness and reliability of the data on which such modelling is based.

3. *Flood Risk Impacts*

In North Somerset the interaction between tidal systems and surface water drainage via the rhynes is complex and finely balanced. It will be important to understand how this will be affected by the barrage proposal and what the implications would be for the future management of rhynes and outfalls. The Internal Drainage Boards have a particularly vital role to play in any further development of these proposals.

4. *Wildlife and Habitat*

Wildlife and habitat in the Severn Estuary would be significantly affected by the proposed Barrage, in a multitude of ways which are far from being completely understood. Lost intertidal habitat would have to be replaced on an unprecedented scale; there is no guarantee that this would be successful and it would presumably involve the loss of productive farmland and habitation.

5. *Economic Effects*

The economic effects of these proposals—ranging through impacts on agriculture, other rural enterprises, port facilities, recreational and leisure facilities and entire communities—would need very careful assessment. It is feared that any benefits to the area are likely to be heavily outweighed by the costs. Small rural communities adjacent to the estuary, such as this, are likely to be particularly badly affected. This aspect of the proposal needs input from the whole spectrum of stakeholders, from the smallest individual landowner to the largest local authority.

6. Consultation

KSPC wishes to be kept informed of the future development of the Cardiff-Weston Barrage Proposal, and to be included in the list of formal consultees.

November 2012

Written evidence submitted by Andrew Short (SEV 17)

As a family, we wish to lodge our objection to the proposed full-width Severn Barrage in any shape or form.

We have researched the information available in the public domain and wish you to register the following points of concern:

A full-width barrage will have far too great an adverse impact on the environment of the estuary, in particular wildlife that relies on the current tidal pattern.

The islands of Flatholm and Steepholm will be adversely affected by the influence of the barrage.

Long-term employment provided by the operation of the barrage will not be significantly greater than the employment positions lost in other areas (notably, the docks areas, etc.).

The construction of the barrage will have a very significant carbon footprint in respect to manufacture, transport and containment of concrete materials.

The energy savings produced by the barrage per unit of investment are no greater than would reasonably be expected from investment in other areas.

Specifically, if the investment were made in public transport (more services, more frequent services, subsidised fares, etc.) and car-share schemes, savings of similar order would be made far earlier and with less adverse environmental impact.

This is based on the assertions that the barrage would save some 5% of the country electrical energy needs, and that total energy use is approximately equally apportioned across domestic, commercial and transport uses.

Please find against the submission for a full-channel width barrage.

We would have no objection against a smaller barrage, although these, in turn, would be less competitive compared with transport investment.

Written evidence submitted by Cloucestershire NFU Severn Estuary Stakeholders (SEV 18)

Gloucestershire NFU Severn Estuary Stakeholders was formed in 2011 to promote information exchange and partnership working between all stakeholders with an interest in water and flood risk management issues relating to land and settlements from the first Severn Crossing to Gloucester. The issues in this area are different from those in the wider mouth of the estuary and need to be considered separately and in detail. Gloucestershire NFU Severn Estuary Stakeholders include local farmers and landowners and private, public and government-run organisations.

We are aware of the DECC Severn Tidal Power Feasibility Study of October 2010 and the Corlan Hafren Severn Barrage Document also of October 2010, but are not privy to any further detail regarding the Cardiff-Weston Barrage proposals. We are aware that many of our membership organisations may make their own submissions to the Committee. Our observations are as follows:

Engagement is of paramount importance from the outset. This should be continuous and at all levels, including parish and landowner level, not just with the large organisations. The original Severn Estuary Flood Risk Management Strategy was withdrawn on the instruction of the Environment Minister through lack of engagement at local level. Gloucestershire NFU Severn Estuary Stakeholders have built on this experience. The broad membership of the group has benefited from sharing individual expertise ranging from that of senior members of staff in a large government-run organisation, to that of a landowner with experience of generations of his family living beside the river.

Engagement should not be limited to the promoters of the Cardiff-Weston Barrage Proposal. The national and local government agencies making their assessment of the suitability of the plan should also engage at all levels, throughout the process, particularly with local stakeholders.

Modelling. There is a need to understand the effect that the construction of a barrage would have on river levels north of the first Severn Crossing. How robust is the modelling presented by the promoters of the Cardiff-Weston Barrage Proposal given the difficulties in predicting climate change and sea level rise? We note that within the feasibility study attention is drawn to the fact that there is a lack of detailed understanding of the movement of silt and mudflat deposits throughout the estuary and the effects that the barrage would have on those movements. This is of concern to us as it mirrors a lack of knowledge also noted in the Severn

Estuary Shoreline Management Plan Review which states "there is little sediment data available upstream of The Shoots" (the first Severn Crossing).

Flood Risk Impacts associated with the Severn Barrage Proposal fall into two categories: those associated with tidal flooding and those associated with fluvial flooding. Tidal flooding issues are extensively covered within the feasibility study but the potential impact of the Barrage Proposal on fluvial flood risk receives very little mention. Surface water drainage from land and settlements along the Severn Estuary is restricted by tide locking (the time when watercourses and drainage channels cannot discharge into the river due to the tide being in). Any increase in the proportion of time that drainage channels are tide locked (which might be brought about by the construction of a barrage) would reduce the rate of surface water drainage into the river and therefore increase the fluvial flood risk to land and settlements. The drainage systems that would be affected extend far beyond the boundary of the floodplain. Therefore the impact of any river level changes emanating from the Severn Barrage Proposal requires extensive investigation and discussion with all stakeholders potentially affected. Gloucestershire NFU Severn Estuary Stakeholders feel it is imperative that a co-ordinated approach is adopted by those organisations tasked with getting surface water through the systems and outfalls. The engagement process should therefore recognise the need to work jointly with all concerned parties rather than with individual organisations.

Wildlife and Habitat in the estuary will be affected by the proposed Barrage and compensatory habitat will be sought to replace lost intertidal habitat. This will have repercussions throughout the Severnside communities of Gloucestershire who have already faced similar discussions during the on-going development of the Environment Agency's current Severn Estuary Flood Risk Management Strategy. The creation of compensatory habitat will inevitably see a loss of productive farmland, housing and infrastructure. We would draw attention to the statement within the feasibility study that compensatory habitat creation on this scale has never been attempted before, many of the suggested methods are untried and it would pose significant delivery problems. This will have wide-ranging implications and it is essential that engagement takes place with all affected parties from major infrastructure providers through to parish councils, farmers and landowners in a co-ordinated way.

The Severn Estuary Flood Risk Management Strategy, as referred to in the feasibility study, is being developed. The Environment Agency is currently undertaking an intensive process of local community engagement with the objective of producing a workable strategy. It should be noted that this also includes a review of the practicality of any proposals for managed realignment.

Economic Effects—Though set up to promote "joined-up thinking" on water management in land and settlements close to the tidal reach of the River Severn in Gloucestershire, Gloucestershire NFU Severn Estuary Stakeholders would be concerned that the economic effects of the barrage on their area are fully and properly assessed. The area would receive few, if any, of the economic benefits to be gained from the construction or operation of the barrage. The economic effect that changes in the character of the land along the Severn Estuary would have on leisure and tourism activities also needs to be carefully assessed, again with an approach that embraces all stakeholders.

The Gloucestershire NFU Severn Estuary Stakeholders currently include the Canal and River Trust, Country Land and Business Association, English Severn and Wye Regional Flood and Coastal Committee, Environment Agency, Frampton Court Estate, Gloucestershire County Council, Gloucestershire Farming and Wildlife Advisory Group, Gloucestershire Wildfowlers Association, Lower Severn Internal Drainage Board, Minsterworth Parish Council, Natural England, NFU, Severn Estuary Partnership, Severn Voice (representing the parishes from Slimbridge to Elmore), Stroud District Council, The Berkeley Estate and the Wildfowl and Wetlands Trust. (The Environment Agency have asked not to be a signatory to this submission as it will be making one of its own to the Select Committee.)

November 2012

Written evidence submitted by the Vale of Glamorgan Council (SEV19)

Purpose of the Report

1. The purpose of this report is to advise Cabinet of the Commons Select Committee's recent public consultation on the potential for a privately financed Severn Barrage.

Recommendations

1. That the contents of the report be noted and that it be further noted that a draft copy of the report has already been issued to the UK Government.
2. That Cabinet endorse the concerns set out in paragraphs 7 and 8 of this report as the Council's formal response to the Commons Select Committee consultation.
3. That in responding, the Select Committee recognises the need to accurately refer to the project for a Severn Barrage as having potential landfall at Lavernock Point, in the Vale of Glamorgan.
4. That the report be referred to Planning Committee and Economy and Environment Scrutiny Committee for information.

5. That a copy of the report highlighting the Council's response to the consultation by the UK Government Select Committee be put on the home page of the Council's website.
6. That the approved report, including all the responses to the consultation undertaken by the Council in responding to the UK Select Committee, be forwarded to the UK Government.

REASONS FOR THE RECOMMENDATIONS

1. To advise Cabinet of the Commons Select Committee Severn Barrage consultation.
2. To obtain Cabinet's endorsement of the response submitted to the Commons Select Committee in respect of the consultation on the Severn Barrage.
3. In order to ensure accuracy and clarity when referring to the project.
4. To advise Planning Committee and the Economy and Environment Scrutiny Committee of the recent public consultation.
5. In order to highlight the Council's response to consultation on this important topic.
6. To ensure an up to date response is issued to the Commons Select Committee, which response includes all comments made as a result of the Council's own consultation exercise.

BACKGROUND

2. A previous report of the Director of Environmental and Economic Regeneration on 22 April 2009 advised Cabinet of the Phase One Consultation into the feasibility of tidal power within the Severn Estuary undertaken by the Department of Energy and Climate Change (DECC) in partnership with the Welsh Government (WG) and the South West Regional Development Agency (SWRDA). That report set out the chronology that had led to the Phase One consultation and provided a synopsis of the range of proposals that were being considered by the UK Government to provide renewable energy from the Severn Estuary. The consultation focussed on a recommended short list of schemes that were being proposed for more detailed analysis and the issues that the feasibility study was considering and how those issues were being approached. The report set out the concerns of the Vale of Glamorgan Council with regard to the work of the feasibility study to date, and was forwarded to the Department of Energy and Climate Change as this Council's response to the Phase One consultation.

3. The government published its response to the consultation on 15 July 2009 alongside its Renewable Energy Strategy and the UK Low Carbon Transition Plan, two complementary documents that set out how the government propose to deliver 15% of the UK's energy from renewable sources by 2020 and a reduction in carbon emissions by 2020 to meet the first three UK carbon budgets.

4. In October 2010, the Government published the findings of the feasibility study and consultation into Severn tidal power and concluded that of all the schemes investigated, despite its high capital cost of approximately £34 billion; the Cardiff to Weston barrage scheme offered the best value for money. It should be noted that the terminology relating to Cardiff-Weston, is Government terminology, and should more accurately refer to Lavernock. The Government however also concluded that there was not a strategic case for public investment of this scale in tidal energy at that time but did not preclude a privately financed initiative coming forward.

5. Recent reports suggest that private financing for a Severn Barrage may now be available but only if it is supported by the proposed Contracts for Difference Mechanism ie long-term instruments that provide stable and predictable incentives for companies to invest in low-carbon energy generation schemes.

6. In response to the privately financed proposals, the UK Government has established a Commons Select Committee to investigate the proposed Cardiff to Weston Barrage. The Committee will examine the potential for the project to deliver low-carbon electricity to the UK and the likely cost to consumers as well as the potential impacts on wildlife and local employment. The Committee has invited written evidence from interested parties on the 30th October 2012 and requires responses by 30th November 2012 addressing some or all of the following points:

— What contribution could the Cardiff to Weston Barrage make to UK energy security and climate change objectives?
— What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?
— What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?
— What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?
— What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?
— Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

— How does the company plan to engage and consult the community in the development of the project?

— How does the company plan to engage and consult the community in the development of the project?

— Are the proposals in breach of EU legislation, and if so how will this be addressed?

— Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

— What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

Relevant Issues and Options

7. In response to the previous consultation exercise, the Council was satisfied that the work undertaken to assess and potentially develop tidal power in the Severn Estuary was thorough and dealt with all of the relevant material considerations and the principle of maximising the opportunity through the promotion of a Cardiff (Lavernock/Penarth) to Weston barrage was generally supported. However there were a number of factors that were felt to require more detailed consideration and assessment which were more specific to the Vale of Glamorgan. It should be noted that a copy of this report has already been submitted to the Commons Select Committee to meet the deadline of 30 November 2012, with a statement that any additional comments that Cabinet may wish to make will be forwarded separately after the closing date. The specific areas of concern are detailed below:

— Should the barrage ultimately prove to be the preferred tidal power option, there would be considerable impact upon land at Lavernock Point both during construction and following completion. The construction phase itself lasting up to seven years and involving thousands of workers. Additional concerns are expressed over the need to transport and accommodate materials and the impact upon the local highway network is of concern. The Council would wish to work closely with DECC and the WG to ensure that environmental impact in this area is minimised.

— The economic benefits of the scheme should not be understated given the employment benefits both during construction and beyond during operation. The scheme also has the potential to generate a significant level of tourism and educational interest. All these issues also have the potential to impact significantly on the local highway network.

— While the generation of renewable power by a tidal barrage is commendable and would be generally welcomed, linking such as facility with the National Grid and the transmission of this power could have significant impacts upon the landscape of the Vale of Glamorgan. The Council welcomes the intention to investigate the potential impact of a tidal power scheme on the energy market, electricity network/grid and in particular the local environment. In this regard, consideration should also be given to whether there is potential to include other options as part of the barrage scheme. By way of example, the potential for lagoons, reefs and even off-shore wind generation as part of the scheme should be considered.

— The development of the barrage could have significant implications for the port of Barry. In this regard the port of Barry would be the closest port on the seaward side of the barrage and there needs to be a careful assessment of the implications for the port not only during the construction phases of any barrage, but also longer term. In terms of wider impacts, especially with regard to ports upstream from the barrage, the issue of displacement of shipping traffic would require detailed consideration as would the need for the provision of infrastructure to facilitate access to ports such as Cardiff and Bristol. Such infrastructure to include locks and harbouring facilities. The potential impact on employment within existing ports also requires detailed consideration as would the potential benefits to ports such as Barry on the seaward side of the barrage. One potential benefit would be to link the tourism and visitor impacts of the barrage and the potential links to Barry and the use of the dock are for leisure and tourist related activity, including the potential for marina development.

— The Vale of Glamorgan currently accrues significant tourism benefits from its attractive and extensive coastline. In the event that the Cardiff (Lavernock/Penarth) to Weston barrage is the favoured tidal power option, while accepting that this scheme could have tourism benefits in its own right, concerns are expressed as to the impact that such a scheme would have on the wider tourism resource within the Vale of Glamorgan.

— The site of the larger barrage proposal is currently indicated to make landfall on the Welsh side at Lavernock Point in the Vale of Glamorgan and should be referred to in the future as either the Lavernock to Weston barrage or by reference to the closest major town, the Penarth or Barry to Weston barrage not Cardiff as is currently the case. Such terminology is misleading and the project should be renamed and referred to as the Lavernock Point to Weston Barrage in all official correspondence.

— The ecological impacts of the larger Cardiff (Lavernock/Penarth) to Weston barrage are noted in the reports that have been circulated and it is acknowledged that considerable work will be required on the impacts on habitats, ecology and biodiversity.

— In the same way, the barrage will be a major piece of infrastructure and the visual impact of a project of this scale will be significant and extend over a wide area. Issues of detailed design will therefore be critical given the potential impact on this part of the rural Vale of Glamorgan and indeed the wider region.

— With increasing sea levels increasing forecast, the role of a barrage in contributing to flood prevention requires detailed assessment.

— A key issue relates to the question of access to the site, not solely during construction but also for servicing, operations and dealing with visitors. In this regard there is a clear need to improve access arrangements to the site not only in the immediate locality but also from the M4 motorway and other parts of the strategic highway network. Such impacts must be delivered as an integral part of such a scheme.

— In progressing the second phase of the Severn Tidal Power feasibility study this Council considers it essential that full and detailed contact is maintained with those local authorities that might be affected by the development of a Severn Tidal power scheme such as the Cardiff (Lavernock/Penarth) to Weston barrage.

8. While the delivery mechanism for the provision of a Severn Barrage may have changed, the resultant impacts of a Cardiff (Lavernock/Penarth) to Weston barrage proposal remain the same and it is considered that in the absence of more detailed and scheme specific information that the comments above should be submitted in response to the current Commons Select Committee consultation.

Resource Implications (Financial and Employment)

9. There are no direct resource implications to the Council at this stage of the Severn Tidal Power Feasibility Study other than the involvement in the development of the project as one of many consultees.

Sustainability and Climate Change Implications

10. The Development of a Cardiff (Lavernock/Penarth) to Weston barrage across the River Severn would produce approximately 5% of the UK energy needs and would assist in meeting the UK target set out in the Climate change Act of 2008 to reduce greenhouse gas emissions by 80% by 2050 from a 1990 baseline. The development of a barrage could however have a significant adverse impact upon the ecology and habitats of the Severn Estuary.

Legal Implications (to Include Human Rights Implications)

11. None arising from this report.

Crime and Disorder Implications

12. None arising from this report.

Equal Opportunities Implications (to include Welsh Language issues)

13. None arising from this report.

Corporate/Service Objectives

14. At this stage in the progression of tidal power proposals within the Severn Estuary it is difficult to identify the impacts upon the various service areas of the Council. However, given the scale of any future tidal power scheme such impacts could be considerable especially in terms of environmental impact and economic development and regeneration.

Policy Framework and Budget

15. This report is a matter for Executive Decision by Cabinet.

Consultation (including Ward Member Consultation)

16. All ward members have been consulted on this report. In addition, all Town and Community Councils within the Vale of Glamorgan have been advised of the consultation exercise. Comments received as follows:

Councllor Traherne

This is an excellent and well balanced report. I would however like to reiterate the importance of the question of access to the site, not only in the immediate locality, but also from the M4 motorway and other parts of the strategic highway network. For too long the Vale has suffered from poor

strategic highway infrastructure. If a Barrage is to be built then this vital issue must be addressed, funded and be part and parcel of the scheme. A failure to do so will result in a significant and an adverse impact upon the quality of life for the people of the Peterston—super—Ely Ward.

Councillor Wilson

Many thanks I also regard that the infrastructure is one of the gains that could be achieved by the barrage; however the risks to the bio-diversity are one of the real dangers of this development and that there needs to be a detailed environmental impact assessment before we could seriously consider the project.

Councillor Penrose

My Ward of Sully and Lavernock would be the most effected in the Vale of Glamorgan by the proposal for "the Severn Barrage", and whilst noting and agreeing with the comments raised in the report, I wish to ensure the additional points are also taken into consideration, and included in the recommendations:

- It is essential that public meetings meeting are organised for residents of Lavernock,Sully and Penarth as soon as possible, where the Consortium for the construction of the proposed Barrage fully explain the proposed location, mode of construction, time period, and all other implications of their proposed scheme.
- That a period of at least six months be afforded for public consultation with local residents before any decision is reached.
- That an enquiry survey be carried out to ascertain the possible effect the barrage would have on residential property values.
- That an enquiry survey be carried out to analyse the possible effect the barrage would have on risk of flooding to the area, due to any possible variation in tide heights.
- Quantification on what impact the construction of the barrage would have to the immediate area of Lavernock, Sully and Penarth.
- Infrastructure and road schemes that would be made should the proposed scheme be approved.
- The aesthetic effect the scheme would have on the immediate area and coastline.

I consider it essential that full information on the scheme be afforded to local residents to enable them to make judgements and form an opinion as to whether they are ultimately in favour or against the scheme.

Councillor Bertin

I note the contents of this report.

Having viewed this document, I endorse the response given during the consultation exercise.

I would ask that we are kindly kept informed of all progress on this important matter.

Councillor Probert

I would like to say that I'm against the massive, continuous barrage proposed by the private developers, as I think the impact on the environment would be catastrophic. In assessing any potential positive climate change benefits, we have to include the adverse impact on the environment of destroying the extensive mud flats which are of great importance to large numbers of migrating and resident birds. We need to find out how losing this rich ecosystem and all the plants and animals in it might release more greenhouse gases and negate any "green" benefits.

I would be in favour of a series of separate generators being placed in the estuary. We need to be familiar with the technical options before we can make a decision.

There is a comment in the report which alleges that the barrage would help to mitigate against flooding—I am not convinced of this. Since the Cardiff Bay barrage has been built, we in Peterston super Ely have seen regular and frequent flooding of the river (a few times a year), something that did not happen in the past, even in years of heavy rainfall, when the river would flood once with the rainfall, and not repeatedly as it does now. This is despite flood prevention schemes up river. We must examine every assertion in the report.

Barry Town Council

"Further to your email of 30 November a meeting of the Town Council's Review Working Party was held on 6 December to consider the Severn Barrage Consultation report.

Members opposed the construction of a Severn Barrage and requested that the following comments be relayed:

- The high capital cost, although covered by private funding, will most likely result in increased prices to end consumers.
- Wales will suffer in the long run as most of the power generated will be transported to England.
- There is a high environmental impact with security concerns around the coastline.

— A Tidal Lagoon, like the one proposed for Swansea, would be better for Wales as the power generated will be used locally."

RELEVANT SCRUTINY COMMITTEE

17. Economy and Environment.

BACKGROUND PAPERS

Severn Estuary Tidal Power Feasibility Study

CONTACT OFFICER

John Marks: Tel 01446 704629.

OFFICERS CONSULTED

All Heads of Service.

Operational Manager Legal—Committee Reports.

Senior Accountant.

Operational Manager Development and Building Services.

RESPONSIBLE OFFICER

Rob Thomas—Director of Development Services.

ADDITIONAL COMMENT RECEIVED AND TABLED AT CABINET

Penarth Town Council considered the Vale of Glamorgan Council's report in response to the Commons Select Committee public consultation at its meeting last night and my Council wishes to thank the Vale Council for giving it the opportunity to see the report and make comment.

This Council supports the content of the report but having regard to the massive impact such a development would have on the whole of the southern Vale it would like to emphasise the need for consultation to establish the facts.

The Town Council is aware of proposals by Hafren Power to set up briefings for key stake holders but this Council would suggest that the proposal calls for public meetings. Indeed the Town Council has been corresponding with Peter Hain's, office for some weeks inviting him to address a public meeting in Penarth but to date have not been successful.

Penarth Town Council would like to work in partnership of the Vale of Glamorgan Council and would request that it is involved in the consultation process as it develops.

Shân Bowden, Town Clerk, Penarth Town Council, West House, Stanwell Road, Penarth, CF64 2YG

ADDITIONAL COMMENT RECEIVED BUT NOT REPORTED TO CABINET

The volume of traffic currently flowing through the Merrie Harrier junction as well as the village of Llandough is currently t its maximum capacity level and this issue will need to be resolved before any possible Severn Barrage scheme is implemented.

December 2012

Written evidence submitted by HR Wallingford (SEV 20)

EXECUTIVE SUMMARY

1. This submission has been prepared by HR Wallingford, one of the UK's leading research and consultancy organisations in engineering in the water environment. We have had a long-standing engagement with the Severn Barrage, including many of the studies undertaken for the Severn Barrage Committee in the late 1970's and published in 1981 and more recently for the 2008–10 DECC studies of tidal power on the Severn. As a result of more recent research, we believe that the evidence has improved in the following areas:

— Far field effects on water levels;

— Effects of infrastructure projects on estuary morphology; and

— The modelling of noise and other disturbance effects, and the response of migratory fish to these.

2. We believe that recent research and experience elsewhere, provide an improved basis for considering the impacts of a barrage and the options to minimise the habitat losses from tidal range schemes in relation to energy yield, so reducing the scale of challenge posed by habitats compensation under the Habitats Directive.

3. We also recommend the following as priority areas to improve the evidence base:

— Bathymetry and morphology survey of the estuary;

— Sedimentology and benthic communities, especially on the intertidal areas; and

— Fish behaviour/mortality and turbine design.

About HR Wallingford

4. HR Wallingford carries out advanced research, consultancy and software development relating to civil engineering hydraulics and the water environment. Established in 1947 as a Government research centre, it is now an independent research and technology organisation (RTO). We operate on a non-profit-distributing basis and employ over 200 engineers, scientists, mathematicians and support staff. Our research and specialist consultancy advice is backed by state of the art computational and physical models. We have techniques available to establish wave and current climate, and to examine issues associated with sediment transport, water quality and aspects of ecology. We also investigate dredging and navigational concerns, structural aspects, and the environmental and coastal impact of maritime projects.

5. HR Wallingford made a substantial contribution to the Severn Tidal Power Feasibility Study, commissioned by Department of Energy and Climate Change (DECC) in 2008–10. We undertook computational modelling and advice to predict the effects of barrage schemes on estuary tidal water levels, the redistribution of estuary sediments, and morphological change of the estuary. Thus we used the tools and data available at the time to predict how the Severn estuary would respond to the introduction of a tidal power scheme.

6. In this submission of evidence we provide a summary of key new areas of evidence that we are aware of, and also highlight major areas of uncertainty that we recommend are considered priority research areas.

Far-field effect on water levels

7. The DECC study found that the Cardiff to Weston Barrage could lead to impacts on high and low water levels along the Devon and Cornwall coasts, the coast of Wales, the east coast of the Republic of Ireland, and potentially further north. Since that time, the Energy Technologies Institute (ETI), with expertise from HR Wallingford, Black and Veatch, and the University of Edinburgh, has developed a continental shelf computer model. This included an assessment of schemes in the Severn Estuary, and further demonstrates the potential for interaction of tidal range energy schemes at this scale. It is expected that the model will be available for wider use in early 2013.

Morphological changes in the estuary

8. An ebb-tide generating scheme of the scale of a Cardiff to Weston Barrage would lead to the loss of more than 12,000 hectares of intertidal habitat, through the effects on tide levels alone. An area of uncertainty at the time of the DECC studies was whether there would be further longer-term loss of intertidal through processes such as wave erosion. This is a pivotal issue because of the implications for compliance with European Directives on wildlife habitat conservation.

9. The morphology/bathymetry of an estuary, and how this develops under different environmental conditions has and continues to be a highly active area of research within the international science community. Globally, this is driven by the need to better predict long-term change, especially in response to climate change. Within Europe, this research has also been given a particular focus by the Habitats and Water Framework Directives. As a result, there is now a better understanding of some of the complex feedbacks that exist within the geo- and eco-morphological systems, which has improved the predictive capability of the models that are now available. With further data (see below), this offers the potential for improved predictions of longer term change, coupled with a better appreciation of the level of uncertainty associated with such estimates. .

10. Investigation of both the morphological and ecological aspects of intertidal areas has been greatly aided by the many habitat restoration and habitat creation schemes that have been implemented over recent years. Notable in this regard are the managed re-alignment schemes in the UK and the across Europe (see list of online resources in Townend *et. al.* 2010) and the post-barrage learning in the Netherlands (de Vriend, 2004; Eelkema *et. al.*, 2012). More recent work has seen the introduction of several large-scale pilot studies to test a number of innovative restoration techniques (http://www.ecoshape.nl/).

11. There is therefore the potential to re-visit the likely impacts of the scheme on the habitats within the Severn estuary and the opportunities to mitigate or compensate, for at least some of these, using a number of techniques in a suitably integrated manner. This would help inform the debate and guide considerations in respect of the various legislative constraints, not least the Habitats Directive.

12. Our understanding and evidence for the effects of tidal schemes is hampered by the absence of robust and long–term basic data for the estuary. For example, all studies of the estuary to date have relied upon a mosaic of bathymetric datasets. A comprehensive bathymetric survey of the entire estuary is needed, to cover the whole of the Estuary from the Bristol Channel, to at least Beachley. In addition, the long term record of intertidal morphological change, under current conditions, should be extended through further LiDAR (Light Detection And Ranging) monitoring at low tide every five years for the foreseeable future.

13. Estimating the likely changes of the morphology and ecology of estuary systems also requires robust data on the make-up of the sediments, a description of the benthic communities and knowledge of the fringing vegetation, notably the saltmarshes. These data are currently of variable quality. The age of much of the data also means that it is often not well matched to the data needs of the types of model that have been developed more recently. These shortcomings only serve to increase the level of uncertainty and make interpretation at an estuary scale difficult.

Habitat Compensation requirement

14. The habitat losses referred to above, trigger the need for compensation under the Habitats Directive; or failing that a derogation of the directive. Derogation was not favoured at the time of the DECC study, with compensation by replacement habitat of "equal value" being the preferred approach. Regardless, we believe there is much valuable work that could easily be done, by making use of the tools already developed for DECC, to optimise the loss of habitat in relation to energy yield. This would principally entail optimising operational modes, looking more closely at a flood-ebb generating scheme, and the more detailed investigation of the type and intrinsic biodiversity value of the habitat that could be lost. By this approach, substantial reductions could be achieved in the compensation/derogation requirement.

Construction risk

15. To our knowledge, the construction process for a tidal power scheme, and in particular during the latter phases where the degree of constriction is high, of a tidal power scheme of this scale has not been the subject of serious study in the last 20 years or more. The major hydraulic forces during this operation therefore remain a risk area for any developer of such a scheme. The means exist to reduce this risk by using a physical model of part or all of the Cardiff to Weston Barrage. This would allow the forces that may exist at closure to be better understood.

Modelling of biological effects

16. The biodiversity impacts assessment conducted on behalf of DECC highlighted anthropogenic noise during construction and operation as a potential threat to fish species in the estuary. The noise assessment was carried out via literature review. Since 2010, the scientific literature has expanded as more species are investigated for their ability to hear noise and their reactions to various noise sources. The ability to model underwater noise has also been improved by, and is now used more regularly to assess effects and plan effective mitigation for new marine development.

17. Techniques have also been further developed since the DECC studies, to predict how fish may move in response to underwater noise and other changes in the properties of the water column. Species behavioural traits can now be used as parameters in a numerical model and their movement in response to noise or other anthropogenic disturbance predicted. For example, many of the fish species in the Severn are migratory, and juveniles must leave the freshwater section of the river at a certain time. Barriers to their exit, whether physical or created by sound or heat, could delay their departure from the upper estuary. The modelling techniques now available, can provide an estimate of how much longer this journey would take and this information could then be used in an assessment of the impacts upon migratory fish.

18. That said, our understanding of the effects of tidal range generation on fish survival and movements would undoubtedly benefit from further primary research. This would improve the certainty level attached to modelling predictions. We are also aware that progress has been made in the development of turbine concepts with low rotational blade speed, that may reduce the risk of fish damage during passage through turbines (e.g. the Atkins/Rolls Royce "low head" turbine). This is also the subject of related research within the hydroelectric power community, supported by resurgent interest in this technology. Thus we recommend that integrated study of fish behaviour/mortality and turbine technology is given priority as a research area.

Conclusion

19. We have highlighted areas of evidence and research priorities for future study of the Severn barrage concept. We would welcome the opportunity to contribute further to informed debate on the effects and practicalities of developing tidal range power on the Severn Estuary.

20. Our archives include reports covering many of the studies undertaken in the 1970's, as well as the more recent studies for DECC that we were involved in. Should there be specific information regarding previous studies that the Committee would like sight of, we would be willing to make such material available (subject to any client restrictions).

References

de Vriend HJ, 2004, *The Eastern Scheldt barrier: Environmentally friendly engineering?,* In: Territorio y Medio Ambiente, II Congreso Internacional de Ingeniería Civil, Colegio de Ingenieros de Caminos, Canales y Puertos, Madrid, pp. 1269–1281.

Eelkema M, Wang ZB, and Stive MJF (*2012*) *Impact of Back-Barrier Dams on the Development of the Ebb-Tidal Delta of the Eastern Scheldt. Journal of Coastal Research: Volume 28*, Issue 6: pp. 1591—1605.

Townend IH, Scott C, Dixon M, 2010, *Managed Realignment: A Coastal Flood Management Strategy*, Ch. 4 In: *Flood Risk Science and Management*. Edited by Gareth Pender, Colin Thorne, Ian Cluckie and Hazel Faulkner, Published in 2010 by Blackwell Publishing Ltd.

November 2012

Written evidence submitted by Tata Steel (SEV 21)

1. Our Role in the Regional Economy

Tata Steel has several major operational sites in Wales, employing over 7,000 people. A recent study carried out by Cardiff University's Business School has demonstrated that the company's network of suppliers, contractors and business partners extends the employment dependency to a figure over 18,000 in Wales alone. Key Tata Steel sites outside Wales, such as the substantial operation at Corby are dependent on the South Wales operations for feedstock. Formally designated an "Anchor Company" in Wales, we are committed to sustaining our industry here, and our major capital investments programme—at over £300 million in the last two years alone—is firm evidence of the company's long term stake in the region.

2. Summary of our Position

Further investment in the Welsh operations will be driven by their (potential) competitiveness, addressable demand for steel products and the infrastructure (physical and regulatory) of the surrounding region. The proposed Severn Barrage Project may have a major impact on all of these factors. Therefore Tata Steel has a deep interest in the considerations around the project.

3. Competitiveness of the Steel Industry in the Region

Our industry is energy-intensive and this cannot be avoided. A secure supply of sustainable, competitively priced energy plays a major part in defining the competitiveness of our operations as a whole. We have made great strides in optimising our energy management through both major investments and practical management, but any development, which positively affects the stability of price and the base-cost of energy, could be critical to us. This point is even more forcefully made in the context of our current position in which we find ourselves currently carrying an additional cost burden of up to 60% above similar operations in mainland Europe.

4. Clarity about the Energy Outcome

Given this context we would welcome a dialogue with the Project developers and the Welsh Government about what impact the Project may have on electricity pricing and what role there could be for substantial local off-takers.

5. Management of the Project Supply Chain

We have stressed to the UK government for a long time how vital it is that the Government ensures that it maximises the benefit of major public projects for the UK community. The project will demand steel products and services, which can be supplied in the UK by companies like Tata Steel Europe and others which have a major role to play as a foundation for the UK economy. A project of this scale, scope and impact must be driven by an overriding principle that public projects are dedicated to the maximum service for the community. A working group must be established to define the procurement parameters to ensure indigenous suppliers of products and services are first-choice participants.

6. Impact on Regional Infrastructure

An efficient and low-cost transport infrastructure is vital to the steel industry. Annually, Tata Steel imports some 2.5 million tonnes of iron ore and an equal quantity of coking coal to Port Talbot. The industry is, by volume, the largest user of the Welsh regional rail and road system. Operating at full capacity, the company distributes some five million tonnes to customers in the UK, mainland Europe and further afield, every year. The ancillary developments to the deep water harbour, rail and road infrastructure—and their effects on availability and costs—will play a part in our developing business strategy. We would therefore welcome a

dialogue with the Project developers and relevant other stakeholders to discern how existing infrastructure can be developed to minimise disruption and maximise benefit for the region as a whole.

November 2012

Written evidence submitted by Prys Davies, Welsh Government (SEV 22)

I am writing in response to Energy and Climate Change Committee's call for evidence on a proposed Severn Barrage.

An assessment of the issues relating to the development of tidal energy in the Severn Estuary is contained in the Severn Tidal Power Feasibility Study[18]. The Committee will wish to consider the findings of this study. The Welsh Government has had initial discussions with the Hafren Power consortium and its predecessor, Corlan Hafren, regarding the latest proposals for a Severn barrage. We are aware of the general thrust of Hafren Power's proposal, which aims to utilise a large number of very low level head turbines to create energy on both ebb and flow tides, and how this differs from the Severn Tidal Power proposal.

The National Assembly held an informative debate on renewable energy in the Severn Estuary on 17 October which can be accessed via the link:

http://www.assemblywales.org/bus-home/bus-chamber-fourth-assembly-rop.htm?act=dis&id=239620&ds=11%2F2012#ynni

The Committee will wish to be aware of the matters raised during this debate.

The Welsh Government believes that a barrage has the potential to make a significant contribution to UK energy security and climate change objectives. The Severn Estuary is famous for having the second highest tidal range in the world. The Welsh Government recognises that this huge tidal range could be a source of carbon-free electricity over a very long term, potentially providing up to 5% of the electricity needs of the UK. The barrage could make a significant contribution to increasing the amount of energy generated from renewable sources.

The economic benefits of a Severn Barrage are likely to be substantial. The scale of the Cardiff-Weston barrage proposal offers Wales, the south west and the UK as a whole the potential to benefit from manufacturing, supply chain and innovation opportunities. The investment would, in our view, result in significant job creation both during the construction and operation phases. Our ports, such as Port Talbot and possibly Milford Haven, are in a strong position to attract caisson and turbine manufacturing, if the barrage goes ahead, and to service these turbines when in operation. We believe that any planned development should also be sufficiently flexible to accommodate potential transport infrastructure, which might in turn provide further economic benefit.

The Welsh Government recognises that the estuary is important for its special environmental features, particularly as a conservation site for a variety of species, including migratory fish and over-wintering birds. The potential impact on these must be fully considered in the assessment of different technologies for harnessing the energy of the tidal range. Appropriate mitigation measures would need to be developed and funding allocated to ensure that we can meet our obligations in relation to the Habitats Directive and the Water Framework Directive.

The flood risk consequences of any structure that might be developed in the estuary depend very much on its design, construction, location and mode of operation. Any scheme proposals would need to include appropriate mitigation to ensure there is no increase in flood risk, either upstream or downstream from any barrage.

In summary, the Welsh Government recognises that there are significant challenges associated with the harnessing of this energy, both environmental and financial. If these issues can be satisfactorily resolved, the harnessing of the energy opportunity in the Severn estuary will have the strong support of the Welsh Government.

November 2012

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[18] Severn Tidal Power Feasibility Study Conclusions and Summary Report; Department for Energy and Climate Change, Welsh Assembly Government and South West Regional Development Agency, October 2010.

Written evidence submitted by WWF (SEV23)

PREAMBLE

1. WWF-UK is concerned that the Committee is holding this inquiry before details of Hafren Power's proposal for a Severn barrage have been published and before any research work relating to the potential impacts of this barrage has been peer reviewed.

2. In view of the lack of a clear proposal, business case and assessments of the environmental, economic and social impacts it is not possible for us to answer all the questions posed by the Committee. However, we will provide evidence regarding question 8, on EU legislation (see paragraphs 7–22), and will also provide a summary of WWF's position on the development of tidal power in the Severn Estuary in the hope that this will help the Committee identify areas where more work is needed.

SUMMARY OF WWF-UK'S POSITION ON SEVERN TIDAL POWER

3. WWF-UK believes that a revolution in our energy systems is vital if we are to meet the challenges of preventing dangerous levels of climate change and maintaining energy security. As made clear in recent reports from the International Energy Agency[19] and the World Bank[20], current investment patterns, unless rapidly changed, are putting the world on track for global average temperature rises to significantly exceed 2C, which would have profound environmental and economic impacts. Our absolute priorities must therefore be a strong drive towards improved energy efficiency and a rapid deployment of sustainable, low-impact renewable energy technologies. We strongly support the government's commitment to deliver the UK's fair share of the EU renewable energy target for 2020 and for renewables to play a leading role in helping deliver a near-decarbonised power sector in the UK by 2030 as repeatedly recommended by the Committee on Climate Change.

4. WWF-UK's *Positive Energy* report[21], based on analysis by energy consultants Garrad Hassan, shows that if the UK's renewable sector is allowed to grow at a steady rate over the next two decades, renewables could provide well over 60% (and potentially up to 88%) of the UK's electricity demand by 2030 and be the key technological driver for delivering a near-decarbonised power sector for the UK. Garrad Hassan's analysis also showed that energy efficiency measures could reduce the required capital investment in renewables, gas power stations, CCS and interconnection infrastructure by up to £40 billion by 2030.

5. However, in supporting the rapid deployment of renewable energy technologies, the Government must respect wider concerns over environmental sustainability. After consideration of the findings of the UK Government's Feasibility Study into Tidal Power in the Severn Estuary (2008 to 2010), WWF-UK came to the conclusion that there is no clear option at this time that would allow for the tidal range energy from the Severn Estuary to be harnessed in an environmentally sustainable way. In particular, the irreversible impacts on fish, birds and habitats are unacceptable for schemes using conventional barrage technology with high head turbines, and there is insufficient information on the impact of low head turbines. Furthermore, the effectiveness and adequacy of proposed compensatory measures are unproven.

6. WWF-UK strongly supports further research into alternative and more sustainable ways of generating renewable electricity from the Severn Estuary. However, we believe that stringent tests should be applied to determine the acceptability and feasibility of any new proposal for harnessing tidal energy in the Severn estuary. In particular, we believe that the environmental conditions resulting from any scheme must meet the following minimum requirements:

(i). the loss of habitat must be less than the area of compensatory habitat that could be secured locally (ie in or near the Estuary);

(ii). any compensatory measures required in relation to habitat and species losses must be provided in full compliance with the Habitats Directive and the European Commission's guidance;

(iii). there would be no far field effects caused by an impoundment that required significant new infrastructure for flood or coastal erosion risk protection away from the Estuary;

(iv). there should be no serious risk that water quality standards would be breached or that eutrophication would be a significant issue;

(v). potentially toxic elements in the sediment would not be at a concentration where they posed a risk to benthic organisms or species further up the food chain;

(vi). the deliverability of Government measures for achieving Good Environmental Status under the European Marine Strategy Framework Directive must not be compromised;

(vii). the transit of fish across or through any scheme (through turbines or fish-pass) would need to result in close to zero mortality so that even multiple transits would pose no threat to the survival of the species within the Estuary.

[19] http://www.iea.org/publications/freepublications/publication/English.pdf

[20] http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

[21] Positive Energy: How renewable electricity could transform the UK by 2030, WWF-UK, October 2011: www.wwf.org.uk/positiveenergy. The underlying technical analysis carried out by Garrad Hassan is also available on the same page.

Habitats and Birds Directives

7. Together, the Habitats and Birds Directives (the "Nature Directives") provide invaluable protection for our rarest and most threatened habitats and species and in so-doing, play a vital role in securing ecosystem services benefitting human-kind. WWF has supported the development, implementation and enforcement of the Nature Directives for over 25 years in recognition of their role as the EU's cornerstone of biodiversity policy and global exemplars in biodiversity protection.

8. In 2001, EU Heads of State agreed to a biodiversity target under which, by 2010, the EU should have halted the loss of biodiversity within its own territory and beyond. This target was clearly not realised, the principal reasons for failure being recognised as: (i) the incomplete implementation of the Nature Directives; and (ii) a widespread failure to integrate conservation and the management of biodiversity into other policies.

9. The effective implementation of the Nature Directives will be required if we are to meet not only our EU targets, but our international biodiversity commitments, including Aichi targets 11 and 12 agreed as part of the CBD Strategic Plan at Nagoya in 2010.

10. Article 6 of the Habitats Directive plays a critical role in ensuring that Natura 2000 sites are appropriately managed and that potential development proposals proceed on a lawful and proper basis. It is clear from the language in Article 6(3) and (4) of the Directive that a site is only to be damaged or destroyed in exceptional circumstances. Moreover, European Guidance[22] confirms that because Article 6(4) is a derogation from Article 6(3), it must be interpreted in a restrictive way, so that its application is limited to circumstances where all the conditions are satisfied. In this regard, it falls on whoever wants to make use of this exception to prove, as a prerequisite, that the aforementioned conditions do indeed exist in each particular case[23].

11. We are fortunate to benefit from nearly twenty years of case-law on the Nature Directives arising from the European and domestic courts. The established jurisprudence of these courts is central to the question as to whether the Cardiff-Weston barrage represents a potential breach of EU environmental legislation. While the answer to that question is categorically in the affirmative, we would reiterate our support for ongoing research into the suitability of other tidal energy options in the Severn Estuary.

12. The following legal principles emerge from that case-law of relevance to the consideration of the Cardiff-Weston barrage:

(i). Member States may not reduce the surface area of Natura 2000 sites, or alter their boundaries, unless the excluded areas are no longer the most suitable territories for the conservation of habitats and species listed on the Nature Directives (C-191/05, *Commission v Portugal*, C-57/89, *Commission v Germany- "Leybucht dykes"* and, more recently Advocate General Sharpston's findings in *Commission v Austria* (C-535/07)*);*

(ii). Member States cannot of their own accord "whether because of economic, social or cultural requirements or because or regional or local characteristics, delete sites which at national level have an ecological interest relevant from the point of view of the objective of conservation without jeopardising the realisation of that objective at Community level" (*First Corporate Shipping* (C-371/98) and *Commission v Ireland* (C-67/99);

(iii). The derogations set out in Article 6(4) of the Habitats Directive must be interpreted strictly. Thus, the implementation of a plan or project under Article 6(4) of the Habitats Directive is, *inter alia*, subject to the condition that the absence of alternative solutions be demonstrated (C-239/04, *Commission v Portugal—"Castro Verde");*

(iv). Article 16 of the Habitats Directive defines in a precise manner the circumstances in which Member States may derogate from Articles 12, 13, 14 and 15(a) and (b) thereof, so that Article 16 must be interpreted restrictively ((C-06/04, *Commission v United Kingdom);*

(v). Permission for a proposal cannot be granted pending information regarding the potential impact on European Protected Species (EPS) as the decision-maker cannot rationally conclude that there are no significant nature conservation issues until it has the relevant data before it (*R v Cornwall County Council, ex parte Hardy*[24]);

Compensatory Measures

13. In the event that a plan or project may be carried out for imperative reasons of overriding public interest (IROPI), Article 6(4) of the Habitats Directive requires Member States to "*take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected*" and to "*inform the Commission of thecompensatory measures adopted"*.

14. Both Member States and the Commission play a critical part in the process of building a coherent Natura 2000 network. Member States are required to propose habitats "*in proportion to the representation within their territory of the natural habitat types*"; they are to do so by proposing a list on the basis of the criteria set out

[22] Managing Natura 2000 Sites—the Provisions of Article 6 of the "Habitats" Directive 92/43/EEC (section 5.2) available at: http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/provision_of_art6_en.pdf

[23] See Cases C182/10 *Solvay v Region Wallonne* and C-239/04, *Commission v Portugal "Castro Verde"*.

[24] [2001] JPL 786.

in Stage 1 of Annex III, for both habitats and species. By way of response (i.e. Stage 2 of Annex III), the Commission makes an assessment of the Community importance of the site. It examines not only its national importance but also its role in the bio-geographical regions concerned and its relation to migration routes and neighbouring ecosystems in other Member States.

15. The result, as and when the Member State designates the site as a SAC is that the site becomes part of the Community network. Its status there, usually reflecting a mixture of designated habitats and designated species, is to aid that coherence.

16. The concept of coherence can be found in the recitals to the Directive, and in the objective set out in Article 3(1) to create a "*coherent ecological European network*," supported by Article 6(4). As the Commission states in 2007 Guidance[25], "*Article 6(4) requires Member States to protect the overall coherence of Natura 2000. Thus, the Directive presumes that the "original" network has been coherent. If the exception regime is used, the situation must be corrected so that the coherence is fully restored.*"

17. There have been a number of cases in which the Commission has been requested to provide an opinion to Member States regarding the requirements of the Nature Directives, and in particular the adequacy of proposed compensatory measures[26]. In these cases, the opinion of the Commission was integral to the project receiving permission. In providing support for the compensatory measures proposed, the EC must, among other things, be satisfied that there are no alternatives to the proposed project, that the test of IROPI has been met and that the overall coherence of the Natura 2000 network would not be compromised.

18. There are also a number of European case studies which demonstrate the importance of developing a comprehensive package of compensatory measures to enable large, strategically important infrastructure projects to proceed[27]. Key attributes of compensatory measures include: (1) the full and proper understanding of the impacts (aided by robust environmental assessments) that must be compensated for; (2) early stakeholder engagement to aid collaboration, cooperation and wide agreement on the measures; (3) measures that at least replace that which is lost (but a net benefit for biodiversity will be favourable) and are in addition to existing conservation measures; (4) taking into account uncertainties and developing long term monitoring and evaluation programmes with regular reporting and review.

Equal Value Compensation

19. A report produced for the [former] Sustainable Development Commission in 2010, as part of the Feasibility Study into Tidal Power in the Severn Estuary, discussed the possibility of a new approach to compensation using "equal value ecological compensation". The report advised that if tidal power proposals in the Severn Estuary were to adversely affect Natura 2000 sites to the degree that traditional "like-for-like" compensation measures would be implausible, it would be possible to compensate for those impacts by providing compensatory measures which were of "Equal Value" to those that would be lost.

20. WWF and a coalition of NGOs sought legal advice on this issue[28]. This advice confirmed that "Equal Value" compensation, as formulated in the report, is not lawful and that if the UK were to proceed with a tidal power option in the Severn Estuary that would result in the extinction of an Annex II species in the UK and the widespread, significant, and irreversible loss of Annex I habitats (some of which could not be re-created)this would result, unequivocally, in a breach of the letter and spirit of the Directive, as well as Guidance published by the Commission concerning its implementation.

21. In terms of compensatory measures more generally, the legal advice identified a number of relevant issues in the context of this review:

(i). There is nothing in the Habitats Directive to support the principle of equal value;

(ii). The European Commission has not accepted compensatory measures in any form other than the same as, or similar to, that which has been destroyed;

(iii). The Commission Guidance is to like effect;

[25] Guidance Document on Article 6(4) of the Habitats Directive available at: http://ec.europa.eu/environment/nature/natura2000/management/docs/art6/guidance_art6_4_en.pdf

[26] See footnote 11.

[27] Available upon request.

[28] Available upon request.

(iv). Compensatory measures in respect of which the Commission has published an opinion generally include the provision of at least three times as much (and often significantly more) habitat than will be lost[29];

(v). Consideration of conservation status at the level of the Atlantic bio-geographic region, whilst playing a part in the original Natura 2000 site selection, would not by itself be sufficient, as this would be ignoring the reasons as to why the particular sites in question warranted being made part of the network;

(vi). The notion of providing compensation on an Atlantic bio-geographic scale is practically unworkable under the Directive. The Directive does not enable the Commission to direct that compensation take place in other member states, nor are Member States entitled to discharge their obligations elsewhere in the European Union;

(vii). There is no legal competence under the Directive (or elsewhere) for Member States to take action in other Member States. Thus, the supposition that it is wholly acceptable for the majority of the UK population of a species (the Allis Shad in the case of the Severn estuary) to be destroyed on the basis that there are much larger populations elsewhere in the EU which may be capable of improvement, is unlawful.

22. The Legal advice also confirmed that compensatory measures must ensure the overall coherence of Natura 2000 at all applicable levels—regional, national and EU. The concept of "Equal Value" has no origins in the Directive—lawful compensation relies on "like for like" replacement.

Additional research needed

23. In order to help consider the feasibility of other potential options of generating renewable electricity from the Severn, we believe the following additional research work must be carried out, either before or as part of any review of Severn Tidal Power, to address the uncertainties and gaps which were identified during the course of the Feasibility Study:

(i). generate more knowledge and certainty about the ecology of the Severn Estuary, particularly in relation to fish and bird behaviour;

(ii). improve understanding of the role and significance of the estuary as nursery spawning grounds;

(iii). assess the value of the ecosystem services provided by the Severn Estuary;

(iv). assess the hydrological and geomorphological impacts of the proposed barrage in the Severn Estuary and further afield, particularly in relation to modelling of water levels, sedimentation effects, coastal erosion and flood risk;

(v). model the impact of low-head turbines on terrestrial and fluvial ecology;

(vi). understand the potential for erosion due to wind-generated waves and to clarify the timescale over which detriment would occur and whether there are mitigating measures that could be put in place;

(vii). model conditions during and after de-commissioning to assess whether the estuary would return to a semi-natural state and over what time period;

(viii). assess changes in dilution and dispersion of effluent;

(ix). assess predicted impacts on water level management upstream of an impoundment and associated changes in land use, habitats and species;

(x). determine whether the creation of freshwater wetlands in close proximity to the Severn Estuary would be an effective measure to help offset impacts on bird species that regularly use freshwater sites;

(xi). quantify the effects of fish passage through turbines; and

(xii). improve understanding of the effectiveness of mitigation measures.

[29] See, for example, the DASA/Hamburg opinion of 2000 "*the area foreseen for the compensation is significantly larger than the area exposed to the significant impact*." Despite this, the Commission reserved its position on the compensatory measures, because Germany had not proposed a sufficient number of sites under Art. 4 of the Habitats Directive, and hence the Commission could not form a view as to whether the compensatory measures would ensure the overall coherence of Natura 2000. Similarly: (i) in the Prosper Haniel mine opinion, Germany proposed 125–150ha of re-afforestation, and 30–45ha of new alluvial forests. The total area proposed was 2.5 to three times larger than the area lost; (ii) in the Mainport Rotterdam opinion of 2003, 19.5ha of Grey Dunes were to be replaced by 100ha of equivalent, to be developed over 20 years. 3,125 ha of Sandbanks were to be compensated by a marine reserve of 31,250ha. The decline of the fen orchid was to be compensated by the creation of 10ha of humid dune, and 23ha of white dunes were to be replaced by an equivalent elsewhere; (iii) in the La Brena II opinion of 2004, 626ha of a SPA/SCI were to be lost, of particular note for the habitat of the Iberian lynx. Compensatory measures estimated to cost 28,288,407 euros were accepted by the Commission. 2,134 hectares (somewhat over 3 times the original) were to be expropriated by Spain to provide compensatory habitats for the lynx; and (iv) in the Tenerife/Granadilla opinion of 2006, the precise area of sea bed to be lost seems to have been about 51ha. This was to be compensated by designation of sandbanks totalling about 7,500ha. See also *"Guidelines on the Implementation of the Birds and Habitats Directives in Estuaries and Coastal Zones"*; with which states there is wide acknowledgement that compensation/damage ratios should be generally more than 1:1.

24. WWF-UK strongly believes that all means of generating renewable energy must be environmentally sustainable, and must not undermine the integrity of important designated sites.

November 2012

Written evidence submitted by friends of the Earth (SEV 24)

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

Its contribution could clearly be considerable, but the opportunity costs need to be taken into account. Other forms of tidal energy development which have the potential to be more cost-effective and more environmentally acceptable would be ruled out by a Cardiff-Weston barrage.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

Significant risks have been identified and are hard to quantify given the uncertainty over the future dynamics of change across the estuary post-barrage. This is an inherent limitation in our ability to predict future change and would remain a significant problem even if the designs of the Hafren Power proposal had been fully published, modelled and tested over a number of years, which of course they have not been.

Some tidal power infrastructure such as barrage or lagoon walls could potentially be in place for over 100 years and given uncertainties over the rate and magnitude of sea level rise (and that it has very likely been under-estimated) it is important that we retain a degree of flexibility in deployment of infrastructure in the Severn. The problem with a Cardiff-Weston barrage is that it is once-and-for-all and all-or-nothing. Other technologies are far more capable of incremental deployment, such that it will be possible to study the changes that result and the longer-term dynamics of change before further commitments are made.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

There are very fundamental obstacles to a Severn barrage because of its huge ecological impacts. It is important to recognise that the Severn estuary satisfies several different criteria for the highest level of habitat designation and supports migratory species of bird and fish. The loss of habitat and physical barrier to passage up and down the estuary would be severe impacts. Hafren Power claim that these impacts have been mitigated through design changes but these claims remain unsubstantiated. It is not possible at present to say whether this mitigation is genuine and significant or not. On present knowledge there is no reason to change the conclusions of the 2010 Feasibility Study that a Cardiff-Weston barrage would have the greatest impact on habitats and bird populations and the estuary ports. The risk of breaches of EU legislation remains very high

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

We remain of the view that the scheme at La Rance is so fundamentally different in scale, and in an estuary environment that is so fundamentally different in nature, that only very limited conclusions can be drawn. The large scale intervention of the storm surge barrier in the Oosterschelde estuary in the Netherlands is more instructive. This shows that even where the protection of environmental assets is central to the aim of a scheme and it is very well studied prior to construction, actual outcomes can be very different from those predicted and lead to serious long term loss and damage both environmentally and economically.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

With a scheme of this nature there is a very high risk that whatever initial commitment may be made on the basis of strictly limited public liabilities turns into a commitment to underwrite its cost escalations because at some point it becomes impossible to withdraw.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

These could well be negative rather than positive because of the opportunity costs for other technologies as outlined above. Other approaches to exploiting the tidal energy resource of the Severn such as lagoons, tidal fences and tidal stream turbines are more widely applicable and the several UK companies that are now in the forefront of marine and offshore renewable energy could benefit from worldwide deployment of innovations tested in the Severn Estuary and Bristol Channel. The Cardiff—Weston barrage is much more of a one-off; it

is very site specific and therefore has considerably less potential for replication and wider economic benefit for UK low carbon industry.

November 2012

Written evidence submitted by the Severn Voice Severn Estuary Flood Rishk Management Strategy Task Group (SEV 25)

We represent Severn Voice, a group of nine parishes bordering the east side of the river Severn from Slimbridge to Gloucester.

We have spent the last two years engaging with the Environment Agency (EA) over the draft of their Severn Estuary Flood Risk Management Strategy.

The original draft Strategy document, brought out for public consultation in January 2011, was withdrawn and shredded under the direction of The Right Honourable Richard Benyon, MP, Under Secretary of State for the Environment. The 2011 Strategy proposed several dozen houses and hundreds of acres of land to be allowed to flood as compensatory habitat for intertidal habitats lost as a result of anticipated global warming.

Richard Benyon said that the EA was wrong to produce the Strategy without proper consultation with the relevant stakeholders which should have included local people and landowners. Since then, a number of items forming the basis for the Strategy have been shown to be scientifically unsound.

The enormous cost to both the public purse and to local communities in terms of wasted time and money of this original poorly developed Strategy has not yet been made known, but it is our expectation that lessons will have been learned. The difference between stakeholder engagement and consultation has been all too clearly demonstrated.

Since publication of the original draft Strategy our group, the Severn Voice Severn Estuary Flood Risk Management Strategy Task Group have worked closely with the EA to ensure that they have been able to engage properly and meaningfully with the local communities. The EA is hoping to produce their next draft of the Strategy in the spring of 2013 with the benefit of proper engagement and local knowledge, and we look forward to continuing to contribute positively to the consultation process.

Based on this experience, and before any plans for a future Severn Barrage are drafted, we would urge you to ensure that engagement with all local and national stakeholders takes place at an early stage of the development of the proposal.

The local stakeholders should include landowners, Parish, District and County Councils as well as environmental groups.

You should be aware that the effect of any Barrage plan will be felt many miles away, and certainly as far as Gloucester, not just in the area adjacent to the river and proposed barrage.

November 2012

Written evidence submitted by Rose Hewlett (SEV26)

Thank you for inviting submissions in respect of A Severn Barrage. I am a local historian living in the upper Severn estuary. I am neither for nor against a Barrage.

The Severn has one of the most unmanageable estuaries in the world. To try to manage it with a Barrage requires modelling, and for that modelling to be realistic it requires accurate data. At the present time, I believe there is insufficient accurate data available, particularly in respect of the area upstream of the First Severn Crossing.

This was exposed in the Severn Estuary Shoreline Management Plan Review which admitted that no account had been taken of the fluvial flow or the tidal bore and that very little sediment data existed upstream of the First Severn Crossing. These three things are amongst the most important in shaping our shoreline and managing flood risk in the upper estuary, and yet no effort was made to overcome this lack of knowledge.

Unfortunately, this knowledge gap looks set to be repeated by the promoters of the Cardiff-Weston Barrage who admit to a lack of detailed understanding of the movement of silt and mudflat deposits throughout the estuary.

The upper estuary will be greatly affected by a Barrage. It is essential that its present dynamics (migration of the main channel, currents, patterns of erosion and accretion, sediment budget and ever-shifting mudflats and sandbanks) are fully understood so that a reliable baseline can be set. This is the only way that the effects of a Barrage will be properly understood.

My research involves studying historical records, site visits and anecdotal evidence. There seems little place for any of this in an age of desktop studies and yet, as has been proved in my own area of study, local

knowledge has successfully managed flood risk for centuries because people watched the behaviour of the river and acted accordingly.

So my plea to the Select Committee is that they ensure that the promoters of the Cardiff-Weston Barrage undertake the research necessary to understand the dynamics of the estuary upriver of the First Severn Crossing and that they consult with the local people all along the banks to Gloucester to increase their knowledge.

November 2012

Written evidence submitted by P R H Clifford (SEV27)

I own lands beside the river Severn and am also a Parish Councillor.

My concern is over the question of engagement.

During the preparation of the Severn Estuary Shoreline Management Plan Review I was not consulted in either capacity. This was despite Defra's *Shoreline Management Plans Guidance* laying down a suggested process of engagement which would have included landowners and Parish Councils.

The lack of engagement was then repeated when the Environment Agency developed their original Severn Estuary Flood Risk Management Strategy. The first I knew of that was at the public consultation stage when a short document was published with no supporting evidence. The Environment Agency had to withdraw their document because they had failed to engage properly.

My land has been in managed retreat for almost 20 years and yet no one has been monitoring the success or failure of the scheme in any organised way other than occasional visits from Natural England to discuss management consents.

My land forms part of internationally and nationally designated habitats (Ramsar, Special Area of Protection, Special Conservation Area and Site of Special Scientific Interest) all of which are in decline because of erosion, and yet that erosion is just accepted. Its cause is not studied and the effects that it may have on the drainage of surface water from our village have not been addressed.

The Environment Agency's second attempt at a Flood Risk Management Strategy has been very different. Engagement Officers have made contact with me as a landowner, and also our Parish Council. We have been able to feed our local knowledge into the development process. We are still doing so. In early December the Environment Agency and the Lower Severn Internal Drainage Board are meeting me on site to discuss short-term problems which the Environment Agency had not envisaged through any of their studies and yet it is obvious to me as the landowner.

Site visits and early consultation on a local basis are key to understanding the dynamics of the estuary. Our part of the estuary is very under-monitored. Desktop studies only tell a partial story.

I do not believe that those promoting the proposal to build a Cardiff-Weston Barrage have thought hard enough about the engagement process. "Drop-in sessions" will not be sufficient.

I look to the Energy and Climate Change Select Committee to ensure that any proposal for a Cardiff-Weston Barrage lays out clear guidelines for engagement at a local level, and that Government monitors that engagement process properly.

All owners of land beside the river Severn should be consulted, together with all Parish Councils who can, in turn, suggest other people or organisations that should be included in the consultation process. Only after that depth of engagement should any proposal be exposed to public consultation.

November 2012

Written evidence submitted by the National Farmers Union (SEV28)

INTRODUCTION

1. The NFU is the largest farming organisation in the UK, providing a strong, respected and independent voice for the industry on behalf of some 56,000 Farmer & Grower members in England and Wales. In addition, we have around 40,000 Countryside members with an interest in farming and the countryside.

2. The idea behind an energy producing barrage in the Severn Estuary has been put forward periodically over many years. Most recently, in 2007 the Sustainable Development Commission (SDC) supported the building of a Severn Barrage, providing a number of strict conditions were met, following which a government-backed Severn Tidal Power Feasibility Study investigated but decided not to proceed with plans to build the Severn Barrage. The idea has now once again been revived in light of interest in the venture from the private sector, and in particular in relation to the Cardiff-Weston proposal assessed by the study.

3. The NFU supports renewable energy deployment, especially on a small-to medium scale where farmers can play an active role recycling waste streams and producing renewable energy for local consumption. At a

larger deployment scale, while supporting the drive to reduce carbon emissions, our principal concern is with the impact of any development and the measures required to mitigate the effects of that impact on members' farm businesses and productive farmland. With this in mind, while in principle we have no objection to the Severn Barrage proposals, our two biggest concerns are (a) how are people to be compensated for land that is at a greater risk to flooding due to the construction of the barrage and (b) if compensatory habitat is required to protect *Natura 2000* goals through compulsory purchase orders, through what process will people be compensated. We also have some concerns over the impact on tidal regime and coastal erosion, as well as the possible closure of Bristol Port if the Cardiff-Weston Barrage proceeds.

Flood Risk

4. If a Severn Barrage is built it is inevitable that water levels, upstream, will rise, or at least remain at a higher level, rather than dropping with the tide. The NFU believe it is only fair that landowners upstream—where their land is affected due to increased flood risk, changes in erosion and a higher water table—are able to claim compensation. The current state of the law suggests that the builders of the barrage would be liable if they are deemed to be diverting typical or normal flooding. While this would seem to suggest that landowners would be able to claim compensation, it is vital that this is confirmed before any work goes ahead. We will therefore be asking the government, in the event that the barrage goes ahead, to ensure there is provision for compensation to be paid to land/property owners/occupiers whose land/property suffers damage as consequence of the construction or operation of the barrage and where the damage arises as a result of flooding, increased flooding, groundwater level rise or erosion.

5. The Cardiff Bay Barrage, which can be used as precedent, was authorised by the Cardiff Bay Barrage Act 1993. In this case the Act contained provisions for ascertaining, preventing and repairing damage to property resulting from alterations in the groundwater levels as a consequence of the construction of the Barrage (section 21 and schedule 7), as well as obliging the developers to keep groundwater levels under review. Under these provisions owners/occupiers could request a survey up to 20 years after the water was impounded, and required the developer to undertake necessary remedial works identified by the survey, or to pay compensation. So in the case of the Severn Barrage it is essential that the legal framework for the construction and operation of the Barrage contains similar provisions.

6. We would also expect much more detailed analysis of the flood risk posed by a Severn Barrage to surrounding land. In particular, while tidal flooding issues are well addressed in existing reports, the potential effects of the barrage on fluvial flooding have been somewhat overlooked, despite the fact that the area of land and number of properties which are potentially at risk from fluvial flooding in the Severn Vale are greater than those at risk from tidal flooding. Any development within the estuary (such as the barrage) which might reduce the flow of water from the river out to sea could significantly increase the fluvial flood risk within the Severn Vale. The detailed effects of the barrage on river water levels and flows therefore require vital further study.

Compensatory Habitat

7. The Severn Estuary is designated under the EU Habitats Directive as a Special Area of Conservation (SAC). Under the Article 6(4) of the Habitats Directive a Member State "must take appropriate compensatory measures to ensure that the overall coherence of the N2000 [Natura 2000] Network is protected." The exact nature of these "compensatory measures" is unclear as they are all viewed on a case by case basis. However, precedent would suggest that a large amount of land would have to be reclaimed to attempt to replicate the environment that will be lost if the barrage is constructed. The SDC guidance says on compensation measures that "ratios should be generally well above 1:1" and that like for like compensation could only be justified where there was evidence that the new site would be 100% effective at re-instating the lost habitats. So, for example, for the Cardiff Bay Barrage the compensatory habitat was twice the area of the original habitat.

8. The SDC suggests that the best way to achieve this compensation would be the surrendering of low-grade farmland to the sea. Around 20,000 hectares, or 30,000 if the 2:1 Cardiff Bay ratio is used, could be compulsorily purchased to compensate for habitat loss. The potential loss of such a large amount of farmland is obviously extremely concerning to the NFU, not least because of the impact on UK food security, as well as the local impact on affected farm businesses and rural communities. Before construction of the barrage is given the go ahead, there are crucial questions that will need addressing: How will any compensatory habitat required be chosen? Where will it be located? What will the extent of the compensatory habitat be? What provisions will there be for landowners or occupiers whose land is acquired for compensatory habitat, or otherwise affected by the creation, recreation or designation of compensatory habitat, to make representations? Will any compulsory purchase orders take into account loss of livelihood as well as assets? What explicit recognition will there be of the value of farmland with regard to food security when assessing farmland for potential compensatory habitat? Before plans for a Severn Barrage progress, these questions must be answered adequately.

Coastal Hydrology and Tidal Regime

9. During discussion of previous barrage proposals, concern has been expressed by farmers and growers over any changes in the "downstream" impact on tidal regime and coastal erosion. There is much uncertainty as to what this impact will be. Vulnerable sea defences may be exposed to increased wave or tidal action,

while river flows during flood events from the River Parrot catchment may also be impeded, increasing flood risk at time of peak flow in the low-lying Somerset Levels. It is crucial that a detailed assessment of these impacts is undertaken before any plans for a Severn Barrage are given the green light. The upstream impact will be entirely different and the consequences of a new tidal regime in relation to the drainage of surface water from low-lying areas needs to be fully explored and understood.

BRISTOL PORT

10. In the 2010 feasibility study, the report stated that the Cardiff-Weston scheme could adversely affect access to the Estuary ports, with possible delays perceived as an unnecessary risk for port customers, impacting on the competitiveness of the ports. In a worst case scenario, this could lead to closure of Bristol Port, according to the study. The loss of such an important regional import/export facility would mean major cost increases for farmers as far afield as Warwickshire and Oxfordshire who benefit from access to non-local and overseas markets. The developers behind the proposal must set out how they plan to ensure the Estuary ports such as Bristol will continue to operate if construction of the barrage goes ahead, not only to current levels, but to the increased levels of capacity over coming years which are currently expected.

CONCLUSION

11. The NFU welcomes this opportunity to look again at a Severn Barrage; as energy demand and the need to decarbonise our energy production increases we will have to look new methods of energy production. The NFU is technology neutral when it comes to how to decarbonise energy production, so we would not support or oppose a Severn Barrage until a specific proposal is made. We would want to make sure that any landowners and occupiers affected by the project, either directly or indirectly through provisions for compensatory habitat creation or difficulties with land drainage, are adequately compensated for the loss of assets or livelihood.

12. It is also vital that in considering whether a Severn Barrage is given the go ahead, proper and full consideration is given to the value of farmland, and the desirability of development that results in farmland being used for non-agricultural purposes or in a reduction in its productive capacity. Development must recognise other demands for the nation's land—not least food production and, renewable energy production.

November 2012

Written evidence submitted by Mary Page (SEV29)

1. SUMMARY:

In the past 2 years since the Government's comprehensive and extensive Severn Tidal Power Feasibility Study the environmental circumstances and case against the barrage has remained stable and conclusive. The call for action to install a barrage to produce energy in order to tackle Climate Change is a spurious one. We are facing the issues with Global Climate Change as we have consistently ignored the environmental harm of human activities, therefore now is not the time to ignore again the environmental cost and consequences of a large-scale barrage. Critically the CO_2 content of the earth's atmosphere has reached and passed the tipping point of 350ppm. However, other projects described as the Severn Embryonic Technologies including tidal stream technology and new wave energy projects have increased in terms of variety, technology advances and available environmental impact data from deployed test sites. In the last two years the Government has created the Catapults for bridging the gap between academia and industry and both the HVM Catapult and the ORE Catapult could provide valuable assistance to move on technologies past first concept TRL1–3 through into TRL 4–7 to enable UK companies to be world leaders in wind/wave/tidal energy.

2.1 *What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?*

A barrage could provide the UK with a regular supply of energy that energy would be produced at the times of the tide and therefore be predictable and reliable. However, it would not necessarily be produced at the time of peak usage need as production would vary by an hour every day and move through the 24 hour cycle in the same pattern as the tides. I have seen it reported that the new Barrage proposal could provide "fifth of UK energy" although that could be a typo but it needs to be checked: 5% was the maximum generation suggested before in the DECC STPFS and that was a generous figure. To create 20% (fifth) of the UK electricity power needed it would need to produce over 70TWh/pa as UK used 368 TWh electricity in 2011 and that's just electricity not UK's energy usage! Compared to the original Barrage predictions of Energy Generated 15.6TWh/pa that's an enormous jump!

There could also be a risk that with international terrorism now so dispersed, fragmented and digitised that a large scale barrage construction could become a terrorist target ether through cyber attack or by bomb threat. It is not relevant to think of it as a tool to tackle Climate Change, as CC has been caused by a consistent under accounting for the environmental impact and consequences of human activities. The construction alone would require such huge provision of aggregates and energy that in the short term which is when we need to take action to reduce emissions and energy use. It would contribute to increasing Climate Change not reduce it. The

submissions to the DECC STPFS report concluded that a Barrage would increase sea level rises for up to 30cm as far as Ireland.

3.1 *What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?*

The major risk from flooding upstream in the Severn is from fluvial waters coming downstream and run off from both agricultural and urban land. So the impounded head of water created by the barrage could increase the problem of flooding in Tewkesbury and Gloucester not alleviate it. It could also prove problematic for the drainage across South Gloucestershire, as there are over 40 outfalls into the Severn from that area. (Ref: DECC STPFS SGlos Council Submission.)

4.1 *What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?*

There would be a loss of 50% of inter-tidal habitat—there is no action that could be taken to mitigate that. The RMSAR designation and the compensatory habitat that would need to be provided would be in the region of 60,000ha as it would require 3:1 ratio some 600 sq km. (Ref: DECC STPFS SGlos Council Submission.)

5.1 *What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?*

It depends what you define as successful. This question should be at least 2 separate questions as there is no direct connection or relation between each project apart from the over-riding point that on each there have been unintended consequences and a significant underestimation of the environmental harm and impact. The construction of the Oosterschelde Storm Surge barrier was a large-scaled and complex project and the environmental impact have been considerable. The intended sea storm surge flood prevention didn't account for the inland flooding that has since occurred. (Ref: RSPB report http://www.rspb.org.uk/Images/RSPBbriefEasterScheldtreportfinal_tcm9–240984.pdf The Bay of Fundy has a number of environmental reports and has caused coastal erosion issues up to 200 miles away http://www.bofep.org/publications.htm

6.1 *What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated?*

In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary? Purely discussing this issue again is having a negative impact on Bristol Port as they are already finding it a negative attractor for long-term investment both in the docks and for their deep sea container port. This will lose jobs and economic prosperity for the city of Bristol. The other options for smaller scale balanced approach schemes as advocated by Regen SW could create long-term jobs in Bristol and all around the UK and that could be exported worldwide rather than one tidal Barrage which would be a one off and which would ultimately transfer employment from the English side of the Estuary to Wales. History tells us that cities caught on the wrong side of the "millers dams" and cut off from the sea decline and are stunted, e.g. Exeter.

7.1 *Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?*

N/A to my area of knowledge.

8.1 *How does the company plan to engage and consult the community in the development of the project?*

N/A to my area of knowledge.

9.1 *Are the proposals in breach of EU legislation, and if so how will this be addressed?*

N/A to my area of knowledge.

10.1 *Are any other proposals for tidal power projects in the Severn estuary currently under consideration?*

Yes Parsons Brinkerhoff have a tidal lagoon project. The Regen SW and Marine Matters report on the Marine Energy Park outlines how a balanced approach could be more beneficial and provide a win-win situation for Bristol and other potential upstream Severn Ports, the environment and still provide 14GW energy production without a Severn Barrage. The report

11.1 *What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?*

Government estimates suggest that we are already 50,000 engineers short of what we need to meet current industry need and it's estimated that will be 200,000 short in the near future. The Government's Catapult centres are going some way to enable UK based industries remain competitive in a global market but there is a huge opportunity if smaller schemes were enabled. However, great UK tidal technology companies have

failed to get enough Government support to keep the innovation in the UK. In the time since the DECC STPFS both Bristol based companies, Marine Current Turbines were bought out by Siemens and Rolls-Royce sold Tidal Generation Ltd to Alstom. Both the HVM Catapult in particular the National Composites Centre (because of the properties offered by composite materials meaning potentially less maintenance and light weighting opportunities) and the ORE Catapult could be critical in enabling maximum benefit from the smaller modular tidal stream technology projects. Not that I wish to underplay the important environmental resource of the Severn Estuary as the other schemes (lagoon, fence & Pulse Tidal, reef, tidal turbine farms, kites etc) will also have potential environmental effects but because they are smaller or able to be deployed in a modular fashion that environmental impact can be properly assessed and monitored.

12. Credibility and Background Expertise

Mary Page Biography in relation to expertise and knowledge regarding Severn Estuary and proposed Tidal technologies.

My full time job is Business Development Coordinator at the National Composites Centre part of the High Value Manufacturing Catapult. My previous post 2005–11 was Political Assistant at South Gloucestershire Council.

In various places I have been opposing a solid structure Barrage but promoting new embryonic tidal energy technologies that the UK could be world leaders in for the past six years.

Past activities include:

In the run up to the Mayoral elections I finally had an opportunity to organise a briefing on the Marine Energy Park and the case against the Tidal Barrage for the Deputy Prime Minister Nick Clegg MP and his PPS Duncan Hames MP. The assembled experts included representatives from new Tidal Stream technologies—(Marine Current Turbines), Peter Kydd from Parsons Brinkerhoff one of the world's leading planning, engineering, program and construction management organisations, Marine life expert Dr Rob Kierle from the Marine Conservation Society, Johnny Gowdy Programme Director Regen SW, (Bristol Port were unable to attend on the day but provided a briefing note) and Environmental Activist & surfer Stuart Ballard.

I have attended every Severn Estuary Partnership event on Severn Tidal Energy in the past six years. I attended the Gloucester Symposium with John Gummer, the Institute of Civil engineers Tidal technology event and most of the DECC STPFS consultation events. In addition I've attended all of the Regen SW events with assembled experts over the past six years and the Bristol Tidal Energy Forum.

I've also heard representation from WWF, Marine Conservation and the RSPB and attended the ITN debate at Slimbridge where I likened the motives of those proposing the large-scale barrage scheme to "big boys with big toys wanting to build big things".

13. References:

Wikipedia: James E. Hansen said that this tipping point had already been reached in April 2008 when the CO2 level was 385 ppm. (Hansen states 350 ppm as the upper limit.) "Further global warming of 1°C defines a critical threshold. Beyond that we will likely see changes that make Earth a different planet than the one we know. He has further suggested potential projections of runaway climate change on Earth creating more Venus-like conditions in his book Storms of My Grandchildren.

November 2012

Written evidence submitted by Paul Crossley (SEV30)

The Severn Barrage was one of several options that was considered by the last government and rejected. The Severn Estuary with its large tidal range and its magnificent bore is an exceptional national asset. Its extensive range of habitats provide a home to a huge biodiversity.

The Bristol and Bath local economy has many innovative firms that are already working in the renewable energy industry. If we can solve these problems in an environment such as the Severn then these are products and skills that can be marketed across the world on several projects. Renewable energy projects based on harnessing tidal energy through lagoons, reefs, barriers, tidal mills etc would create long term employment and prosperity.

By contrast a dam with a lock is technology that every country already possesses and would create no intellectual or skill base for future decades.

Tidal harvesting has low impact whilst a dam has a huge impact.

The idea that the dam could be used as a transport link is in my view preposterous. The extra width required would make the project completely unviable and would add to the width of the dam and to the impact.

Bristol Port is a large employer and is one of the few/only ports in the country that is directly accessible by rail and motorway links. It is also capable of being transformed into a deep water port capable of taking the largest ships on the drawing boards or being envisioned. Serving as it does the Midlands it represents the best way of import and export to the country's industrial heartlands. The port has plans to invest £600 million in this facility. Currently talks of barrages are inflicting blight and uncertainty on these proposals. The plans it should be noted already have planning approval.

A barrage by contrast would completely destroy this opportunity as a lock system would cause delay that would not work for the shipping industry. In addition the barrage would cause silting that would require continuous dredging. This would cause other damage to beaches and pose flood risks elsewhere in the system.

Also the claim that the Country would have to pay nothing for the energy and investment smacks of the logic of nuclear energy where the costs are hidden or subsidised in other ways. In summary the barrage proposal should be rejected as it is bad for jobs, bad for the economy, bad for the environment and a poor solution to creating renewable energy. Losing the port would mean more lorry journeys taking freight from less suitable ports to the heart of the country.

November 2012

Written evidence submitted by The Wildlife Trusts (SEV31)

Introduction

1. The Wildlife Trusts are pleased to be able to submit evidence to the Energy and Climate Change Committee Select Committee inquiry into the proposal for a Severn Barrage.

2. There are 47 individual Wildlife Trusts covering the whole of the UK and the Isle of Man and Alderney. Together The Wildlife Trusts are the largest UK voluntary organisation dedicated to protecting wildlife and wild places everywhere—at land and sea. We are supported by more than 800,000 members, 150,000 of which belong to our junior branch—Wildlife Watch. Every year The Wildlife Trusts work with thousands of schools and welcome millions of visitors to our nature reserves and visitor centres.

Over-Arching Comments

1. The Wildlife Trusts were engaged in the Department for Energy and Climate Change (DECC) feasibility study which concluded with a public consultation in April 2009.

2. We produced a report, *Energy at any price?* which coincided with the public consultation: http://www.wildlifetrusts.org/publications. The report examined each of the five short-listed options in turn. The Wildlife Trusts did not support any of these five options, and believe that a barrage from Cardiff to Weston would have a devastating impact. We were, and remain interested in more innovative options which were on the table at the time—none proposed to block the flow of the tide in such a devastating way, and therefore held the most promise for the best technology possible, with the least impact. The Wildlife Trusts believed that they should have been researched further.

3. Whilst nothing more has been heard about those more innovative technologies Hafren Power has come forward with a proposal—yet we have not seen a detailed technical proposal to date. As such this evidence is based on the work which we undertook during the DECC feasibility study. Without detailed information on the Hafren Power proposal it is very difficult to assess the impacts and make informed comments.

Individual Questions

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

1. The Wildlife Trusts support the UK's targets to reduce greenhouse gas emissions and the Government's ambitions to tackle climate change and increase the proportion of overall energy generated from renewable sources. We share the sense of urgency in deploying and developing solutions to move the UK towards a low carbon society. However, deployment of large-scale renewables can not be at the expense of our wildlife and habitats; it is essential that the right technologies are developed in the right place.

2. The two year feasibility study carried out by the DECC demonstrated that whilst the Cardiff-Weston barrage would have the highest energy production 8.64 GW, with CO_2 savings per year 7.2mt and cost per unit of energy 12.9p/kWh, it also had the greatest overall impact, with far more intertidal habitat loss than any other option. More than 95% of habitat within protected areas would be lost (20,000ha) Fish passage to all tributary rivers would be impeded, leading to likely regional extinction of Atlantic salmon and twaite shad. As such the proposed Cardiff-Weston barrage would fundamentally change the Severn's ecology, affecting both people and wildlife.

3. We need to ensure that decisions made balance our energy needs against the Estuary's ecological, recreational, social and cultural value. The Wildlife Trusts believe that any development should respect the

intricate natural processes which have developed here over millennia, at present we do not believe that a Cardiff-Weston Barrage does this.

What risks and opportunities could it pose with regard to flooding in the Severn Estuary, and how might any risks be mitigated?

4. The Wildlife Trusts believe that there are far more risks associated with the Cardiff-Weston barrage than opportunities, especially with regard to flooding. Far from bringing benefits, a tidal barrage is likely to make our coast less resilient against the effects of sea level rise.

5. There has been much talk that a barrage is likely to bring major flood relief benefits due to the reduction in tidal flow and therefore the amount of sediment in the water, which will lead to increased sediment deposition on foreshores. However, lessons arising from both the surge-tide barrage across the eastern Scheldt in The Netherlands and the tidal power barrage at Annapolis Royal in Canada, both silty estuaries like the Severn, have resulted in foreshore erosion, rather than deposition. These examples show how removal of energy from coastlines has unexpected consequences potentially resulting in flood defences being undermined in the long-term as foreshores become less muddy rather than muddier.

6. The ecology and the shape of the Estuary are constantly changing due to the complex interchange of water and sediment. This regime distinguishes it from other estuaries and influences the whole ecosystem. Technology that extracts some of this energy will inevitably affect the way the coast develops. The main impact will be to reduce sediment supply to the coast and to increase sedimentation in the subtidal area. This means that putting any structure in the Estuary will lead to some degree of erosion. In the long-term this process has important implications for flood defences and other coastal structures such as ports, railway lines and roads.

What risks and opportunities could it pose to wildlife and habitat in the Severn Estuary, and how might any risks be mitigated?

7. The Severn Estuary is an extensive site of international importance for coastal and marine biodiversity, with much of the Estuary designated as a Site of Special Scientific Interest, a Ramsar site (a wetland of international importance), a Special Protection Area and a Special Area of Conservation. Furthermore there are 228 Wildlife Trust nature reserves in the region, totalling 3,450ha, and 17 Living Landscape schemes covering 372,700ha, or 1,400 square miles. Up to 16 reserves would be affected by construction of a barrage, including the destruction of part of the Penarth Coast SSSI, and with it The Wildlife Trust Lavernock nature reserve, if the proposal was on a similar alignment to the original Cardiff-Weston barrage proposal.

8. It is one of the major estuarine sites for unique invertebrate species, providing irreplaceable habitat for some 69,000 overwintering waders and wildfowl, over one hundred species of fish and a nursery ground for 10 species of commercial fish. Its extensive saltmarsh, mudflats and subtidal reefs are important features in their own right, with some estimated 10 million tonnes of sediment carried up and down the Estuary on a spring tide—it is the dynamic nature of the Estuary which not only makes it unique but also presents the opportunity to harness energy from the second largest tidal range in the world.

9. In terms of risks and opportunities for wildlife and habitat in the Estuary, the Cardiff-Weston barrage is likely to have significant impacts on this internationally important Estuary and so once more The Wildlife Trusts believe this poses risks on an unprecedented scale. We do not believe that there are opportunities for wildlife and habitat by extracting energy from the system.

10. With reduced sediment mobilisation the water column will no longer provide sediment onto the mudflats and sand flats resulting in the loss of these habitats. This would have a profound effect on the Severn Estuary's wildlife, including its internationally important bird and fish populations. It is not merely loss of habitat which is represented here, but the total disruption to the ecosystem on which many species depend.

11. The huge productivity within the mudflats of the Severn makes it a winter refuge for white-fronted geese, and thousands of wigeon, teal and pintail, which migrate from Russia. It is also an essential refuelling stop of long distance migrants that winter in sub-saharan Africa and pass through the UK twice in spring and autumn. Adults and young birds need to put on half their body weight in fat to enable them to make these journeys, therefore biological rich estuaries like the Severn are vital. A reduction in the area available due to the development of a Cardiff-Weston barrage would have significant impacts on bird numbers and is likely to result in a significant adverse effect on site integrity.

12. The survival of fish populations would also be severely threatened. Fish passage to all tributary rivers within the Severn Estuary, including the improving Wye, and the Usk Special Areas of Conservation (SAC) would be hindered. Salmon for example enter the Estuary system and swim up and return on average 15—20 times before finally making their way upstream. This could mean that a salmon would have to try and pass through the turbines 15—20 times, increasing the risk of mortality. This would have a catastrophic impact on populations of migratory fish and lead to severe decline or local extinction of species such as genetically distinct Atlantic salmon and twaite shad. Loss of important nursery and feeding areas could also result.

13. The Wildlife Trusts believe it would be very difficult to mitigate all the risks associated with a full barrage across the Severn. The DECC feasibility describes the chance of finding like-for-like habitat elsewhere as "impossible". Any habitat creation, it admits, would have to be on an "unprecedented" scale.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

14. When assessing the potential environmental impacts of a Severn barrage it is important that comparisons and lessons learnt are made using examples from estuaries that are similar to the Severn. As detailed above (in relation to flood risk) one of the key environmental considerations is the alteration in geomorphology in the Estuary and as such comparisons needs to be made with similar silty estuaries. Research undertaken during the DECC feasibility study suggests that La Rance is a poor analogue for considering possible changes on the Severn. La Rance lies on a rocky coast and its form is largely determined by hard geology. Thus, its overall form is unlikely to change greatly, even though localised changes in sedimentation and erosion will occur. In addition its sediment was mainly sandy—unlike the Severn which is a sink for fine sediments in various locations.

15. The Wildlife Trusts believe that the Eastern Scheldt, even though it is not a tidal power project, provides a better comparison than La Rance to assess the potential impacts a barrage may have on the Severn. There, the construction of a storm surge barrage has had, and continues to have significant impacts on the Estuary ecosystem. There has been significant and ongoing coastal erosion, as predicted for the Severn. This has resulted in loss of important habitat, expected loss of bird populations over the next 50 years as a result and ongoing cost to the tax payer to mitigate the increased flood risk.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

16. The DECC feasibility study considered a short-list of five options, which were assessed as part of the study. As we are yet to see technical proposals from any private developer, or otherwise from Government, it is impossible to comment at this stage whether such a proposal is in breach of EU legislation. We acknowledge that the proposal from Hafren Power is an ebb/flow, low-head barrage to sit across the Cardiff-Weston alignment, however, given the likely magnitude of impacts to European wildlife sites, including the Severn Estuary and its tributary rivers, and the low confidence in mitigation and compensation measures of the original Cardiff-Weston barrage, we consider it highly doubtful that the proposal could comply with the European Directives.

17. Legal advice which we attained jointly with WWF-UK, the Wildfowl and Wetlands Trust, and the Wye and Usk Foundation in 2010 stated "If compensation cannot be achieved in a broadly like-for-like manner, as conventionally required under the Directive, then the proposals for the barrage as they stand cannot be lawfully fulfilled, because they cannot show the compensatory measures necessitated by Art.6.4 can be attained". (In reference to the Birds and Habitats Directive).

18. As we have seen no proposal of the detail, we cannot give evidence or comment upon how the company propose to address this.

Are any other proposals for tidal power projects in the Severn Estuary currently under consideration?

19. There are proposals for a tidal lagoon development in the Bristol Channel between Port Talbot and Swansea, the details of which are expected to be published in spring 2013.

20. Parsons Brinckerhoff also intend to present their proposal for the Stepping Stones lagoon in Bristol on 11 and 12 December.

November 2012

Written evidence submitted by the University of Bath (SEV32)

Addendum to "An Energy and Carbon Life Cycle Assessment of Tidal Power Case Study: the Proposed Cardiff-Weston Severn Barrage Scheme", published May 2012

Abstract

A life cycle assessment was carried out on the "Cardiff-Weston" Severn barrage proposal as it was in 2010. The inventory analysis carried out for that work and the results of the life cycle energy and carbon analyses were published in the international journal *Energy* in May 2012(Kelly, 2012). That publication showed that the energy and carbon intensity of the Severn barrage is small in comparison to the National Grid mix and that the Severn barrage could contribute to meeting the UK carbon reduction target. Importantly, the operation stage was identified as both the most energy and carbon intense by a large margin. This is a notable finding as preceding studies have tended to dismiss the consequences of the barrage operation. This finding lead to a further "improvement" analysis in order to investigate the implications of operating the plant in ebb generation mode only and it was shown that the slight reduction in power output was far outweighed by the savings available in terms of energy demand and carbon emissions. This conclusion is further confirmed by the

environmental impact analysis which shows that environmental impact of the operation stage is reduced so much by the removal of flood pumping that it in facts becomes the least impactful stage. When carbon and energy are examined in isolation, the operation stage is always the most dominant contributor. This does however mean that if, as is hoped, the National grid becomes more energy efficient and less carbon intensive the impact of the Severn barrage will follow suit.

1.1 Introduction

A life cycle assessment was carried out on the "Cardiff-Weston" Severn barrage proposal as it was in 2010. The inventory analysis carried out for that work and the results of the life cycle energy and carbon analyses were published in the international journal *Energy* in May 2012(Kelly, 2012). The inventory has since been subject to some small improvements, but the overall findings and conclusions published remain largely unchanged. This addendum presents the most up to date results for the study with regard to carbon and energy analysis. Perhaps more significantly, however, a full set of environmental impact results and interpretations are presented.

1.2 Environmental Impact Assessment Methodology

The impact assessment methodology "ReCiPe" was used to generate the results presented here. The ReCiPe 1.01(Goedkoop, De Schryver, Heijungs, Huijbregts, van Zelm, & Struijs, 2008) methodology was released in 2008 following a collaboration of RIVM, Radboud University, CML and PRé Consultants; their initials making up the capitalised letters in the methodology name. The method is largely a combination of the pre-existing Eco-indicator 99 (Goedkoop & Spriensma, Eco-indicator 99, 1999) methodology and CML method (Guinée, 2002).

1.3 Inventory Revisions

Mostly identical to that presented in the *Energy* publication (Kelly, 2012) but with the following minor changes:

- Inclusion of some grid connection infrastructure at the construction. An adaptation of data from EcoInvent was used. Inventory data for the grid connection for 30 kW, 150 kW, 600 kW and 800 kW onshore windfarms (Burger & Bauer, 2007) was used to make a scaled estimate for the material required for the grid connection infrastructure.
- Adoption of the study's re-estimates for "on site" activities across all three barrage models ie "best", "worst" and "initial".
- The mass of material required for the barrage turbines had been represented in both the construction and maintenance inventories by a factor of 1,000. This has been corrected, but it has been shown that this is only really significant when the model assumes that "flood pumping" is not employed, otherwise the operation stage is so dominant that this large charge is barely noticeable

1.4 Life Cycle Impact Assessment Results Interpretation

Table 1 summerises the revised carbon and energy key findings of the life cycle assessment case study.

CARBON ANALYSIS MAIN RESULT			
	Life time carbon (equivalent) emissions ($Mt.CO_2equiv$)		Specific carbon (equivalent) emissions ($kg.CO_2equiv/MWh$))
Severn barrage	120		59
Potential error range	169 - 27		83 - 13
CARBON SAVINGS COMPARED TO NATIONAL GRID			
	Severn barrage, compared with the (approximate) grid mix that supplies the barrage (kg.CO2eq/MWh(e))		**Potential error range (kg.CO2eq/MWh(e))**
UK National Grid 1990, baseline	730		730 - 799
UK National Grid 2008	502		478 - 547
UK 2050 – Central Control V1.1	74		5 - 74
UK 2050 – Market Rules V1.1	99		29 - 99
UK 2050 – Thousand Flowers V1.1	83		14 - 83
ENERGY ANALYSIS MAIN RESULTS			
	Life time energy demand (PJ)	Energy Gain Ratio	Energy Payback period (yrs)
Severn barrage	19 952	3.6	33
Potential error range	25 486 - 16 208	2.8 - 4.5	42 - 27

Table 1 Case study: Severn barrage - summary table of main findings

Table 1 Case study: Severn barrage—summary table of main findings

Table 2 shows the characterised impact results for the three modelled life stages of the Severn barrage for the "initial" case and a potential error range generated by the "best" and "worst" models. The operation stage is the largest contributor in every impact category. The variation in results is also greatest at the operation stage.

Impact category	Unit	Construcflon, 'Iniflal' case	Construcflon Range, 'Worst' to 'Best' cases	Operaflon, 'Iniflal' case	Operaflon Range, 'Worst' to 'Best' cases	Maintenance, 'Iniflal' case	Maintenance Range, 'Worst' to 'Best' cases
Climate change	kg.CO2-eq	6 520 860 000	6 474 960 000 - 6 142 430 000	109 456 900 000	158 631 000 000 - 17 083 900 000	3 535 510 000	3 579 450 000 - 3 528 710 000
Ozone depleflon	kg.CFC-11-eq	581	614 - 480	2 843	3 899 - 2 535	189	195 - 188
Human toxicity	kg.1,4-DB-eq	1 813 640 000	1 855 460 000 - 1 775 190 000	23 219 800 000	45 329 600 000 - 16 148 700 000	2 310 700 000	2 316 620 000 - 2 309 960 000
Photochemical oxidant formaflon	kg.NMVOC	24 064 800	24 351 200 - 21 533 100	236 326 000	435 416 000 - 125 085 000	12 193 900	12 759 500 - 12 176 400
Parflculate matter formaflon	kg.PM10-eq	16 482 000	219 865 000 - 15 825 600	112 610 000	242 662 000 - 62 306 400	17 100 100	17 302 400 - 17 116 000
Ionising radiaflon	kg.U235-eq	805 144 000	890 022 000 - 768 945 000	35 345 600 000	49 701 100 000 - 58 596 900 000	725 082 000	730 062 000 - 724 809 000
Terrestrial acidiflcaflon	kg.SO2-eq	23 016 600	25 624 500 - 21 544 300	366 251 000	844 141 000 - 165 231 000	17 036 300	17 637 800 - 17 121 600
Freshwater eutrophicaflon	kg.P-eq	1 253 330	1 339 330 - 1 226 410	32 387 900	65 018 300 - 15 322 200	1 688 090	1 694 190 - 1 688 100
Marine eutrophicaflon	kg.N-eq	1 066 520	1 097 970 - 976 579	16 388 900	30 939 900 - 8 054 090	733 889	754 508 - 733 474
Terrestrial ecotoxicity	kg.1,4-DB-eq	565 665	536 727 - 528 205	1 905 370	5 204 460 - 29 543 000	596 298	601 553 - 594 733
Freshwater ecotoxicity	kg.1,4-DB-eq	143 238 000	144 136 000 - 142 503 000	498 443 000	987 783 000 - 259 112 000	266 799 000	266 925 000 - 266 782 000
Marine ecotoxicity	kg.1,4-DB-eq	150 030 000	151 290 000 - 149 208 000	529 710 000	998 643 000 - 278 506 000	278 228 000	278 426 000 - 278 228 000
Agricultural land occupaflon	m^2	69 853 400	70 395 000 - 68 195 000	1 494 920 000	3 054 480 000 - 4 254 520 000	90 091 800	90 240 200 - 90 052 300
Urban land occupaflon	m^2	58 488 700	258 157 000 - 55 796 200	489 528 000	943 466 000 - 292 910 000	53 682 200	54 015 100 - 53 555 400
Natural land transformaflon	m^2	4 125 580	17 639 100 - 2 726 280	22 969 000	16 639 000 - 9 431 130	359 110	377 594 - 357 542
Water depleflon	m^3	78 549 000	78 741 000 - 77 071 100	557 048 000	697 271 000 - 500 895 000	23 059 800	23 196 800 - 23 018 500
Metal depleflon	kg.Fe-eq	5 870 400 000	5 858 690 000 - 5 857 340 000	541 499 000	727 907 000 - 1 334 540 000	10 619 300 000	10 620 700 000 - 10 618 700 000
Fossil depleflon	kg.oil-eq	1 755 170 000	1 734 030 000 - 1 644 380 000	35 479 900 000	45 020 520 000 - 16 450 300 000	1 054 940 000	1 070 620 000 - 1 052 060 000

Table 1 Characterised results by impact category of the life cycle stages of the Severn barrage, using Midpoint (H European) Analysis (to the nearest 6 s.f.s)

Table 2 Characterised results by impact category of the life cycle stages of the Severn barrage, using Midpoint (H European) Analysis (to the nearest 6 s.f.s)

Figure 1 shows the normalised impact scores of the whole Severn barrage model according to impact category and includes error bars which depict the potential range of scores, from "best" case to "worst" case. Figure 2 shows the same data as that shown in Figure 1 but arranged according to life stage rather than by impact category so that the life stages can be compared more easily. The biggest contribution to the overall environmental impact in the normalized context is also from the operation stage, which also has the greatest range of error. This large operational impact was, however, ignored (Black & Veatch, 2007)(Woollcombe-Adams, Watson, & Shaw, 2009) or underestimated (Roberts, 1982) (Spevack, Jones, & Hammond, 2011) in the existing analyses previously reviewed (Kelly, 2012). This is probably due to a failure to acknowledge the proportion of the operational electricity demand that would not be met by the plant itself, as would normally be the case for an energy generation plant, nor the consequences of that inventory subtly. The total impact associated with decommissioning was estimated to be considerably less than that of construction. Given that the construction stage itself has been shown to be a minor contributor to the overall impact, it can now be estimated that the impact of the decommissioning stage would make negligible difference if it were included in the analysis.

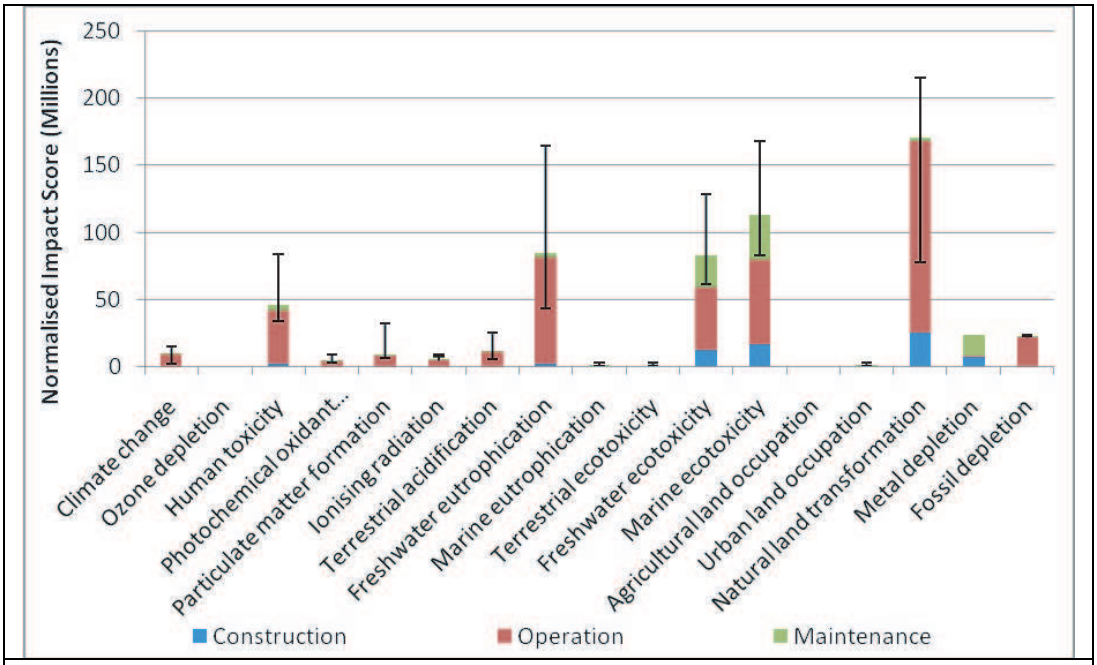


Figure 1 Normalised results by impact category for each of the modelled life stages of the Severn Barrage, including the possible range of scores, using Midpoint (H European) Analysis

Figure 1 Normalised results by impact category for each of the modelled life stages of the Severn Barrage, including the possible range of scores, using Midpoint (H European) Analysis

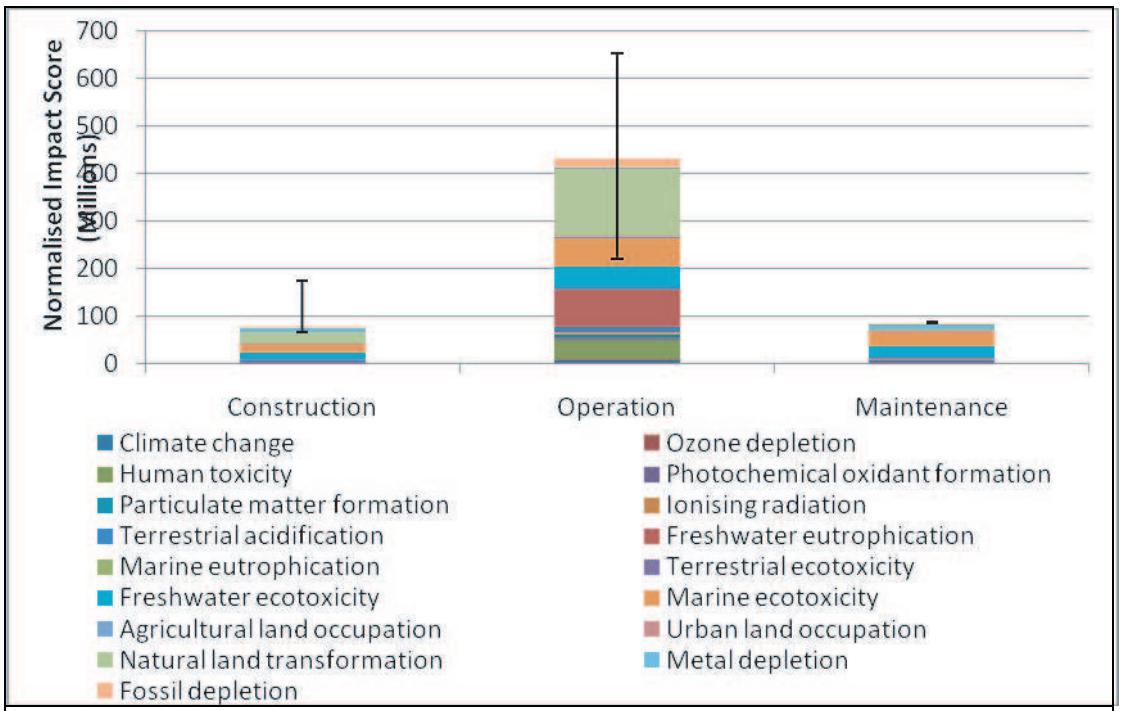


Figure 1 Normalised impact results for by life stage for the Severn barrage, including the possible range of scores, using Midpoint (H European) Analysis

Figure 2 Normalised impact results for by life stage for the Severn barrage, including the possible range of scores, using Midpoint (H European) Analysis

1.5 Life Cycle Assessment Results Interpretation: Power In Context

The characterised results for each impact category per 1MWh of power generated are presented in Table 3.

Impact category	Unit	Severn barrage, 'Iniflal' case	Error range, 'Worst' to 'Best' cases
Climate change	kg.CO2-eq/MWh(e)	59	83 - 13
Ozone deple□on	kg.CFC-11-eq/MWh(e)	0	0 - 0
Human toxicity	kg.1,4-DB-eq/MWh(e)	13	25 - 11
Photochemical oxidant forma□on	kg.NMVOC/MWh(e)	0	0 - 0
Par□culate matter forma□on	kg.PM10-eq/MWh(e)	0	0 - 0
Ionising radia□on	kg.U235-eq/MWh(e)	18	26 - 30
Terrestrial acidi□ca□on	kg.SO2-eq/MWh(e)	0	0 - 0
Freshwater eutrophica□on	kg.P-eq/MWh(e)	0	0 - 0
Marine eutrophica□on	kg.N-eq/MWh(e)	0	0 - 0
Terrestrial ecotoxicity	kg.1,4-DB-eq/MWh(e)	0	0 - 0
0Freshwater ecotoxicity	kg.1,4-DB-eq/MWh(e)	0	1 - 0
Marine ecotoxicity	kg.1,4-DB-eq/MWh(e)	0	1 - 0
Agricultural land occupa□on	m^2/MWh(e)	1	2 -2
Urban land occupa□on	m^2/MWh(e)	0	1 - 0
Natural land transforma□on	m^2/MWh(e)	0	0 - 0
Water deple□on	m^3/MWh(e)	0	0 - 0
Metal deple□on	kg.Fe-eq/MWh(e)	8	11 - 12
Fossil deple□on	kg.oil-eq/MWh(e)	19	24 - 10

Table 1 Specific characterised results by impact category for the power generated by the Severn barrage, using Midpoint (H European) Analysis (to the nearest whole unit)

Table 3 Specific characterised results by impact category for the power generated by the Severn barrage, using Midpoint (H European) Analysis (to the nearest whole unit)

Figure 3 compares the normalized impact score per 1MWh of the Severn barrage, with the potential range of error shown, to that of models of the UK National Grid mixes taken from the Transition Pathways Whole Systems work (Hammond, Howard, & Jones, The Energy and Environmental Implications of More Electric UK Transistion Pathways: A Whole System Perspective, In Press). It appears that the proportional spread of impacts across the suite categories included for the Severn barrage is extremely similar to all National Grid representations. This is not surprising because the overall impact of the Severn barrage is almost entirely made up of its electricity demand at the operation stage.

The relative normalized impact saving when compared to the 2050 grid is much great than the carbon saving. This is because the future scenarios developed by the Transition Pathways team (Hammond & Jones, Whole System Appraisal Feedback v 1.1, 2010) are optimised for low carbon generation rather than low impact or even low energy generation. For instance, the Market Rules scenario has a high proportion of coal fired energy generation with CCS, this explains why its specific GWP is just less than a twice that of the Severn barrage "initial" case while its specific normalized impact score is almost six times as much.

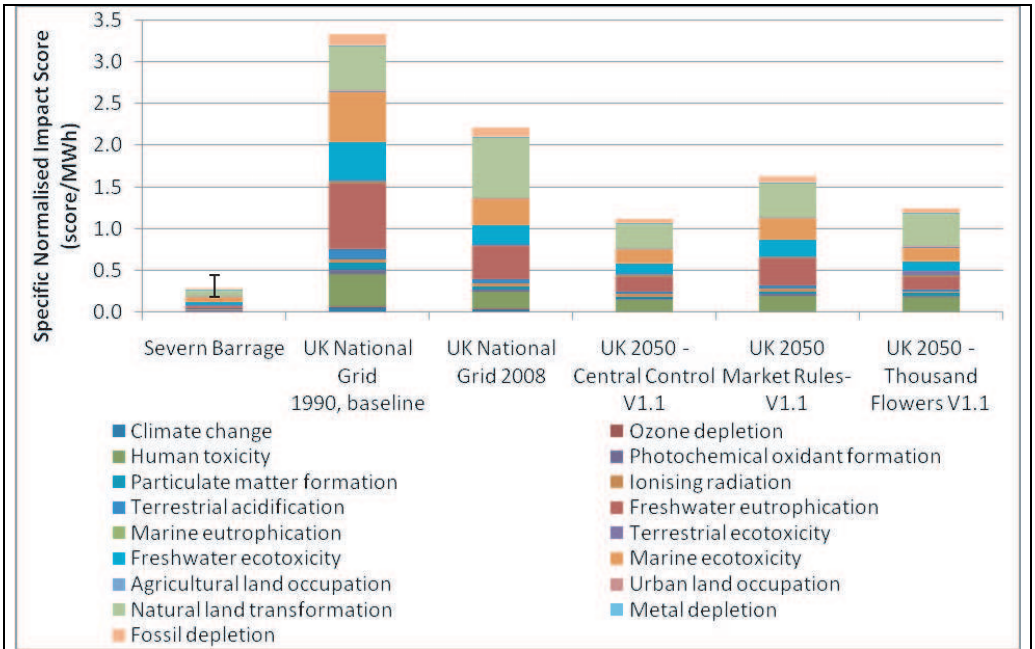


Figure 1 Comparison of specific normalised scores of the Severn barrage with that of the UK National grid, using Midpoint (H European) Analysis, using Midpoint (H European) Analysis

Figure 3 Comparison of specific normalised scores of the Severn barrage with that of the UK National grid, using Midpoint (H European) Analysis, using Midpoint (H European) Analysis

1.6 Improvement Analysis: Exclusion of "Flood Pumping"

Table 4 summarises the revised carbon and energy key findings of the life cycle assessment improvement analysis for the Severn barrage life cycle assessment under the assumption that the plant operates in ebb generation mode only.

CARBON ANALYSIS MAIN RESULT		
	Life ⍰me carbon (equivalent) emissions ($Mt.CO_2equiv$)	Specittc carbon (equivalent) emissions ($kg.CO_2equiv/MWh$))
Severn barrage, ebb generation only	21	11
Potential error range	26 - 11	14 - 6

CARBON SAVINGS COMPARED TO NATIONAL GRID		
	Severn barrage, compared with the (approximate) grid mix that supplies the barrage (kg.CO2eq/MWh(e))	**Potential error range (kg.CO2eq/MWh(e))**
UK Na⍰onal Grid 1990, baseline	804	788 – 804
UK Na⍰onal Grid 2008	549	536 – 552
UK 2050 – Central Control V1.1	79	63 -79
UK 2050 – Market Rules V1.1	103	88 – 103
UK 2050 – Thousand Flowers V1.1	88	72 - 88

ENERGY ANALYSIS MAIN RESULTS			
	Life ⍰me energy demand (PJ)	Energy Gain Ra⍰o	Energy Payback period (yrs)
Severn barrage, ebb generation only	325	21.5	6
Potential error range	382 - 282	18.3 – 37.8	7 - 5

Table 1 Case study: Severn barrage - summary table of main findings

Table 4 Case Study: Severn barrage—summary table of main findings

Table 5 shows the characterised results for the lifetime environmental impact of the Severn barrage on the assumption that it operates in ebb generation mode only, the savings that are available over operating in ebb generation with "flood pumping" and the potential error range. Impact savings are available in every impact category and are 50% or more of the impact for the originally analysed system, i.e. ebb generation with flood pumping, in most instances, and are over 80% in seven out of 18 categories. It is only the category of metal depletion that sees a saving of much less than 50%; only a 3% saving is available in this category because the operation stage was already the smallest contributor, the largest being the maintenance stage which makes up 62% and 64% of the lifetime metal demand, with and without pumping respectively.

Impact category	Unit	Severn barrage, exclusive of flood pumping	*Saving/cost over flood pumping operation*	Error Range, 'Worst' to 'Best' case exclusive of flood pumping	*Saving/cost error range*
Climate change	kg.CO2-eq	21 257 500 000	*98 255 700 000*	26 287 700 000 - 11 419 400 000	*142 397 000 000 - 15 335 560 000*
Ozone depletion	kg.CFC-11-eq	1 062	*2 552*	1 208 - 927	*3 500 - 2 276*
Human toxicity	kg.1,4-DB-eq	6 500 500 000	*20 843 600 000*	8 810 834 094 - 5 737 710 512	*40 690 800 000 - 14 496 200 000*
Photochemical oxidant formation	kg.NMVOC	60 442 900	*212 141 000*	81 668 600 - 46 509 900	*390 858 000 - 112 284 000*
Particulate matter formation	kg.PM10-eq	45 105 900	*101 086 000*	262 000 000 - 39 316 600	*217 830 000 - 55 930 400*
Ionising radiation	kg.U235-eq	5 147 280 000	*31 728 600 000*	6 706 200 000 - 7 490 210 000	*44 615 000 000 - 52 600 500 000*
Terrestrial acidification	kg.SO2-eq	77 532 800	*328 771 000*	129 647 000 - 55 574 600	*757 757 000 - 148 322 000*
Freshwater eutrophication	kg.P-eq	6 255 810	*29 073 500*	9 687 100 - 4 482 490	*58 365 000 - 13 754 000*
Marine eutrophication	kg.N-eq	3 477 560	*14 711 800*	5 018 680 - 2 534 260	*27 773 700 - 7 229 890*
Terrestrial ecotoxicity	kg.1,4-DB-eq	1 356 950	*1 710 390*	1 670 870 - 4 146 190	*4 671 870 - 26 519 700*
Freshwater ecotoxicity	kg.1,4-DB-eq	461 044 000	*447 435 000*	512 145 000 - 435 802 000	*886 699 000 - 232 596 000*
Marine ecotoxicity	kg.1,4-DB-eq	482 465 000	*475 503 000*	531 911 000 - 455 936 000	*896 448 000 - 250 006 000*
Agricultural land occupation	m^2	312 926 000	*1 341 930 000*	473 212 000 - 593 630 000	*2 741 900 000 - 3 819 140 000*
Urban land occupation	m^2	162 266 000	*439 433 000*	408 721 000 - 139 326 000	*846 917 000 - 262 936 000*
Natural land transformation	m^2	6 835 190	*20 618 500*	19 719 400 - 4 048 950	*14 936 300 - 8 466 000*
Water depletion	m^3	158 614 000	*500 043 000*	173 292 000 - 151 348 000	*625 916 000 - 449 637 000*
Metal depletion	kg.Fe-eq	16 545 100 000	*486 085 000*	16 553 900 000 - 16 612 600 000	*653 417 000 - 1 197 980 000*
Fossil depletion	kg.oil-eq	6 440 900 000	*31 849 000 000*	7 411 780 000 - 4 379 860 000	*40 413 400 000 - 14 766 800 000*

Table 1 Characterised results by impact category of the Severn barrage when 'flood pumping' is excluded and the impact savings available in comparison to including 'flood pumping', using Midpoint (H European) Analysis (to the nearest 6 s.f.s)

Table 5 Characterised results by impact category of the Severn barrage when "flood pumping" is excluded and the impact savings available in comparison to including "flood pumping", using Midpoint (H European) Analysis (to the nearest 6 s.f.s)

The total normalized impact score of the Severn barrage when it is assumed to operate in ebb generation mode only is 204,800,000, in a range of 325,900,000 to 173,900,000. Figure 4 compares the overall environmental impact of the Severn barrage when operating in ebb generation with flood pumping for its full lifetime to that of the Severn barrage when ebb generation only is adopted for operation, along with a possible range of error for each. The reduction in impact and in error range can be seen clearly. Importantly the maximum impact estimate for the Severn barrage when it is assumed that flood pumping is not adopted is less than the minimum impact estimate when it is assumed that it is, indicating that the excluding flood pumping will always yield a better environmental impact score, irrespective of what other decisions are made.

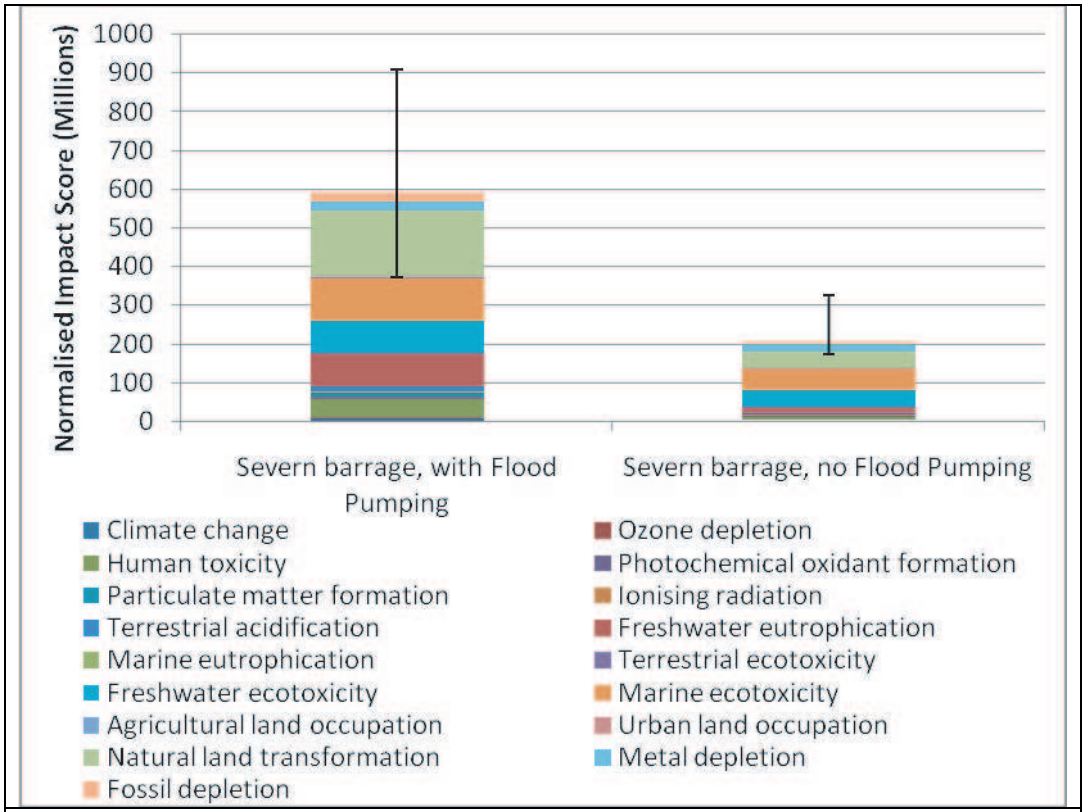


Figure 1 Comparison of the total normalised scores for the Severn barrage, with and without 'flood pumping'

Figure 4 Comparison of the total normalised scores for the Severn barrage, with and without "flood pumping"

Figure 5 shows the normalized impact scores for Severn barrage when it is assumed the plant operates in ebb generation mode only for each impact category, with the contribution from each life stage shown and a possible range of error. When this figure is compared to Figure 1, the effect of removing the electricity demand can be seen.

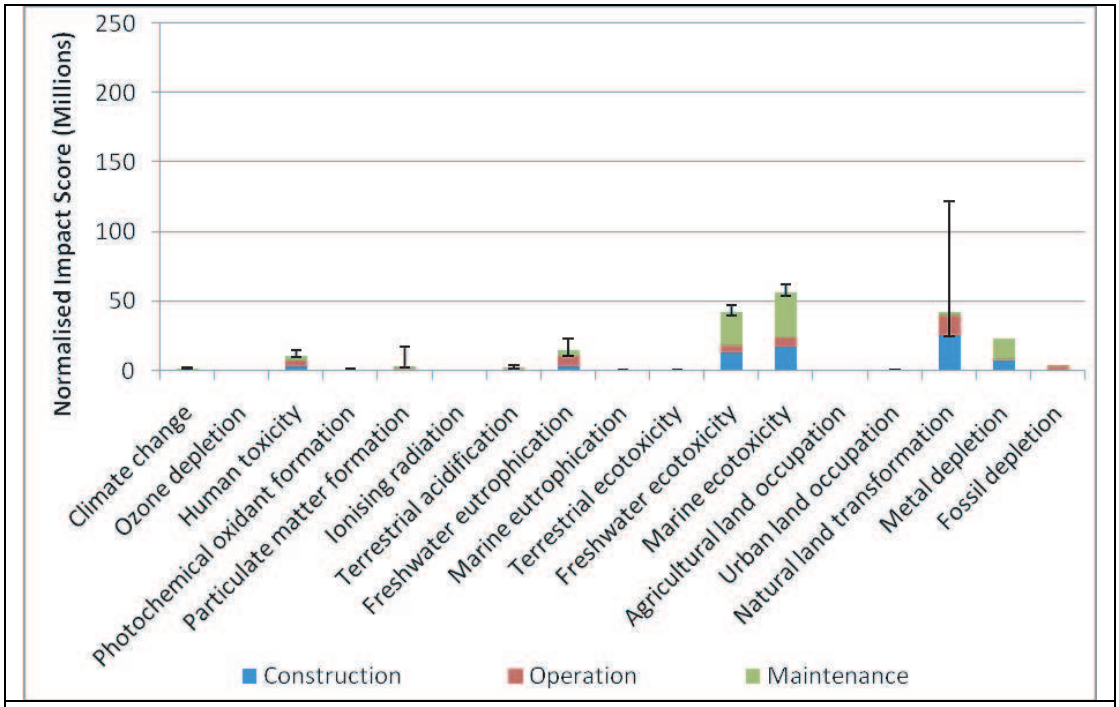


Figure 1 Normalised results by impact category for each of the modelled life stages of the Severn Barrage 'without flood pumping', including the possible range of scores, using Midpoint (H European) Analysis

Figure 5 Normalised results by impact category for each of the modelled life stages of the Severn Barrage "without flood pumping", including the possible range of scores, using Midpoint (H European) Analysis

Figure 6 shows the same results as Figure 5 but with the axis reversed so that the impact of the three life stages can be more easily compared. It can be seen that despite the long operational life of the barrage, the impact of the operation stage could be reduced so that it is the least impactful stage in almost all scenarios. The "worst" case operation impact score is approximately equal to the "best" case construction score, but this is the only instance where the separate life stages come close. In the "worst" case the construction stage is now estimated to be the dominant contributor to overall life impact, but in all other scenarios the maintenance stage dominates. Figure 6 also shows that the magnitude of the impact error range is now dominated by that of the range estimated at the construction stage. This indicates, if the plant operates without flood pumping, the next greatest impact reductions depend on the decisions made at the construction stage.

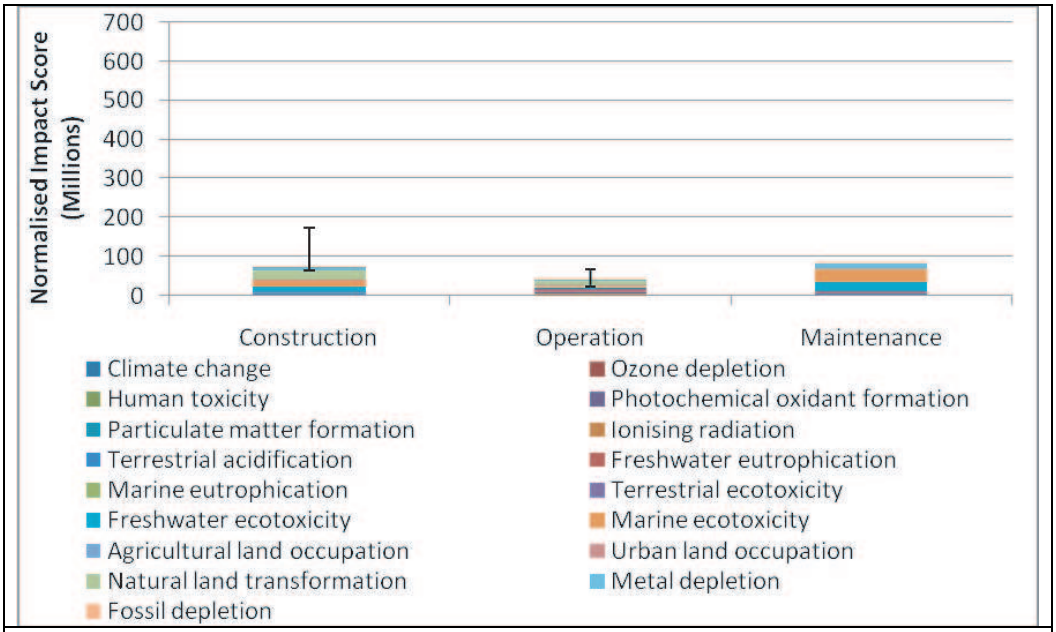


Figure 1 Normalised scores per life stage for the Severn barrage without 'flood pumping', including the possible range of scores

Figure 6 Normalised scores per life stage for the Severn barrage without "flood pumping", including the possible range of scores

1.7 LiFeCyCle Assessment Results interpretation: Power In Context

It was assumed that operating the Severn barrage in ebb generation mode only would reduce its average annual output to 16 TWh and, hence, its lifetime power output to 1920 TWh (Kelly, 2012). Table 6 presents the specific characterised impact results per impact catergory. As was the case for the overall lifetime results, the removal of flood pumping offers significant savings over the originally modeled operational mode.

Impact category	Unit	Severn barrage, exclusive of flood pumping	Error Range, 'Worst' to 'Best' case exclusive of flood pumping
Climate change	kg.CO2-eq/MWh(e)	11	14 - 6
Ozone depleᵽon	kg.CFC-11-eq/MWh(e)	0	0 - 0
Human toxicity	kg.1,4-DB-eq/MWh(e)	3	5 - 3
Photochemical oxidant formaᵽon	kg.NMVOC/MWh(e)	0	0 - 0
Parᵽculate matter formaᵽon	kg.PM10-eq/MWh(e)	0	0 - 0
Ionising radiaᵽon	kg.U235-eq/MWh(e)	3	3 - 4
Terrestrial acidiᵽcaᵽon	kg.SO2-eq/MWh(e)	0	0 - 0
Freshwater eutrophicaᵽon	kg.P-eq/MWh(e)	0	0 - 0
Marine eutrophicaᵽon	kg.N-eq/MWh(e)	0	0 - 0
Terrestrial ecotoxicity	kg.1,4-DB-eq/MWh(e)	0	0 - 0
Freshwater ecotoxicity	kg.1,4-DB-eq/MWh(e)	0	0 - 0
Marine ecotoxicity	kg.1,4-DB-eq/MWh(e)	0	0 - 0
Agricultural land occupaᵽon	m^2/MWh(e)	0	0 - 0
Urban land occupaᵽon	m^2/MWh(e)	0	0 - 0
Natural land transformaᵽon	m^2/MWh(e)	0	0 - 0
Water depleᵽon	m^3/MWh(e)	0	0 - 0
Metal depleᵽon	kg.Fe-eq/MWh(e)	9	9 - 9
Fossil depleᵽon	kg.oil-eq/MWh(e)	3	4 - 2

Table 1 Specific characterised results by impact category for the power generated by the bio gas fuelled CHP, using Midpoint (H European) Analysis (to the nearest whole unit)

Table 6 Specific characterised results by impact category for the power generated by the bio gas fuelled CHP, using Midpoint (H European) Analysis (to the nearest whole unit)

Figure 3 compares the specific normalized impact score of the Severn barrage, assuming ebb generation only, with that of the five representations of the UK National grid(Hammond, Howard, & Jones, The Energy and Environmental Implications of More Electric UK Transition Pathways: A Whole System Perspective, In Press). It has already been shown that the barrage could offer significant impact savings even when flood

pumping was employed, so it is not surprising that the removal of flood pumping just increases the magnitude of the savings available.

A further interesting observation can be made at this stage. When the operational impact is dominant, as is the case for ebb generation with flood pumping, increasing the operational lifetime of the plant would not significantly improve the specific impact as the overall impact would increase proportionally to the power output; however, if the "one off" activity of construction is the dominant contributor, as is estimated would be the case in the "worst" case scenario assuming ebb generation only, extending operational lifetime and hence lifetime power output would reduce specific impact and further increase the savings against the National Grid. If maintenance is the dominant contributor the effect on specific impact becomes more complicated as the maintenance regime that might be implemented after 120 years of life and its subsequent effect on power output is subject to a number of unknown, and arguably unknowable, variables.

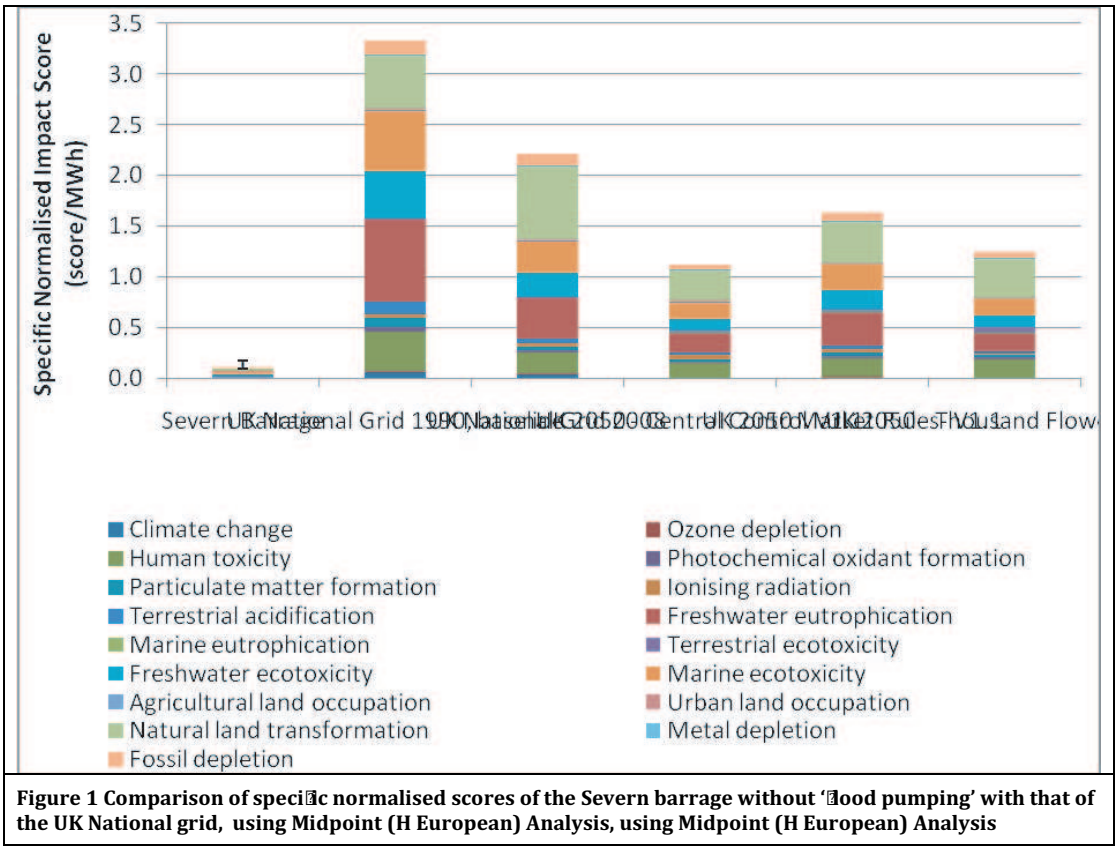


Figure 1 Comparison of specific normalised scores of the Severn barrage without 'flood pumping' with that of the UK National grid, using Midpoint (H European) Analysis, using Midpoint (H European) Analysis

Figure 7 Comparison of specific normalised scores of the Severn barrage without "flood pumping" with that of the UK National grid, using Midpoint (H European) Analysis, using Midpoint (H European) Analysis

1.8 Works Cited

Black & Veatch. (2007). *Research Report 3—Severn barrage proposals.* UK: Sustainable Development Commission.

Burger, B., & Bauer, C. (2007). *Teil XIII: Windkraft.* Switzerland: Paul Scherrer Institut Villigen, Swiss Centre for Life Cycle Inventories.

Goedkoop, M., & Spriensma, R. (1999). *Eco-indicator 99.* Netherlands: PRé Consultants.

Goedkoop, M., De Schryver, A., Heijungs, R., Huijbregts, M., van Zelm, R., & Struijs, J. (2008). *ReCiPe.* Netherlands: RIVM, CML, PRé Consultants, Radboud Universiteit Nijmegan and CE Delft.

Guinée, J. B. (2002). *Handbook on LCA.* Netherlands: CML, Universiteit Leiden.

Hammond, G., & Jones, C. (2010). *Whole System Appraisal Feedback v 1.1.* UK: Transition Pathways for a Low Carbon Economy Consortium Research.

Hammond, G., Howard, H., & Jones, C. (In Press). *The Energy and Environmental Implications of More Electric UK Transistion Pathways: A Whole System Perspective.* UK: Energy Policy.

Kelly, K. M. (2012). An Energy and Carbon Life Cycle Assessment of Tidal Power Case Study: the Proposed Cardiff-Weston Severn Barrage Scheme.

Roberts, F. (1982). *Energy Accounting of River Severn Power Schemes.* Applied Energy 11, pp 197–213.

Spevack, R., Jones, C., & Hammond, G. (2011). *Technical Assessment of Two Tidal Power Barrage Schemes Across the River Severn.* UK: University of Bath.

Woollcombe-Adams, C., Watson, M., & Shaw, T. (2009). *Severn Barrage tidal power project implications for carbon emissions.* UK: Water and Environment.

November 2012

Written evidence submitted by CH2M HILL (SEV33)

EXECUTIVE SUMMARY

Halcrow, a CH2M HILL company, has been heavily engaged in the Severn tidal power project for the past six years and prior to that played a lead role in design of the Second Severn Crossing. Our involvement in the Severn Barrage commenced as supporting the Severn Tidal Power Group in 2007 and subsequently as a founding member of Corlan Hafren Ltd (now Hafren Power Ltd) until July 2012 when it ended.

In this submission, we set out an independent perspective on the Cardiff-Weston barrage, which draws on our long experience with the project and our interaction with many of the key stakeholders.

The key messages we wish to convey in response to the questions posed include:

— A large renewable source of energy such as the tidal power of the Severn is a long-term national, regional and global asset both in terms of energy supply and carbon reduction. It is not appropriate to compare this to other forms of power generation on an "either/or" basis; the opportunity should be taken if it can be delivered in a sustainable manner.

— Flood impacts will be reduced upstream of a barrage, which will provide valuable protection (and future cost savings) against the effects of climate change. Localised elevated water levels should be expected seaward of a barrage and these may require additional flood risk management measures to be implemented.

— The impacts on designated habitat would be significant, as the inter-tidal area will reduce by a large margin. However, the remaining habitat may well be able to accommodate the demand from feeding birds as food density is expected to increase. The impacts on fish are difficult to determine in the absence of comprehensive baseline data.

— This project has the ability to reinforce the UK's ability to deliver large infrastructure projects, potentially in partnership with private funders and operators, when many sectors and geographies are struggling with the same issues. The benefits to the UK of making a mark in this field are substantial now and will reduce over time.

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

1. The UK energy mix is changing as we develop more wind capacity and look to replace coal, gas and nuclear facilities that are at the end of their life. At the same time, it should be expected that the demand profile through a daily cycle will both increase and flatten with the advent of smart energy distribution and increased electrification of domestic and commercial transport and heating. Challenges of intermittency, predictability of supply, consumer willingness to pay can all be addressed to some extent by incorporating a large tidal energy supply into our network.

2. The tidal resource of the Severn is globally significant and it would be remiss of the UK to not harness this sustainable source as long as it can be done in a way that enhances the regional environment and mitigates impacts on protected species.

3. The construction of a large Cardiff-Weston barrage will generate CO_2 through construction activities and embed carbon in the materials in the structure itself. However, such is the significance of generating electricity using tidal power, the scheme would be CO_2 neutral in less than three years (Severn Tidal Power Feasibility Study, DECC, October 2010) and actively reduce net CO_2 omissions for a century thereafter.

4. Any scheme on the Severn should not damage the future potential for energy extraction from the estuary. In other words, if small scale energy generation is planned as a stepping stone to build confidence in the technology and the ability to predict and manage environmental impacts, this must not limit the future potential for a larger scale, more efficient and hence more economic plant.

5. A barrage proposal has the potential to represent an economic alternative to offshore wind and offers a number of advantages including predictability and asset longevity (including very low generation costs once the initial capital outlay is paid off).

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

6. A barrage would play a key role in reducing flood risk and hence lowering the required expenditure on flood risk management for up to 400km^2 of tidal flood plains, and would be resilient to the effects of increased storminess and sea level rise.

7. The modification to the tidal rise and fall upstream of a barrage can be mitigated to an extent by optimisation of the operating mode, but will still require some engineering work to maintain drainage from low-lying land.

8. Closing the mouth of the estuary will result in elevated water levels locally in the Bristol Channel so, when storm surges coincide with high water events, flood risk could be increased in some areas. These effects are predictable and can be managed by appropriate flood risk management improvements and operational intervention.

9. We have carried out hydrodynamic modelling which has indicated that the following predictions can be made in relation to a Cardiff-Weston barrage:

- Maximum impacts due to a closed (fully impermeable) barrage agree with those predicted in DECC, 2010, with water levels increased by 500–600mm in Swansea Bay.
- The increase in high water level in Cardigan Bay due to an impermeable barrage is predicted as 50–100mm (compared to those presented in DECC, 2010 at 200–300mm). This is believed to be due to an improvement in model boundary set-up.
- By modelling a scheme in operation (i.e. a permeable barrage that represents sluice and turbine movements) the elevations in water level are much reduced with peak increases of 200–300mm predicted in Swansea Bay. The order of 10km of frontage would require improved sea defence measures as a consequence.
- Additional mitigation measures have been modelled and are effective in reducing the impact for local water level rises further.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

10. The habitat of the Severn estuary and certain species of birds and fish are protected species under the European Habitats Directive. The designation of the inter-tidal mudflats and migrating birds are closely related, as the former provides a source of food to the latter. The density of feeding birds on the Severn is almost the lowest for any UK estuary and is a function of the high loads of sediment in the water, which restricts light penetration and hence biological productivity is low. Further studies would determine whether the reduced turbidity associated with a barrage proposal would result in more productive mudflats and hence a bird density that is more in keeping with the remainder of the UK's west-coast estuaries.

11. Potential impacts on fish are difficult to predict in the absence of comprehensive baseline data. Previous studies have adopted an understandably conservative approach to the possible damage to both protected and commercially valuable fish stock. Areas of likely conservatism include the migration routes adopted, the number of passages past the site of a proposed barrage, the timing of passage relative to operating times for the turbines (these will not be permanently "on"), the impact that the lock system and possible fish passes could have on migration success and the depth at which fish tend to migrate (the turbines will be located in very deep water for maximum efficiency). It is expected that a more comprehensive study of fish habits, linked to precautionary mitigation measures to increase the opportunity for continued migration plus enhancement of nearby water courses and nurseries, would demonstrate rather more manageable effects on fish.

12. Our modelling has been used to assess the opportunity to modify the operation of a barrage such that the extent of productive inter-tidal mud-flats remains at a maximum or, in other words, to minimise the requirement for compensatory habitat under the EU Habitats Regulations. Some simple modifications to barrage operation and localised land raising with locally won material could reduce the compensatory habitat requirement by more than half from the ca 120km^2 identified in previous studies.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

13. The method of implementation of the tidal power barrage at La Rance involved cutting off the estuary from the sea for the duration of the construction phase. This had a rapid and significant impact on the estuary environment, which means that comparisons with the expected impacts on the natural environment in the Severn would not be meaningful. However, La Rance has been operating since 1965 with very limited maintenance requirement and provides a predictable and reliable source of energy, which (now that the initial capital costs of the project are "sunk") is some of the lowest cost energy in Europe. There are certainly operational lessons that can be learnt, including confidence around cost predictability in the long-term.

14. Halcrow has also undertaken studies on the effects of the Osterschelde barrier in Holland, which was constructed following the severe flood events of 1953. Experts from the Rijkswaterstaat have studied the

Osterschelde and some innovative schemes to raise land and create functioning mudflats have been implemented there. Such lessons will be of value to the consideration of the mitigation measures that might be adopted in the Severn, although different sediment characteristics may limit this.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

15. Halcrow has considered the direct, indirect and induced effects on employment for a Cardiff-Weston barrage, drawing on multiplier values from the South West England Regional Accounts as a proxy for the area local to the scheme.

16. The analysis is limited by its assumptions over the ability of the region to respond to the opportunities generated by such a large scale project and the proportion of goods and services that will be procured in the UK. With the majority of jobs falling in the caisson construction and ancillary works, a significant number of opportunities will require quite specific skills and experience in a number of white and blue collar sectors.

17. Jobs would be created in direct construction works, through the supply chain, via the induced effects on household spend, and later in Operations & Maintenance, tourism and the potential development of a renewable energy sector. Across these areas, more than 20,000 long term (sustaining for 10 years or more) jobs are possible as a result of a Cardiff-Weston barrage.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

18. A wide range of levelised costs have been proposed in relation to a Cardiff-Weston barrage, with figures ranging from £150 to £350/MWh. Much of the differential relates to the application of contingencies, including Optimism Bias. There is a tension between the application of Optimism Bias, which is used for developing a robust price estimate for the purposes of evaluating publicly funded projects, and what level of contingency should be included in a private sector investment opportunity. For private sector projects, where investor return is balanced against commercial risk, the promoter and funders will perform their own due diligence on cost and productivity estimates and contingencies will be applied accordingly.

19. It is important that costs of renewables are compared on a "level playing field." Such comparisons should consider the system level, to reflect the full cost to the consumer including the costs of grid connection, strengthening and distribution, as well as any mitigation measures required to balance predictable and unpredictable intermittency.

20. Investors might be expected to express interest in a Cardiff-Weston barrage if supported by a Contract for Difference (CFD) with a strike price set toward the lower part of the range set out in paragraph 18, subject to their own technical due diligence. Such a CFD might reasonably be expected to have a duration of 30–40 years to cover the period required to pay back the capital cost of the project.

21. Levelised costs for electricity for a barrage after the capital pay-back period should be competitive with gas, and significantly cheaper than gas with carbon capture and storage, given the low operation and maintenance (O&M) costs required for the barrage and the longevity of the structure.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

22. A low carbon energy project on this scale presents something of a dilemma as, on the one hand it represents a significant move to meeting the EU targets for carbon reduction, yet is also a large infrastructure project within an area that is protected under the EU Habitat Directives. Hence, the barrage sits at the nexus between two pieces of legislation that were both implemented to protect the natural environment yet which consider impacts at differing geographic and temporal scales.

23. Initial dialogue between Government Departments and EU officials in 2010 would form the basis of guidance on how to address the potential for the long term (and international) environmental benefits of a barrage solution to be seen to conflict with a shorter term perspective on environmental protection at a local/ regional scale.

24. It is possible that the tension between these objectives would be resolved by broadening the geographic scope for consideration of sites for compensatory habitat.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

25. A number of alternative proposals for extracting tidal energy from the Severn exist and their credibility is dependent on the time available for proposed implementation. Many projects are in the early stages of development and the technology on which they are founded remains conceptual.

26. Many proposals do not represent a sound financial business case in their present stage of development and some include flaws around buildability or basic economics.

27. A traditional barrage with tried and tested bulb turbine technology could be implemented relatively quickly and would provide the high degree of confidence that will be necessary to attract investors.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

28. There are a small number of other sites globally where the potential for significant tidal power can be found in an estuary with a relatively narrow shape, like the Severn, where this can be harnessed economically.

29. By delivering one of the largest projects of its type, British industry will be well-positioned to export the knowledge to other sites. Moreover, the demonstration of the ability to deliver large scale public infrastructure projects to time and budget, and in particular alongside private investors, will add to recent success stories in the UK.

30. The UK is currently at the forefront of wave and tidal renewable energy development and deployment. There are strong parallels with the offshore wind sector, where such an early position of strength was not retained by the UK through prompt and positive signals to industry and investors.

November 2012

Written evidence submitted by Natural England (SEV34)

1. Introduction

1.1 Natural England was established in 2006 as a non-departmental public body. Our purpose is to ensure that the natural environment is conserved, enhanced, and managed for the benefit of present and future generations.

1.2 We note that this inquiry is focussed specifically on the Cardiff-Weston barrage, the largest of the 5 schemes previously considered. Of the questions posed by the Committee, Natural England's response relates to 3 of these: the risks and opportunities to wildlife and habitat; the lessons from La Ranche scheme; and the relevance of EU regulation. Natural England contributed to the DECC 2010 Severn Tidal Power feasibility study.

1.3 Natural England recognises that climate change represents a serious long term threat to the natural environment because of the damage it will cause to ecosystems, and the benefits to society which they support. Increasing our use of renewable energy is one of the key steps to help reduce that threat, and these schemes can produce renewable energy on a large scale. However, our submission focuses on the impacts of the development itself on the natural environment, and we leave it to the Committee to consider these points in the broader context of the debate as a whole.

1.4 Natural England's evidence is drawn mainly from the impacts which were identified around the time of the 2010 study. We understand that new proposals may be forthcoming which involve different designs, in which case the impacts of these would need to be reconsidered. Natural England is not aware of any consultation on detailed proposals or design ideas since the 2010 study.

1.5 Natural England works actively with developers in all major infrastructure projects. We adopt a solutions-focussed approach which aims to facilitate needed development while ensuring that the natural environment is protected and where possible enhanced. We will be happy to engage with developers of this project to help them understand the requirements of the legislation and in assessing impacts.

2. Summary of Natural England's response

- A barrage proposal in the Severn Estuary, however designed, is likely to have a range of impacts on European designated sites within the estuary and in a wide geographic area beyond it, on important migratory and other fish species, and potentially on landscape character.
- DECC's 2010 study concluded that the ecological impacts of the proposal would be such that it would require compensatory habitat on an unprecedented scale. In addition, there seemed no convincing way at that time to mitigate the impacts on important migratory fish, including Atlantic salmon.
- Different designs may have different impacts so will need to be assessed. Natural England is not aware of any consultation on new detailed design plans since 2010.
- The developer's environmental assessment will need to be extremely rigorous, and consider potential impacts over a wide geographic scale.
- Lessons can be learned from other barrage schemes outside the UK but we urge caution against simplistic assumptions about similar environmental impacts, given that these schemes have very different geographical settings and environmental impacts.

3. Response to specific questions

3.1 *What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?*

We understand the Environment Agency is submitting evidence to this enquiry and have nothing to add to their evidence on this question.

3.2 *What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?*

Important habitats and species likely to be affected

3.2.1 The Severn Estuary has a number of important habitat features including 6–7% of the UK's intertidal mud and sand flat resource. These mud flats support internationally important populations of wintering and passage birds. In recognition of its importance the Severn is internationally designated as a EU Special Protection Area (for birds), RAMSAR (international wetland designation), and EU Special Area for Conservation (SAC) and UK Site of Special Scientific Interest (SSSI).

3.2.2 The Estuary supports important populations of migratory fish species including Salmon, Sea Trout, Twaite and Allis Shad, Sea and River Lamprey. These fish pass through the estuary on route to the Wye and Usk, both also designated as SACs in their own right. Salmon, Twaite Shad and Lamprey are primary reasons why these sites were selected for SAC designation.

3.2.3 The Severn is a hyper-tidal estuary system and has the second highest tidal range in the world. At Avonmouth there is a mean tidal range of 8.2m. The Severn is also important for its landscape and cultural interest. In particular the phenomenon of the Severn Bore is very well known.

3.2.4 Outside of the Severn estuary, there are also very important habitats that are likely to be affected by a barrage proposal. Principally these are Usk (in Wales) and Wye SACs which have very important migratory salmonid fish and eel populations.

Potential impacts on important habitats and species

3.2.5 Any tidal barrage proposal across the Severn Estuary is likely to have impacts on the internationally designated wildlife and habitat in and around the estuary. However, different designs and locations may have different impacts in terms of type and scale. Before such a proposal could proceed, these impacts would need to be carefully assessed in order to confirm the feasibility of providing appropriate mitigation or compensation. The 2010 feasibility study was characterised by the level of uncertainty that pervaded the environmental assessments.

3.2.6 The principal wildlife impacts which are likely and would need to be assessed include:

- Direct loss of inter-tidal habitat and consequent impacts on feeding areas for important bird species.
- Possible wider impacts on inter-tidal habitats in the estuary resulting from the loss of energy in the estuary system; and also possible impacts on sub-tidal habitats eg *Saballaria* reef.
- Impacts on important migratory fish species (seven SAC fish populations were predicted as at risk of extinction or collapse for a Cardiff-Weston scheme as proposed by the Government's 2010 study).

Impacts on fisheries and fish species:

3.2.7 The previous assessment of Severn Estuary tidal power options predicted that a Cardiff-Weston barrage would have significant negative effects on migratory and estuarine fish species, both upstream and downstream of any development, and in tributaries of the Severn itself. Predicted effects included reductions in abundance of sturgeon, eel and river and sea lamprey, to the extent of population collapse and local extinction for some (Twaite shad, genetically distinct local salmon populations). Many of these species are protected under European (e.g. Habitats Directive, Eels Regulations) or domestic legislation (Eels Regulations, Salmon and Freshwater Fisheries Act).

3.2.8 The previous assessment also noted that reductions in migratory species may have complex knock-on effects on ecosystems, and that tidal power development may also lead to reductions in freshwater fish species populations in the Severn catchment generally

3.2.9 Adverse effects could occur as a result of construction and operation, eg passage through turbines, disruptions to routes of passage, altered migratory cues, habitat change, degradation or loss, changes to water quality, or anthropogenic noise disturbance.

Ecological impact assessment

3.2.10 The environmental assessments required for this proposal will be complex, multi-faceted, and over a large scale. It will be a major exercise which would need to be allowed for fully in the project planning for any proposal. Note that the 2010 study highlighted that some of the relevant data was decades old.

3.2.11 Note also the proposal for Hinkley C nuclear power station at the outer reaches of the estuary; new proposals would need to assess any implications to or from that development, and also consider the proposed Marine Protected Areas in the region.

3.2.12 Uncertainty in modelling the hydraulic and geomorphological response of the estuary affects the certainty of any predictions on the impact on the Natura 2000 Network of sites. These effects could result in adverse effects on sites outside and distant from the Severn Estuary that are dependent upon sea water levels which would need to be assessed.

3.2.13 There may also be some opportunities for wildlife provided by a scheme; any such opportunities should be considered, but based on the 2010 evidence they are unlikely to be of a scale that would mean the net impact overall was positive.

3.3 *What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?*

The geography of the sites are very different, La Ranche being a Ria (rocky shore) environment. Other sites which were looked at in 2010 included the eastern Schelde (Europe) and Bay of Fundy (Canada). We would expect that an assessment supporting a Cardiff Weston proposal to be considerate of lessons learnt from similar projects elsewhere. However, we would caution against an assumption that projects that have worked in certain geographical situations will work in Cardiff-Weston.

3.4 *Are the proposals in breach of EU legislation, and if so how will this be addressed?*

3.4.1 The Severn Estuary is a European designated site so would be subject to tests within the EU Birds and Habitats Directives. Following a review in 2012, the UK government re-iterated its support for the objectives of the Directive. Essentially this Directive puts in place a structured process of rigorous ecological assessment and subsequent decision making.

3.4.2 Any tidal barrage across the Severn Estuary is likely to have impacts on the wildlife and habitat in and around the estuary. Consequently, any proposal would need to be able to show these impacts would not have an adverse effect on the ecological integrity of the estuary or that the impacts could be compensated for elsewhere to maintain the coherence of the wider network of European sites (the "Natura 2000" network).

3.4.3 It is not possible to judge at this stage whether any development would or would not be compliant with European legislation—this would require a robust assessment of the project at proposal stage, which cannot be undertaken until plans have reached a much more detailed stage.

3.4.4 Having carefully assessed potential impacts, the project will need to consider whether these can be mitigated. Our experience with the 2010 feasibility study was that some impacts might be partially mitigable, but there were significant remaining impacts on inter-tidal habitats, and very limited options in terms of mitigation measures for migratory fish. However, impacts may be different with a different design.

3.4.5 If the assessment conclusions were similar to the 2010 study, then for the project to comply with the Birds and Habitats Directives it would need to demonstrate (sequentially):

- First that there are no alternatives to the project with lesser environmental impacts;
- Secondly, that there are imperative reasons of overriding public interest (IROPI) for it going ahead;
- Thirdly, that there is an adequate compensation package (for the remaining loss of habitat etc)to ensure that the coherence of the Natura 2000 network is maintained. .

3.4.6 A key issue identified in the 2010 study was the significant challenges to the development of practically feasible and sufficient compensation i.e. the need for novel (not like for like) compensation and of a geographical scale unprecedented in this country.

November 2012

Written evidence submitted by RWE Npower Renewables Ltd (SEV36)

RWE Npower Renewables is one of the leading developers of onshore and offshore renewable technologies in the UK. Our existing portfolio includes onshore and offshore wind, hydropower and biomass projects. RWE Npower have thermal generation assets in England and Wales and as a group RWE is one of the largest inward investors into Wales.

RWE does not have any current involvement with the Cardiff-Weston Barrage proposal under consideration in this consultation. RWE through its operational assets would have a keen interest in the potential impact of any future energy generation within the Severn Estuary area. Potentially directly affected projects and operational assets include thermal generation (most notably at Aberthaw) and renewables both offshore (e.g. Atlantic Array) and onshore. Our overall concern is that the barrage is a significant infrastructure project which has been considered and rejected several times previously. The Corlan Hafren proposals are at an outline stage and therefore there are significant unknowns and uncertainties at present. We therefore consider that we do not

have the required detailed information to substantially comment on the viability and environmental and socio-economic impacts which could result from the proposals.

RWE Npower Renewables and its predecessor companies has been considering tidal range proposals tabled for the Severn Estuary since 2005. On this basis our initial considered responses are presented below.

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

Previous studies[30], most recently in 2010, suggest the at the Cardiff-Weston Barrage could have a capacity of 8.6GW generating approximately 16.5 TWh/yr or 5% of current UK electricity consumption. However, the direct and indirect impacts of the Cardiff Weston Barrage on existing power generation and transmission require careful consideration. A scheme of this size would have requirements for major changes to grid and other infrastructure.

We are concerned that through Levy Control Framework the substantial size of this one scheme and its requirement for government support mechanisms could significantly offset the development of other established renewable generation technologies. Therefore, the direct investment benefit from this scheme is not as attractive as first presented. A spread of investment in a number of proven technologies, projects and development companies presents a lower risk profile and cheaper option to the UK.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

The Severn Barrage if appropriately designed and operated could be used to provide flood protection from tidal surges and sea-level rise for properties upstream from the Barrage although the future benefits from this would require detailed modelling and evaluation. However, conversely the barrage does have the potential to exacerbate existing flooding in some upstream areas within the lower Severn region. Therefore, this is currently a significant area of uncertainty with the proposals.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

Risks and opportunities to wildlife and habitat would need to be quantified through the Environmental Impact Assessment. We are concerned that the size of this scheme could result in unacceptable environmental impacts requiring significant derogation to European Directives despite the initial mitigation outlined by the Corlan Hafren proposals of lower velocity ("fish friendly") turbines and reduced permanently flooded area.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

No Response.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

The project would require substantial local employment. However, there could be distributional consequences of a future scheme on industry within the Severn Region. For example, the potential for detrimental impacts on Bristol Ports and other industries upstream from a barrage need detailed consideration. Port impacts could include changes to water level regime and access; siltation and dredging requirements and delay and cost to pass through barrage locks.

The significant material requirements for the scheme are likely to exceed local resources requiring imports to the area, potentially from overseas supplier sources.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

Yes, the project is likely to require significant support under the CfD mechanism. DECC's own feasibility report[31] in October 2010 suggested that the levelised cost of electricity from the Cardiff Weston scheme on the basis of a 10% cost of capital is around £300/MWh (page 7 in the report). A revised economic assessment is not available from Corlan Hafren but unless the new proposals are a significant capex reduction from the previous estimates this does suggest that such a strike price may be difficult to justify for consumer affordability against future benchmarks for alternate low carbon technologies of ~£100/MWh and government's aspiration to move to technology neutral auctions.

[30] SDC, 2007. Tidal Power in the UK Research Report 3—Review of Severn Barrage Proposals

[31] http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/severn-tp/621-severn-tidal-power-feasibility-study-conclusions-a.pdf

How does the company plan to engage and consult the community in the development of the project?

No Response.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

No Response.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

There have been several proposals for tidal power projects in the Severn Estuary previously proposed some of which remain currently under consideration. We are concerned about the impact of the Cardiff-Weston Barrage (as one of the larger schemes) could negate the development of other smaller proposals which are more cost effective with potentially lower impact on the environment. For example, we believe a coastally attached lagoon approach at ~1GW capacity may provide a better initial value for money with significantly lower capital cost. RWE would wish all viable options for tidal range within the Severn Estuary to be evaluated and are not committed to any project at this stage.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

Investment in the Severn Barrage could divert investment away from other renewable technologies within which the UK has a substantial international role. The number of suitable international sites for tidal barrages are limited and all would require significant national government funding. It is considered that export opportunities could be limited.

November 2012

Written evidence submitted by The Crown Estate (SEV37)

The Cardiff-Weston Barrage could make a significance contribution to a secure low carbon energy sector here in the UK and The Crown Estate welcomes the opportunity to provide written evidence for the Energy and Climate Change Committee's (ECCC) inquiry.

We do not intend to respond formally to the specific questions posed in your terms of reference, but feel it would assist the committee in their deliberations if we set out details of our role in the development of offshore renewable energy to date. We hope that this information will provide you with useful background on this organisation's track record in facilitating sustainable development and seabed leasing for similar projects.

- The Crown Estate is commenting from its unique position as steward of the UK marine estate which includes over half of the UK's foreshore and the vast majority of the seabed out to the territorial 12 nautical mile limit, with vested rights for the development of renewable energy in the UK Continental Shelf.
- Since 2000 The Crown Estate has undertaken and continues to undertake leasing activities for offshore wind, wave and tidal stream renewables in support of government policy to decarbonise the UK's electricity generation, assist in meeting the UK's binding EU 2020 targets and develop the UK low carbon industries.
- Appendix 1, Table 1 and 2 sets out the current situation with leasing round for OffShore Wind, Wave and Tidal Stream energy. This has seen the UK become a world leader in the development of offshore electric energy generation with The Crown Estate acting as programme manager.
- In addition, The Crown Estate has sought to de-risk and accelerate the energy programmes on our estate through a wide range of enabling actions projects such as collecting survey data to support consent applications and carrying out analysis supporting cost reduction. We are also working with developers and key stakeholders to overcome challenges in five strategic workstreams: health and safety; planning and consenting; supply chain and skills; technology and transmission; project finance and economics.
- The Crown Estate has developed the award winning Marine Resource System (MaRS): MaRS is a decision support system based on GIS (Geographical Information system) technology. MaRS is one of the key tools to help plan and manage our portfolio and optimise use of the seabed. We developed MaRS to help support the sustainable management and development of the marine estate.
- The Crown Estate works with a wide range of stakeholders in the Severn Estuary including the port and marine aggregate sectors. In particular it is clear that a barrage would require the ports and marine aggregate business to adjust their operational practices. The impacts on these businesses should form a key component of any further assessment and The Crown Estate can provide evidence to assist any study. Moreover, The Crown Estate also recognises the prominent role we could play in facilitating engagement with a broad range of stakeholders on any tidal range option selected for the Severn Estuary.

— In terms of tidal range, we are currently aware of two potential tidal range schemes at an early stage of their development, lying in Welsh waters in the Bristol Channel. These proposals do not spatially conflict with any possible barrage route in the Severn Estuary lying as far west as a Lavernock Point—Brean Down route. In addition, historically there has been interest in a coastally attached tidal lagoon in Bridgwater Bay which is not being progressed at present and there is also an existing tidal stream interest at Lynmouth.

— The combination of landlord of the UK seabed and programme manager for the UK offshore energy programmes gives The Crown Estate a unique enabling role in any tidal range project that could be brought forward. If government policy was to develop in favour of a tidal range such as the Cardiff-Weston Barrage proposal, we would be able to draw on our expertise to support government in delivering this or any other tidal range project.

— The Crown Estate owns the land on either side of the estuary and the entire route involved in the proposed barrage's construction, and consequently further work would be required to understand in full any competition/procurement compliance requirements.

We trust that you will find these comments constructive and of relevance to the inquiry to the Cardiff-Weston Barrage. We would be very willing to provide additional information on any of the points we have raised or discuss these matters with you further.

The contents of this letter may be put into the public domain and there is no part of it that should be treated as confidential.

Appendix 1

TABLE 1
OFFSHORE WIND

Round	*Launched*	*Number of sites*	*Current Status*
Round 1	2001	13	1 in construction (62MW) 12 operational (1112MW)
Round 2	2003	17	0 in pre planning 1 in planning (1200MW) 6 are consented (2235MW) 4 in construction (1793MW) 5 operational (1235MW) 1 did not receive planning consent
Round 3	2008	9 Zones	7 zones (29.7GW) in pre planning 2 zones (5 projects, 2.5GW) in planning 0 are under construction 0 are operational
Scottish Territorial Waters	2008	5	3 in pre planning (3395MW) 2 in planning (1370MW) 0 are under construction 0 are operational
Round 1 and 2 Extension projects	2009	4	2 in pre planning (974MW) 2 in planning (555MW) 0 are under construction 0 are operational
Demonstration	2009	4	1 in pre planning (12MW) 2 in planning (99MW & 77MW) 1 in construction (12MW) 2 are operational (14MW, Blyth and Beatrice, not leased by TCE)
Northern Ireland	2012	1	1 in pre planning (600MW)

TABLE 2
WAVE AND TIDAL STREAM

Round	*Launched*	*Number of sites*	*Current Status*
Pentland Firth and Orkney Waters	2008	11	1200MW in pre planning 400MW in planning
Demonstration (pre Application Window)	Pre 2010	13	8MW in pre planning 21.2MW in planning 21.7MW in operation
Demonstration (Application Window 1–3)	2010	14	65.1MW in pre planning 70.7MW in planning
Northern Ireland	2012	2	200MW in pre planning

November 2012

Written evidence submitted by the Countryside Council for Wales (SEV39)

1. CCW response to the above inquiry dated 30 October 2012.

2. In discharging its functions under Section 130 of the Environmental Protection Act 1990 the Countryside Council for Wales (CCW) champions the environment and landscapes of Wales and its coastal waters as sources of natural and cultural riches as a foundation for economic and social activity, and as a place for leisure and learning opportunities. CCW aims to make the environment a valued part of everyone's life in Wales.

3. As the Government's statutory advisor on sustaining natural beauty, wildlife and the opportunity for outdoor enjoyment in Wales and its inshore waters we have worked with other statutory advisors like Natural England and the Environment Agency to advise DECC, the Welsh Government and DEFRA during the Severn Tidal Power Feasibility Study (STPFS).

4. CCW provided a significant amount of environmental data to contribute to the evidence base. We also provided scientific advice to the STPFS team on the habitats, species and landscapes that could be affected by the short-listed options for harnessing the tidal energy of the Severn Estuary. We seconded a member of staff to support the work within the Severn Tidal Power team at DECC for two years as well as contributing our organisation's expertise and advice to the project board and the various steering and working groups for the study. Our overall aim in doing this was to ensure that Governments could make their decisions on the feasibility of generating energy in the Severn Estuary based on the best evidence available, taking full account of the natural heritage of the Severn, its tributaries, and environmental commitments set out in legislation.

Main Points

5. The STPFS compiled a detailed assessment of the environmental, economic, engineering, energy generation, social and legislative aspects of developing a large scale tidal energy scheme in the Severn estuary. It also highlighted significant gaps and uncertainty in information or data. These reflect many of the gaps in understanding identified in previous feasibility studies in the 1980s and early 1990s. It is our view that prior to any scheme applying for planning consent the data and information gaps identified in the STPFS need to be addressed; these are as follows:

(a). investigating how migratory fish species use and move within the Severn estuary and its tributaries and what specific habitats they depend upon;

(b). improving understanding of the relationship between the Severn estuary and the birds that depend on it. In particular the densities of the marine invertebrates that birds rely upon for their food and differences in the results from two models (habitat association modelling and individual based models) used to investigate this relationship;

(c). a bathymetric survey of the estuary and detailed study of sediment distribution and transport; and

(d). the effectiveness of novel mitigation measures, especially on a large scale, including topographic modification, habitat creation and fish translocation proposed to reduce impacts.

6. The STPFS concluded that many years of further detailed work would be needed to plan, finance, and assess the impacts of such a large structure as a Severn power scheme before a case could be put forward for planning consent. Even over a period of two years the study was only able to consider feasibility and impact at a strategic level. If consented, the construction times would be between four and nine years depending on the scheme. In addition, any of the schemes would first require new habitats to be created, or species re-introduced, to replace those that would be displaced; these habitats and measures require time to be effective.

7. These investigations would take a number of years and given the significant lead in time we believe it is crucial that this requirement is promoted early. Addressing these data gaps would allow greater certainty in any future assessment, in the design process, understanding of environmental impact and effectiveness of mitigation measures. These significant uncertainties and data gaps are not development specific but are fundamental gaps in our knowledge of the estuary functions.

Our response focuses on the questions most relevant to our remit; specific comments are as follows:

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

ORNITHOLOGY

8. The Severn Estuary is protected by multiple designations: a Special Protection Area (SPA), Special Area of Conservation (SAC), Ramsar site and Special Site of Scientific Interest (SSSI), particularly for its value as a cold winter refuge and as important feeding and resting grounds for migrating waterbirds. The STPFS baseline for the Severn estuary reported 72,909 waterbirds. The Severn Estuary is a vital resource for UK and international populations of waterfowl, particularly in cold winters where birds are forced from the east coast to take refuge in the warmer west. The feeding and resting grounds of the Severn Estuary then act as a lifeline to these national and international populations.

9. Taking the STPFS Cardiff-Weston barrage as proxy for a new proposal the change in tidal regime would result in a significant reduction of feeding and resting habitat with likely detrimental impacts on populations. The STPFS reported that compensation would be very challenging and require land change within the Severn Estuary and at sites further afield. Compensation at distance raised issues of compliance with the Habitats Directive, whether this would be sufficient to maintain the coherence of the network in addition to whether the proposed compensation was like-for-like.

10. In accordance with the Habitats and Birds Directives the STPFS gathered some of the information required for a strategic level Habitats Regulations Assessment (HRA) for each of the schemes. This was termed a "shadow" HRA as the process produced "Reports to Inform a HRA" rather than conducting an official HRA. These reports assessed the potential impact of the tidal power options on any site designated as a Special Protection Area (SPA) or Special Area of Conservation (SAC); in line with Government policy this was also extended to include Wetlands of International Importance (Ramsar sites).

11. The shadow HRA concluded changes to or loss of access to the intertidal or saltmarsh habitat would be likely to have an adverse affect on the waterbird species of the Severn Estuary. In addition, waterbirds would also likely be negatively affected during construction and decommissioning phases by disturbance effects.

12. The STPFS concluded for a large barrage that 30 waterbird species would experience significant declines. Likely significant effects or reduction in populations between 20% and 48% were identified for the six waterbird features of the SPA following Habitat Association Modelling (HAM); species within the waterbird assemblage incurred average population reductions of 47% under the HAM. This would incur a compensation requirement for approximately 34,000 birds.

FISHERIES

13. Baseline data for fish that inhabit or transit through the Severn Estuary is poor, this would create significant uncertainty for an impact assessment of any new scheme that has not first obtained this data. Over 100 species have been recorded in the estuary but data informing their abundance, distribution and residence time is yet to be adequately recorded; until this data is available any assessment of scale of impact or efficacy of mitigation or compensation measures will likely be insufficient to inform a Habitats Directive assessment.

14. The STPFS concluded that fish populations designated as features of the Severn Estuary Mor Hafren SAC, River Usk Afon Wysg SAC, River Wye Afon Gwy SAC and potentially the River Tywi Afon Tywi SAC, could be adversely affected by a tidal barrage. Impacts would result from alteration to migratory cues and disruption to route of passage, including injury and death from passage through turbines and sluices and the barrier presented by the structure may prevent migration and/or reduce the frequency of successful migration and spawning. The same fish populations would also be affected by habitat change and/or loss, habitat fragmentation, changes to water quality and anthropogenic noise disturbance. These impacts may be compounded under an in-combination assessment.

15. The shadow HRA reported a significant adverse effect on fish populations; including the migratory SAC features: sea lamprey, river lamprey and twaite shad and Ramsar site migratory fish assemblage features including: allis shad, Atlantic salmon, sea trout and European eel and other marine, estuarine and freshwater species. The assessment notes the limitations of current baseline data and ecological understanding. Distribution and behaviour of fish throughout the estuary and beyond was a key area of uncertainty introduced to fish impact modelling. Without this information the assessment could not accurately predict the number of times individuals may pass a barrage to calculate the associated risk from turbines and sluices on populations. Any impact assessment for a scheme conducted without such data would incur considerable uncertainty and would risk failing a HRA.

16. For a large barrage the STPFS concluded that the three SAC fish features: river lamprey, sea lamprey and twaite shad would experience population reductions of 28%, 35% and 100% respectively; relating to approximately eight million individuals. This highlights the risk of whole UK stock extinction for twaite shad, and by association, allis shad; these are currently protected features of the Severn Estuary Mor Hafren SAC, River Usk Afon Wysg SAC, River Wye Afon Gwy SAC and the River Tywi Afon Tywi SAC.

17. Of the migratory fish assemblage, population reductions were calculated at 24% for adult salmon, a 16% reduction in the eel population and an unknown impact on sea trout. For Atlantic salmon this would mean potential for river specific population collapse and effective extinction of genetically distinct salmon populations.

18. Potential adverse affects on fish populations of SACs beyond the Severn estuary were identified but knowledge limitations prevented reliable assessment; this knowledge gap would need to be addressed prior to any HRA.

Designated Habitat

19. The altered dynamic of an impounded estuary would significantly affect the proportion of intertidal and subtidal habitat,. The STPFS reported a pre-mitigation compensation requirement of around 15,000 hectares for various intertidal habitats, which are protected in their own right but on which many other protected features depend; it also reported a 40% to 50% loss relative to the baseline following mitigation. Several mitigation measures were proposed to redress residual impacts on an unprecedented scale for the UK; the efficacy of such measures would need to be established by any new proposal. Uncertainty also exists as to whether intertidal habitat created for saltmarsh creation would actually deliver saltmarsh habitat, the quality of this habitat would also need to at least replicate the value of lost habitat.

20. Baseline data for a number of subtidal habitats also generated uncertainty in the STPFS. The distribution of such habitats is either poorly understood, such as seagrass habitat, or is dynamic in nature such as *Sabellaria* reef distribution and abundance which changes annually. These inadequacies would have to be rectified prior to any assessment of effects and would require a number of years of survey data.

Other Protected Features

21. The STPFS identified indirect effects following reduction of migratory fish populations; potential adverse affects on otter, a feature of the River Usk Afon Wysg SAC and River Wye Afon Gwy SAC, and freshwater pearl mussel at distant SACs from the reduction of salmonid hosts required to complete their life cycle.

22. The STPFS only considered impact, mitigation and compensation for primary features; any new scheme would be required to consider all designated features.

Hydraulics & Geomorphology

23. The Severn estuary is a unique hyper-tidal system, defined by having a tidal range exceeding six metres, and is designated in part for its characteristic extreme nature and harsh environment, these qualities would be lost under a large barrage scheme; mitigation and compensation for these qualities would be challenging to deliver within the requirements of the Habitats Directive. The overall estuary extent would also reduce and would equally require compensation for any residual change representing a further challenge to compensation.

24. Reduction of tidal range within the impounded part of the Severn estuary would lead to a change in the characteristic form and function of the designated estuary and intertidal habitat. Decreased flows and flow speeds incurred by a barrage would reduce the suspended sediment concentration within the impounded area and downstream leading to further changes in the estuary extent and composition of intertidal and subtidal habitat features of the Severn Estuary. Changes to the estuary's form and function would continue until an equilibrium is established, potentially on a decadal scale, following construction of a barrage; these changes remain a challenge to predict especially without accurate bathymetric and sediment transport baseline data for the estuary and beyond. These changes represent modification to SAC features and will influence the habitat availability for protected features.

25. Predicted changes in water levels and changes to the sediment transport regime beyond the Severn estuary would lead to uncertain effects on the designated intertidal and coastal habitats of the Carmarthen Bay and Estuaries Bae Caerfyrddin ac Aberoedd SAC and the Kenfig Cynffig SAC increasing the compensation requirement of a project.

26. Distant effects were identified by computer modelling and predicted increases in spring high tide levels of up to 30cm along parts of the west of Wales, as far north as the Lleyn Peninsular and along the north Devon coast; 10cm increases were predicted off parts of the east coast of Ireland. Results of the far-field water level modelling also imply adverse effects could be experienced by features of the Dyfi Estuary Aber Dyfi SPA and the Cors Fochno and Dyfi Ramsar sites; these sites would potentially require compensation.

27. Any potential scheme would require similar computer modelling but must incorporate recommendations from the STPFS; including: an extended far-field boundary since effects may reach farther than identified in the STPFS model, detailed baseline bathymetric and sediment transport data to incorporate into the new model and increased resolution at distance from the Severn Estuary.

What lessons can be learnt from the successful development of La Rance tidal barrage in France and other tidal power projects?

28. The La Rance tidal barrage was built in the 1960s in a non-designated location with substantially different geomorphology; as such only limited comparisons may be drawn. Lessons learnt from La Rance acknowledge that there was a loss of marine flora and fauna during construction resulting from salinity fluctuations, heavy sedimentation and accumulation of organic matter within the impoundment. Following a ten year equilibrium period certain fish species had disappeared whilst others accommodated the change; sandbanks also disappeared following construction.

29. Comparison with other tidal barrage schemes will ultimately be dependent upon the technology used, the environmental sensitivity of each site and the local geomorphology and hydrology. Some effects may be roughly comparable but it is important each scheme must be assessed on its individual characteristics.

30. Certain hydraulic and geomorphological changes are likely regardless of scheme design; typically changes to: water levels locally and at distance, the tidal curve, tidal flows, wave heights, suspended sediment concentrations, sand transport and short and long-term changes to estuary morphology. Each of these likely to directly or indirectly affect protected features.

Are the proposals in breach of EU legislation, and if so how can this be addressed?

31. The risk of breaching EU legislation cannot be assessed without full details of a project; however, the STPFS concluded that any tidal barrage proposal would be likely to have a significant effect on a number of European sites. To avoid breaching the Habitats (and Birds) Directives and subsequent infraction proceedings a project must demonstrate through iterative design that it will effectively mitigate any negative effects through prevention, reduction and avoidance measures. Through appropriate assessment of the conservation objectives the project must demonstrate it will not adversely affect the integrity of the European site(s) alone or in-combination with other projects.

32. Where an appropriate assessment concludes a negative assessment the project must demonstrate there are no alternatives and demonstrate that the project must be carried out for imperative reasons of overriding public interest (IROPI). Only if these requirements are met can compensation measures be considered.

33. The STPFS concluded that there was a risk of breaching the Habitats Directive through construction of a barrage. The study reported considerable uncertainty in the predicted scale of impact, owing to the dearth of baseline data across a range of species and habitats, and uncertainty in effectiveness of mitigation and feasibility of novel approaches to compensation.

34. The key requirement for any new project would be to address the lack of baseline data for species and habitats that may be affected by a new proposal; this may require data collection over a number of years. The project promoter must provide the competent authority with information sufficient for an appropriate assessment, inclusive of details of mitigation, and later compensation measures, adequate to reduce uncertainty.

35. The challenge to any proposal is developing effective mitigation measures and subsequently accurately predicting the efficacy of such measures to calculate any required compensation. The study concluded that compensation for the loss of intertidal habitat could not be delivered within, or near to, the Severn Estuary. Compensation at distance was considered a potential infraction risk, as was non-like-for-like compensation with regard to potential UK stock extinction of shad with compensation benefiting alternative species.

36. Other EU legislation that would require compliance would be: the Water Framework Directive, Marine Strategy Framework Directive and various regulations such as Council Regulation (EC) No 1100/2007 Establishing Measures for the Recovery of the Stock of European Eel. This latter regulation would also require assessment of non-SAC rivers such as the River Severn which maintains an important eel population.

What risks and opportunities could it pose with regard to flooding in the Severn Estuary, and how might any risks be mitigated?

37. Current flood protection measures would be significantly undermined by creation of a barrage without considerable mitigation; despite this a barrage would offer protection from tidal storm surge within the estuary. Extensive tidal defences currently protect property, infrastructure and agricultural land including 90,000 properties and commercial assets. These defences may be undermined through the creation of a barrage.

38. The STPFS concluded that a barrage could protect from tidal storm surges but areas upstream of a barrage would be at risk from water being held back for longer. Holding this water in the estuary for longer would reduce drainage off adjacent land increasing the risk of flooding; extensive mitigation would be required to address this. Increased duration of higher tides and concomitant erosion of tidal defences may necessitate significant upgrading of current defences.

39. Water level increases predicted at distance from the Severn estuary along the Welsh, English and Irish coasts of up to 30cm would have to be addressed; effects may potentially extend beyond these regions due to inadequacies in the modelling.

November 2012

Written evidence submitted by the Devon and Severn Inshore Fisheries and Conservation Authority (SEV40)

The Devon and Severn IFCA welcome the opportunity to provide written evidence to the Energy and Climate Change Committee. As the lead regulator for marine fish species out to six nautical miles we are responsible for ensuring the long term sustainability of both commercial and recreational angling within the river Severn.

Much has been written concerning the potential impact of a Severn Barrage and we would wish to refer you to both the Frontier Economics and the Atkins reports.

This IFCA supports the need to generate renewable energy and recognises the potential of tidal power. It is important that such schemes are developed in appropriate locations where impacts can be managed and mitigated.

The Severn estuary is arguably the most important estuary system in Europe and this is recognised through the myriad of designations it holds, most notably under Habitats Directive. In addition it is important to understand that it also feeds to further Special Areas of Conservation—the River Usk and the River Wye. Therefore any change within the Severn Estuary has the potential to impact upon three designated sites.

The role of the IFCA is to manage fisheries within the Severn and conservation; this response therefore focuses on these elements and how they will be impacted by a Severn Barrage and does not consider questions that are outside its remit.

The Severn Estuary supports over one hundred species of fish. The estuary is designated as important for its small fish assemblages. It is a nursery ground for a wide range of commercially important species including bass, pollock, sole, flounder and mullet. The construction of a barrage would irreversibly alter the tidal regime, sediment loading and transport, geomorphology and salinity of the feeding grounds. As the nursery for so many species this could jeopardise the viability of both commercial fishing and recreational angling in the area to the detriment of the local economy and tourism industry.

The turbines that form part of the barrage are known to kill and injure fish that pass through them. This reduces the number of mature breeding fish stocks and also increases the risk of disease transmission through damage to the fish.

The Severn, Usk and Wye are designated for their migratory species. These fish rely on both fresh and salt water habitats to fulfil their life cycles. The Allis and twaite shad are both anadromous species. These fish are only found in four rivers in the UK—the Severn, Usk and Wye and the Solway in Scotland. Both species are protected and UK and European law.

The report by the Sustainable Development Commission indicated that a barrage would result in the extinction of both species of shad in the Severn estuary as well as the Atlantic salmon.

The Severn is known for its migratory salmon, sea trout and eels, all of which are commercially important. The barrage would act as a barrier to migration and reduce the size of the populations and putting into question the long term viability of these species for commercial exploitation.

Under the Marine and Coastal Access Act the IFCA must consider the economic and social impacts within a fishery. Within the barrage proposals much is made of the economic development opportunities this would afford however these assessments do not factor in the job losses that would arise from the fishing and tourism sectors. The impacts on Recreational Sea Angling are also not fully recognised within this work.

The Severn's intertidal mudflats are used by some 69000 over-wintering birds. The creation of the barrage would permanently submerge 14,000 hectares of mudflat. Under Habitats Directive the UK government is required to provide an equivalent area of compensatory habitat to mitigate for the loss on the Severn. We fail to see how this can be achieved.

This IFCA believes that the environmental impact of the barrage is disproportionate to the power generation potential. Barrages are twentieth century technology. Tidal power technology is developed apace and with the lead time to build such a structure the barrage will be obsolete by completion. Alternative tidal power proposals have been made, most notably the Evans Engineering tidal reef. Whilst noting that this generates less energy the trade-off is that the environmental impact would be negligible. These schemes should be considered in preference to the barrage proposed.

November 2012

Written evidence submitted by South West TUC (SEV41)

The South West TUC is the voice of the West Country at work. With unions representing more than 500,000 working people in the region, from all industries and occupations, we campaign for a fair deal at work, for social justice at home and abroad, and for a fair and just transition to a low carbon future. The TUC supports balanced energy mix of low carbon, secure and affordable energy, including investment in large and small scale renewables. The tidal power of the Severn Estuary, if appropriately harnessed, could make a major long-term contribution to the UK's renewable energy strategy.

- It is important that the economic and environmental impacts of any potential barrage project—or indeed any scheme to harness the potential renewable energy opportunities of the Bristol Channel—are properly evidenced. This evidence should be robust, independently and publically available at the earliest opportunity to allow stakeholders and the wider community to assess the potential benefits and costs of any scheme. The scheme—and indeed any scheme on this scale—should aim to provide credible independently-validated estimates of the employment, skills and economic benefits.
- There is clearly concern about the impact of the proposals on employment in Bristol Channel. Hafren have indicated that they believe the proposal will not have a negative impact on the Port. It is important that Hafren set out in detail how they believe the barrage can be delivered in a way that does not impact negatively on the Port/employment in the Port.
- It is important that Hafren's proposal—and indeed any scheme which sets out to harness the potential renewable energy potential of the Bristol Channel—sets out in detail how they will ensure that their investment has the maximum potential impact in terms of creating and securing high quality employment; building the skills base in South Wales and the South West of England; and maximises procurement and supply chain opportunities for UK based firms and employment.
- There are clearly different views on the potential benefits and impacts of the barrage scheme on both sides of the Bristol Channel—it is therefore important that robust consultation processes are put in place in both Wales and South West England at every stage of the project.

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

The tidal power in the Severn Estuary, if harnessed, could make a big contribution to UK energy needs. The debate should not be whether or not to support renewable tidal generators but whether to opt for a single large barrage or for a mixture of alternative technologies such as tidal stream, lagoons and tidal reef.

The government feasibility study calculated the large barrage at 8.64 GW and lagoons at 1.36 GW each.

The bi-directional turbine concept plan by Atkins/Rolls Royce (not considered by the Severn Tidal study) claimed that a tidal barrage could generate up to 21 TWh/year. Tidal Electric, one of the companies seeking to build tidal lagoons claims potential output at 32.9 TWh/year compared to the large ebb-only barrage at 16.8 TWh/year. Other estimates have put the potential generation using a mixture of renewable technologies at around 60% of a large barrage.

Details of the latest large barrage proposal have not been released. It differs from the one considered by the Severn Tidal Power Study in that it will be designed to generate electricity on both ebb and flow tides, based on the Atkins/Rolls Royce concept ideas. The plans include up to 1,200 turbines apparently turning at speeds slow enough for fish to pass through.

Government has a responsibility to develop a comprehensive strategy to utilise the tidal power of estuary and balance the environmental, economic and social impacts. It may be that a mixture of tidal stream, reef and lagoon options is preferred option to a large barrage but it is unlikely that these can co-exist.

The iconic status of the large barrage captures imagination and media headlines but its size and scale will mean many years of planning and legal challenges. Such a project holds out the opportunity of considerable supply chain benefits especially if the innovative turbines were to be manufactured in the area.

Alternative renewable technologies, however, are on a more manageable scale and could be built and deployed much quicker, possibly creating more jobs and driving a range of innovative technologies. On-going consideration of a large barrage will deter investment in other projects and inevitably delay deployment of any devices.

The large barrage option could not be planned and built in time to meet climate change targets for 2020.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

A large barrage would be able to hold back incoming high tides and be used in flood-prevention but it would impede out-flowing fluvial waters and raise sea levels outside the barrage. Any proposal demands a thorough independent study to assess the impacts.

The Severn Tidal Power Study found that "The large barrage option would raise the high tides downstream of the structure. "A Cardiff-Weston barrage is likely to have the greatest impact with a predicted increase in

high tide levels on the largest Spring tides of up to 30cm along parts of the West Coast of Wales, as far north as the Llŷn Peninsula and along the North Devon coastline, and of up to 10cm off parts of the East coast of the Republic of Ireland."

The idea that the turbines could be turned into pumps was not taken into account by the previous study and this warrants more independent assessment.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

The full impact on the complex and shifting sand will need considerable research. Academic studies calculate that the loss of habitat from a large barrage, that would need at least 100% compensation under EU Directives, would be 14,000–20,000ha of mud flats and salt marsh. Atkins/Rolls Royce believe their concept design could significantly reduce the habitat loss to less than 6,000ha. This has not been independently assessed. It would be a considerable challenge to find sufficient compensatory land to meet the requirements of EU legislation.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

The RSPB published a report as part of its contribution to the Severn Tidal Power study on the lessons to be learnt from the Eastern Sceldt storm surge barrier in the Netherlands. The report highlights the significant and ongoing erosion of inter-tidal habitats leading to a "catastrophic decline in internationally important bird populations". The RSPB suggested that the Eastern Sceldt barrier was a better comparator than the La Rance barrage although noted that the Eastern Scheldt is less than two thirds of the size of the Severn.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

The opportunities for employment creation during the construction phases would be considerable. This would be magnified given an effective strategy for the development of a local supply chain including turbine and caisson manufacture.

There are considerable risks after construction, however and we agree with the Severn Tidal Power Study that found that:

> "The ports in the Severn estuary handle a significant proportion of UK trade and support a large number of regional jobs. This sector, and in particular the ports at Bristol, Cardiff, Newport and Sharpness might be significantly affected by a tidal power scheme. Barrage options have the greatest impact on ports upstream of them as port traffic would be required to pass through locks to access port facilities. Changed water levels as a result of schemes would also affect the access opportunities for vessels. For the ports a scheme could therefore mean:
>
> — longer timescales for ships to reach them if they have to pass through locks;
>
> — fewer opportunities for vessels to travel up the estuary as the higher tides that the
>
> — larger ships need to reach the ports are reduced;
>
> — sediment may collect in navigation channels which would need to be regularly dredged; and
>
> — potentially greater impacts on larger ships which bring the most value to the ports.
>
> "Provision of locks and dredging would reduce the impact of the schemes on ports. Although locks and dredging would largely mitigate the navigational impacts presented by barrages, port customers may still consider possible delays as a risk, thus potentially impacting on the competitiveness of the ports.
>
> "In a scenario where a power scheme displaced 60% of port activity, job losses at the ports in the Severn estuary could rise to a peak of 3,900 during the nine year construction period for Cardiff-Weston. This means that in a typical construction year port-associated employment could be 2,100 (1,400–3,500) lower than it would otherwise have been (ranges represent 40% and 100% displacement).
>
> "The Bristol Port Company have recently been granted consent for a major new Deep Sea Container Terminal Development (a £600 million investment). If these expansion plans are realised the figures on benefits and jobs for Cardiff-Weston are likely to change. We estimate that the net benefit to the region is reduced to £1.9 billion (£-1.5 billion–£5.5 billion) GVA for a Cardiff-Weston barrage since job losses during the construction period are estimated to be 2,500 (1,600–4,100)."

In considering alternatives to the large barrage, the Severn Tidal Power study concluded that: "The Bridgwater Bay lagoon could produce a substantial energy yield and has lower environmental impacts than barrage options. It also offers the larger net gains in terms of employment."

All the options carry massive potential for the development of key innovative sectors in the UK and especially locally to the estuary. There are big opportunities to design and manufacture the turbines close to the estuary and pioneer the technology for a global market.

A coherent strategy is required for the range of projects and industrial developments along the Severn Estuary to ensure maximum sustainable benefit to the local economies.

The negative side to a large barrage include the risk to employment at and around Bristol Port—calculated by independent studies at more than 7,000 jobs excluding those created by the planned deep water container port. This highly successful port has the advantage of allowing cargo to reach Britain's industrial market place with reduced reliance on road transport.

The future development relies on the construction of a £600 million deep water container port. Legal consents and planning permissions have been agreed and the construction is ready to commence.

Shipping doesn't like locks in any event and a massive one in mid-estuary would not be easy to navigate through and would add three to four hours to the turnaround time. The tidal range will be reduced, water density will fall and silt will settle and require dredging. This would risk making Bristol Port commercially unviable.

The plan to use the barrage construction in order to build a deep-water port at Port Talbot as an alternative to Bristol may not see the work or employment transfer. The additional road mileage required would deter cargo being routed to Port Talbot.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

How does the company plan to engage and consult the community in the development of the project?

Are the proposals in breach of EU legislation, and if so how will this be addressed?

It would appear unlikely that land on such a scale required to compensate for the loss of intertidal habitat is not available in the UK and a large barrage may not be possible without a significant breach of EU legislation.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

We welcomed the previous government's encouragement to embryonic technologies and recognise that there are a number of developing ideas to harness the energy from the tidal power. ReGen South West has done a good job in championing renewable energy generation across a range of technologies in the region. It is unlikely that the alternatives can co-exist with a large barrage and there is a risk that investment in such technologies will be curtailed whilst proposals for the Cardiff to Weston barrage are being seriously considered.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

The options to capture energy from the Severn Estuary will require pioneering and challenging engineering. With government support and an active policy toward supporting local industry and manufacturing, these projects could help establish an international lead in a critical sector.

We cannot afford further delay and there are concerns that the large barrage may not be built even after many years of planning. The proposal of a barrage could, however, deter investment in alternative technologies as well as prove a "blight" on the development of the port at Avonmouth.

The Severn Tidal Power feasibility study concluded: "Many years of further detailed work would be needed to plan, finance, and assess the impacts of such a large structure as a Severn power scheme before a case could be put forward for planning consent. Even over a period of two years this study has only been able to consider feasibility and impact at a strategic level. If consented, the construction times would be between four and nine years depending on the scheme. In addition, any of the schemes would first require new habitats to be created, or species re-introduced, to replace those that would be displaced. These habitats and measures require time to be effective."

November 2012

Written evidence submitted by Black & Veatch Ltd (SEV43)

INTRODUCTION

1. Black & Veatch (and formerly Binnie & Partners) have been involved in the Severn Tidal Power project opportunities since 1970s. We are very active in the evolving & emergent ocean energy industry and of recent our UK work in this field has been for ETI, DECC, Carbon Trust, various ocean energy developers and with Parsons Brinckerhoff for the Severn Tidal Power Feasibility Study (STPFS).

2. Since completing the STPFS, a combined team from Parsons Brinckerhoff and Black & Veatch has reviewed, on a pro-bono basis, the outcomes of those studies to establish how they should be used to inform future energy development policy from the large energy resource of the Severn Estuary.

3. Our motivation is to ensure that the knowledge we gained from the Feasibility Study was translated into a tangible set of outline proposals that could help potential project developers and policy makers consider tidal power generation in the Severn in a form that was acceptable to stakeholders, and that increase the probability of driving the a scheme forward.

4. Our conclusions were that the uncertainties associated with the impacts of large tidal range projects need resolution, in order to advance the prospects of tidal barrage energy for UK plc, and that an appropriate means of achieving this would be best achieved by taking a step by step approach in the development of the tidal power resource in the Severn Estuary. This would allow smaller and significantly lower risk options to be developed initially and used to inform knowledge gaps during planning, construction and operation. Jobs could be created more quickly and a better evidence base for decisions on larger schemes could be established.

Key Points

- Tidal energy from the Severn estuary is a valuable, reliable and significant low carbon energy resource that should be utilized for the benefit of UK plc;
- Abstracting energy from the Severn has environmental impacts whichever projects are deployed and whilst these can be mitigated, some forms of mitigation can create further issues (for example using ebb and flood generation on a Severn Barrage to reduce the loss of inter-tidal habitats will have adverse impacts on upstream ports, particularly Bristol, due to the reduction in high tide level)
- Land connected lagoons and tidal arrays located away from navigation channels do not impact the current or proposed operations on the Severnside ports.
- Rather than considering development of one of the largest tidal power schemes in the UK as the first step, we believe a more incremental approach would be more attractive to investors, reduce the blight effect on ports, create and sustain construction and operational jobs in the UK tidal power sector as well as allowing valuable operational evidence to inform development of subsequent larger tidal power projects;
- Land connected tidal lagoons use existing technology and, in a suitable site, would be an effective stepping stone in a tidal power development plan for the Severn. We have modelled such an option on one site in South Wales to assess feasibility, costs and gauge stakeholder perspectives. This is described in the submission to this inquiry by Mr Peter Kydd, Parsons Brinckerhoff.

Responses to Inquiry Questions

This is described in the joint submission to this inquiry by Mr Peter Kydd, Parsons Brinckerhoff, incorporating Black & Veatch input.

November 2012

Written evidence submitted by the Gloucester Harbour Trustees (SEV45)

Set out below are comments from Gloucester Harbour Trustees in response to the questions posed by the Commons Select Committee regarding a proposed Severn barrage between Cardiff and Weston.

Given that Hafren Power has neither published details of its scheme, nor approached the relevant authorities for any information, it is very difficult to respond to this consultation. However we feel that it is important to respond as best we can on the basis of the previous STPG work that considered a Cardiff—Weston Barrage and recent anecdotal evidence from reports suggesting that Hafren Power will use low-head turbines and generate power on both the flood and ebb tides. There are unsubstantiated claims of intertidal habitat loss in the order of 5,000 ha.

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

Whilst it has been stated that the barrage may have the potential to generate approximately 5% of the UK's current electricity requirement, we would suggest that the contribution to UK energy security is very limited. The scheme would only produce power on the ebb and flood, hence there will be interruptions (albeit

predictable) in the flow of energy. The scale of such interruptions has neither been acknowledged nor quantified by the promoters of the "new" scheme, nor have any energy "storage" schemes been examined which might deal with overproduction of energy during tidal cycles which do not correspond with periods of high demand.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

The issue of tidal locking needs further examination to address the impact upon fluvial and pluvial flooding and drainage issues.

What risks and opportunities could it pose to wildlife and habitat in the Severn Estuary, and how might any risks be mitigated?

No comments.

What lessons can be learned from successful development of La Rance tidal barrage in France and other tidal power projects?

The La Rance scheme is several orders of magnitude smaller than a Severn Barrage and operates in an entirely different environment. We feel that it would be inappropriate to draw comparisons.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

Only a very limited amount of information is currently available from the promoters of the scheme presently under consideration. However, papers which we have seen indicate a significant lowering of impounded basin levels that would, in all likelihood, render the port of Sharpness completely inaccessible to the majority of the ships which presently trade via the port of Sharpness.

The ports of Avonmouth and Portbury would be similarly affected, and plans for a deep water container terminal to serve the West Country and Midlands (and beyond) would fail to come to fruition.

The aggregate extraction industry in the Severn Estuary is, we understand, sustainable at present due to the net input of sediment from the Bristol Channel and beyond. A barrage of the type proposed seems likely to reduce the opportunity for sediments to be replenished, and the marine-dredged aggregate industry would die.

The promoters of the current barrage cite economic growth in South Wales (and particularly Port Talbot) as one of their key drivers and fail to address the adverse impacts on existing and potential employment within the Estuary and South West. The Select Committee should fully understand these social and economic impacts.

Would the project require support under the proposed new Contracts for Difference mechanism?

No comments.

How does the company plan to engage and consult the community in the development of the project?

No comments.

Are any other proposals for tidal power projects in the Severn Estuary currently under consideration?

None known.

What could be the wider implications of the scheme for UK engineering and UK low-carbon industry?

No comments.

In our view the proposals for a Severn Barrage lack credibility. There are alternative ways of generating renewable tidal energy from the Severn Estuary without such devastating impacts on the existing environment and economy.

November 2012

Written evidence submitted by Owain Jones (SEV47)

TERMS OF REFERENCE

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

This is not a relevant question. The barrage would be such a destructive intrusion into a complex set of ecosystems, habitats and landscapes that it could not be considered as a "green development" or a meaningful step to sustainable development. This would not be clean energy production as it rests upon the large scale destruction of biodiversity/habitat/landscape.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

Not answered.

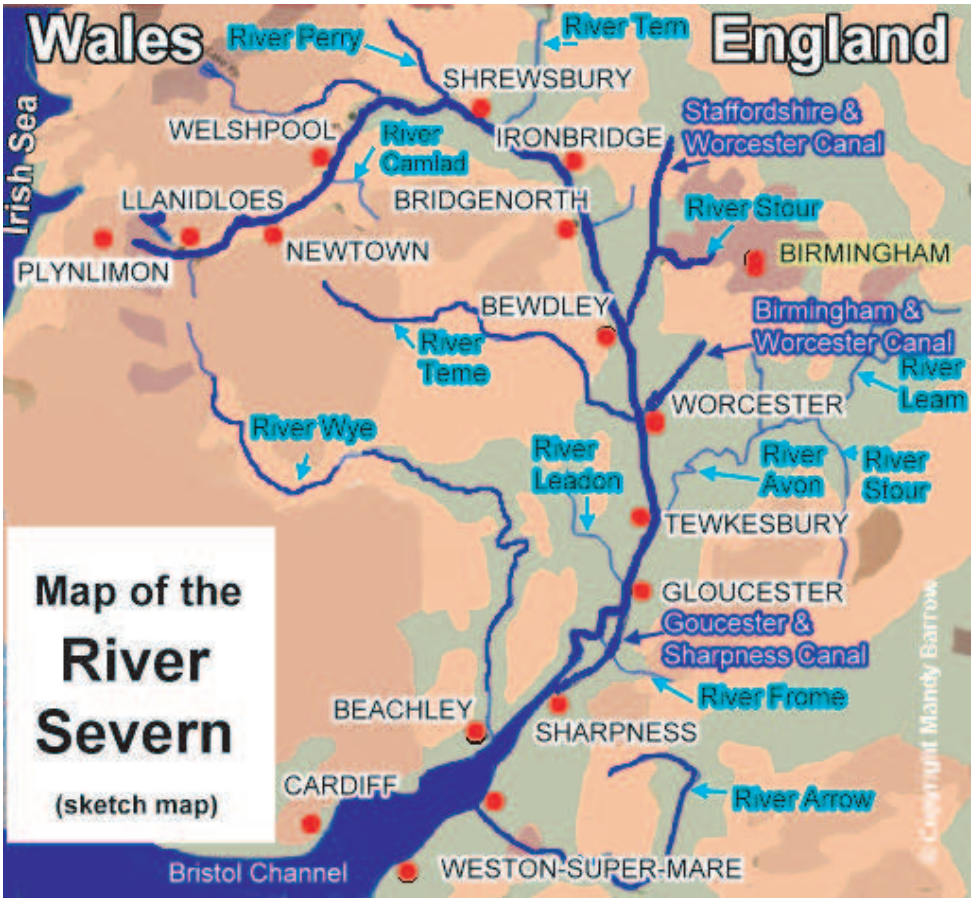
What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

Habitat/ecological mitigation measures could not fully compensate for the loss of landscape/biodiversity/habitat. This is in part due to a) the scale of the potential impact a barrage would have, and b) due to the complexity of the current landscapes in terms of their tidal dynamics and the ecological responses to them.

The proposed barrage will impact on seven major rivers including Britain's wildest and longest river, the Severn, and also the rivers Wye, Avon, Usk, Taff, Ely, Rhymney, and many other smaller water courses (Fig 1). The estuary is the fulcrum of the Severn Catchment area in terms of fish migration and aquatic ecology (Fig 2).

Figure 1

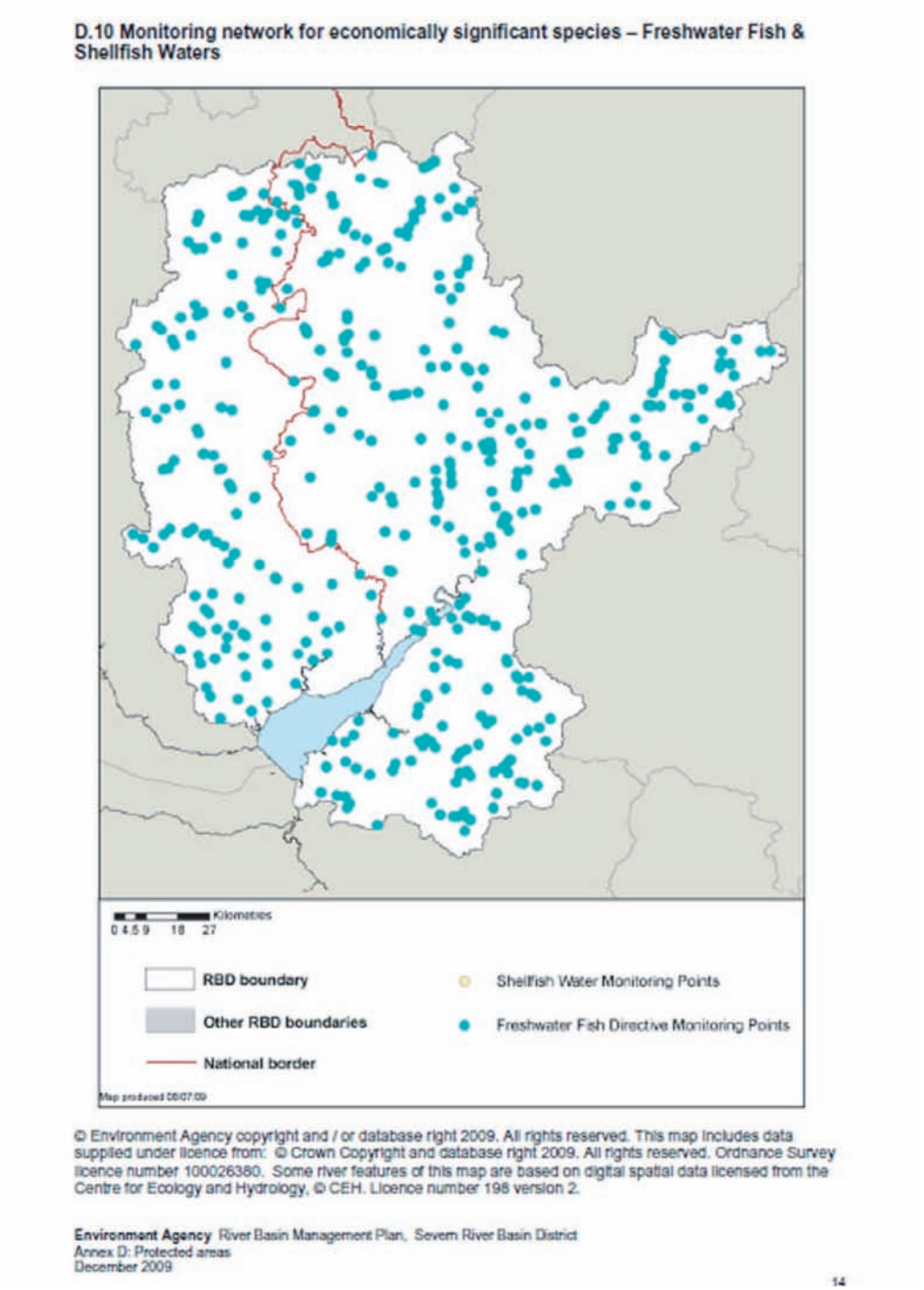
SKETCH MAP OF SEVERN CATCHMENT RIVER/WATERCOURSE NETWORK



Source: http://www.chiddingstone.kent.sch.uk/homework/riversevern/map.html

Figure 2

ENVIRONMENT AGENCY FRESHWATER FISH AND SHELL MONITORING NETWORK SEVERN ESTUARY CATCHMENT AREA. SOURCE ENVIRONMENT AGENCY RIVER BASIN MANAGEMENT PLAN, SEVERN RIVER BASIN DISTRICT 2009



Please note the Environment Agency have been considering a non fish take angling policy on the Rivers Taff and Ely.

See:
http://www.gwentanglingsociety.co.uk/attachments/article/752/110317%20FINAL%20for%20publication%20TAFF%20Building%20the%20Case.pdf

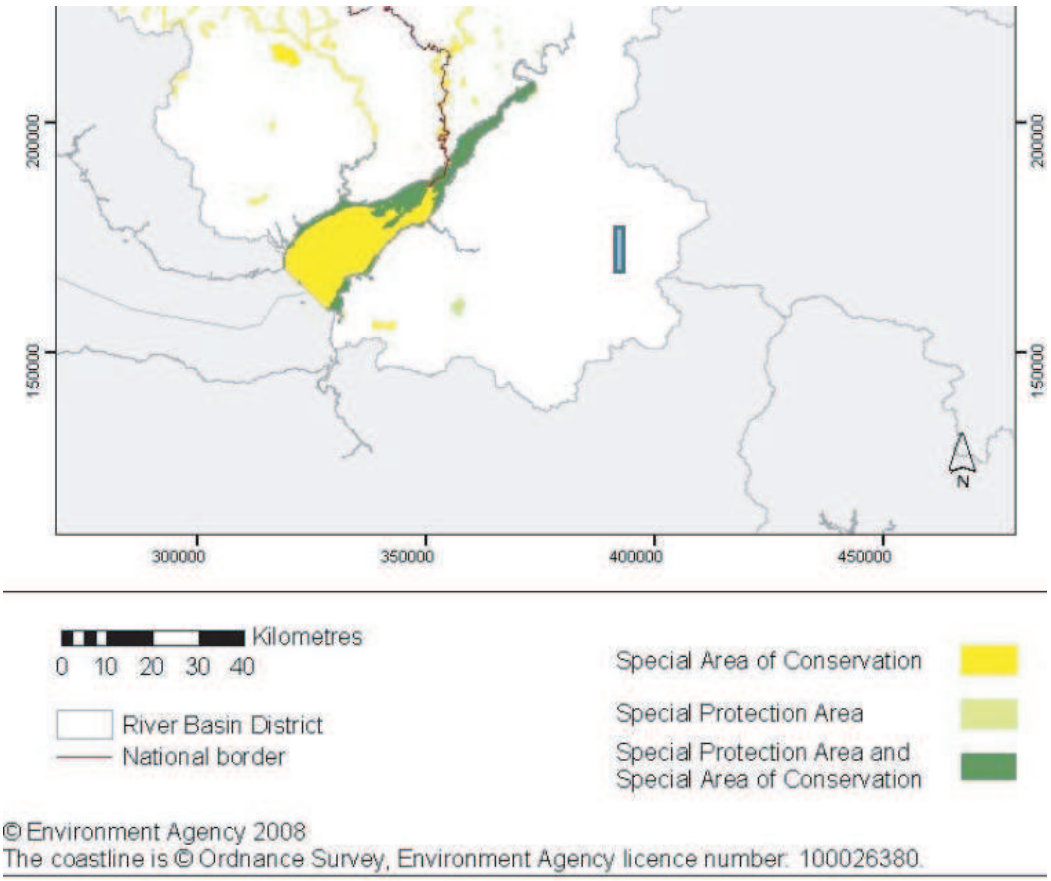
This is in part due to the environmental pressure put on these rivers by the Taff Barrage. If a Severn Barrage was built these rivers would have two barrages between them and the waters of the Bristol Channel. This is also a warning re the impacts on the marine/aquatic biodiversity of the other rivers upstream of the barrage.

A Severn Barrage would not only damage and/or destroy large areas of habitat protected under a range of conservation designations (Fig 3) it would fly in the face of the recent UK Government approach to the environment developed under the ecosystem services approach. UK National Ecosystem Assessment. http://uknea.unep-wcmc.org/

Very little attention has yet been paid to the very substantial ecosystem services provided by tidal rise and fall and the resulting flows of water. These services include habitat creation, dispersal of pollutants, the facilitation of navigation, a range of cultural ecosystem services (recreation).

Figure 3

SEVERN ESTUARY CONSERVATION AREAS. SOURCE ENVIRONMENT AGENCY RIVER BASIN MANAGEMENT PLAN, SEVERN RIVER BASIN DISTRICT 2009



What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

Please also consider the decision not to build new barrages in the Bay of Fundy area in Canada after the ecological damage caused by previous barrages was assessed and recognised. See http://www.freepressseries.co.uk/news/2044560.expert_warns_against_severn_barrage

This decision should also been seen in the context of pressures upon and loss of, delta and estuarine landscapes across the globe.

See A global network for the resilience of deltas: http://www.gpa.depiweb.org/docman/doc_view/197-delta-alliance-a-global-network-for-the-resilience-of-deltas.html

This would set a destructive global precedent and make the UK stand out as a leader in development which is destructive of biodiversity.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

The high tidal rise and fall in the Severn Estuary are a defining landscape characteristic of the Severn Estuary and are central aspects to a number of communities' "senses of place" and "practices of place", and thus linked

to well-being. A number of notable artists and writers have responded to the tidal estuary in ways which capture this. See Severn Estuary Art Atlas.

https://maps.google.co.uk/maps/ms?hl=en&ie=UTF8&msa=0&msid=
207566868165594769502.00049d926fe4c577a82fa&ll=51.464275,-2.287903&spn=1.119088,3.56781&z=9

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

Not answered.

How does the company plan to engage and consult the community in the development of the project?

Don't know.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

Yes clearly.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

See below.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

Much greater benefit to UK engineering, low-carbon economy and UK exports would accrue from supporting the on-going development of non-barraged based tidal power generation. For example that being developed at The European Marine Energy Centre (EMEC) Ltd. This much less environmentally intrusive kind of technology will be applicable in the Severn Estuary, other parts of the UK, and exportable worldwide. A concrete barrage has none of these advantages is it dinosaur technology.

November 2012

Written evidence submitted by the Canal & River Trust (SEV48)

We set out below the evidence of the Canal & River Trust in respect of the following questions to which the Select Committee have invited responses.

What risks and opportunities could it pose to wildlife and habitat in the Severn Estuary, and how might any risks be mitigated?

The Trust is concerned about likely impacts on the Estuary. The Severn has international wildlife designations based largely on its existing tidal character which will be irrevocably changed by this type of barrage. This will have an impact on internationally important areas for water birds which could have a knock-on effect to the wildlife of the Gloucester and Sharpness Canal and the upstream navigable River Severn.

Regarding mitigation, the example given of La Rance in France suggests that irrevocable changes *did* occur and only suggests they were not significant because the estuary area was not very large—the scale of this proposal is much bigger. Therefore the Trust would have concerns how they could successfully mitigate for changing the tidal influence.

Regarding fisheries, we are being pressed to make substantial investments and changes in operation to accommodate improvements for migratory fish and eels in the Severn and Usk catchments which could be rendered pointless if the barrage has (as seems likely) a very significant impact on migration. While it is entirely possible to mitigate fishery impacts with the type of hydro-schemes the Trust is considering on our weirs, the barrage is of an entirely different scale.

The other environmental factor could be any potential impact on water quality at Gloucester which could affect the water supply made by the Trust to Bristol Water. Whilst the scale of any such impact is not clear from the information provided, we would like to raise this as an issue for consideration.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

The new Dock at Sharpness was opened in 1874 and is one of the most inland Ports in Britain, and the eighth largest in the South West. Sharpness is Stroud District's largest operating dock and serves as the gateway from the River Severn to the Gloucester & Sharpness canal.

As tidal ranges are high (up to 10m typical for a "spring" tide), relatively deep vessels can use the Port thus offering viable and sustainable cargo handling business opportunities. This is supported by excellent road and motorway links to major commercial centres such as Bristol, Cardiff, Gloucester and the wider Midlands area.

The Port has a number of important historic features and as well the industrial activities that take place, also serves a vibrant leisure industry, evidenced by the 180 berth Marina in the Old Arm—the Severn Area Rescue Association (SARA) maintain a rescue station here.

The Port Authority for the impounded dock is the Canal & River Trust, and the quayside activities are run by Sharpness Dock Limited.

The Trust has invested heavily in the Port infrastructure in recent times, including replacing the entrance gates (£1.3 million), rebuilding the North Pier (£1.2 mllion), and stabilising the north revetment (£0.7 million). Further investment in the infrastructure is anticipated in future years.

The employment allocations at Sharpness are one of the largest in the District and the Trust, who are one of the major landowners in the area, are committed to providing employment and have continued to rigorously market the site for new employment development.

Sharpness Port lies at the head of the Bristol Channel and handles ships of up to 6,000 tonnes (with cargo), maximum beam 16.76 m and unlimited length. In 2011, over 500,00 tonnes of cargo were carried though the Port, a proportion of which was exported scrap. Recently, the Port has experienced an increase in custom and major operators have established key operational bases in the Port, eg Dragon Cement and EMR Metals.

The Port is experienced in handling a diverse range of cargoes including dry bulks, minerals, timber and many other products, using modern quay-transfer equipment and has extensive open and covered storage including grain silos.

Freight is mainly imported from Northern Spain and the Baltics but also serves inter-coastal Ports on the West Coast of England and Scotland.

In addition to freight, the Port also houses a major Dry Dock facility, Sharpness Ship Yard.

The impact of a Barrage would almost certainly decimate the Port freight traffic due to the shallower depths, unfavourable flows in the channel downstream of Sharpness (created by a Barrage), and reduced tidal windows. This would not only affect the Dock Operators, but also the adjacent Navigation Authority, Gloucester Harbour Trustees.

Commercial Income for the Trust from the current revenue streams would substantially fall.

Are any other proposals for tidal power projects in the Severn Estuary currently under consideration?

If tidal flows are reduced upstream of a Barrage, then opportunities to harness the tidal power and range could be severely limited on the upper reaches of the Severn Navigation, ie above Gloucester. This would have a detrimental impact on proposed hydro-power schemes such as those currently being taken forward by the Herefordshire & Gloucestershire Canal Trust at Llantony Lock (which connects the Herefordshire & Gloucestershire Canal with the River Severn).

We would strongly urge that a thorough examination be undertaken on the impacts of the Barrage and tidal waters further upstream the Severn channel.

November 2012

Written evidence submitted by the Energy Technologies Institute (SEV49)

1. The Energy Technologies Institute (ETI), a public-private partnership between global energy and engineering firms and the UK Government, believes the UK can have an affordable, secure and sustainable energy system in the future however it is critical that the right steps are taken to ensure that the costs of carbon reductions are affordable in the context of sustaining UK economic growth and industrial development.

2. The ETI submission to this call for evidence concentrates on the question of what contribution the Cardiff-Weston Barrage could make to UK energy security and climate change objectives.

3. It is important to consider any potential Cardiff-Weston Barrage as part of the UK's overall energy system and not as an isolated development. The ETI's Energy System Modelling Environment (ESME) outlines six key priorities to ensure the UK's future energy system is affordable, secure and sustainable.

4. These are as follows:

— Improving efficiency—demand reduction and smarter use of energy in vehicles, businesses and homes to minimise the overall requirement for new infrastructure and energy delivery growth in line with rising population and demand.

— Progressing new nuclear build—ETI modelling shows that it is possible to create a future energy system capable of meeting our 2050 emissions targets without new nuclear build but the system wide cost is increased by up to £8 billion pa as alternative (higher cost) low carbon energy technologies are used instead.

— Carbon capture and storage—a critical technology in delivering energy security whilst meeting climate change targets, allowing the continued UK use of global supplies of fossil fuels.

— Bioenergy—offering energy security and climate change benefits and with the potential to provide a significant proportion of the UK's energy needs if sufficient sustainable supplies can be sourced (onshore in the UK and globally).

— Offshore renewables—particularly offshore wind but also marine energy—provide an important low carbon opportunity which acts as a hedging option should the introduction of other technologies (above) be significantly delayed. Cost reduction is critical in ensuring affordability compared to the alternatives above.

— Gas—whether delivered from fossil sources or alternatives such as bio-crop feedstocks, the ETI expects gas to remain a critical element of the UK energy system. There are many ways in which gas could be used and its use may spread from heat and power into vehicles where, particularly in heavy duty vehicles, there is potential for significant efficiency gains over diesel fuels. Delivering UK climate change targets whilst increasing use of gas is achievable through the use of bio-crops as a feedstock, application of CCS and substitution of lower carbon alternatives in some heating systems.

5. There are significant uncertainties around the potential deployment extent and timing of each of these options and, in the event of slow deployment (or non-deployment) of one or more of these capabilities, ETI analysis shows that offshore renewables are the marginal cost low carbon power technologies which could be expected to be the most effective solution to fill the resulting shortfall in UK generation capacity—even when appropriate backup generation capacity is included.

6. In practice, delivering energy security and effective system operation means it is not a question of choosing one technology over another, but rather of developing an effective, integrated system incorporating a range of technologies. Cost reduction in all areas is vital if the overall energy system is to be affordable.

7. A Severn Barrage could provide an important element of secure energy supply, but there are many alternative ways to meet the same objective. To decide which is the most attractive option requires a detailed consideration of the net contribution of each scheme, their capital and lifetime costs, the economic benefits they may offer and how each of them might contribute to the UK energy system. Whilst much of this has been assessed for a range of barrage and tidal schemes, the contribution and integration into the broader UK energy system has been only partially assessed to date.

8. The ETI has developed a Tidal Resource Modelling (TRM) project to help improve understanding of the possible interactions between various tidal energy extraction systems which are being considered for deployment between now and 2050.

9. Working for ETI, marine energy consultants Black & Veatch, in collaboration with tidal modelling experts HR Wallingford and tidal range experts at the University of Edinburgh, developed a Continental Shelf Model of UK waters to assess the tidal energy potential around the UK, to inform the design of energy harnessing schemes and to evaluate their impact on other sites around the UK and European coasts.

10. The project has identified that it is possible to get an equivalent energy yield to that from a Severn Barrage from combinations of other smaller-scale tidal range schemes (barrage or lagoons) and/or tidal current schemes. It also found that the Cardiff-Weston barrage could impact the tidal energy resource potential at other sites as far away as Bridgewater Bay, around North Wales and the West Coast of England.

11. A Severn Barrage could provide a large amount of secure and sustainable energy, although a mixture of smaller-scale tidal stream or tidal range projects could generate similar levels of electricity.

12. Given the results from TRM to date, it would seem very likely that the energy yield from a single large-scale Severn barrage could be achieved with a lower level of interaction and impacts through a combination of tidal energy extraction at a number of smaller, different sites.

13. It is worth noting that the optimum use of the UK tidal resource is likely to be through a combination of tidal range and tidal current schemes, for a number of reasons including cost of energy, phasing of generation, and environmental impact. Using the TRM system an initial investigation has been made of the combinations of sites that may result in optimum phasing of generation across the UK. This has provided initial estimates of the interaction of different schemes with key environmental parameters such as near- and far-field tidal range impacts, and also provided insight into the methods by which a strategic optimisation and hence strategically planned utilisation of the UK's tidal range and current resource could be undertaken.

14. Different tidal schemes will interact with each other so it is important to manage how they interact and ensure a properly planned roll-out is in place. This needs to consider the associated environmental, economic, infrastructure and industrial growth aspects of the projects.

15. There is a general recognition that large capital investment into the UK's energy infrastructure is needed (£100's billions over the coming decades). This scheme is very large and estimates of its cost vary. The risk weighted return on this investment will depend on the degree of long term price certainty. In the case of tidal that is likely to include subsidy. However if this project does go ahead it shows that large low carbon power investments can earn a financial return and it could act as powerful, positive demonstration to the broader investment community.

November 2012

Written evidence submitted by Rt Hon Dawn Primarolo (SEV50)

I wanted to contribute to this inquiry as one of the MPs representing the Bristol area because of the potential impacts of a Severn Barrage on the city of Bristol and the surrounding area.

I believe the River Severn offers huge potential to provide renewable energy which is much needed as we move towards becoming a low carbon economy and I am in favour of establishing a scheme (or schemes) which harnesses this valuable tidal power and contributes to the UK's future energy security.

The environmental impact of any such tidal power scheme is of course very significant, and every effort must be made to minimise potential damage to wildlife. I appreciate this will not be easy, but very careful consideration must be given to the type of scheme progressed and its likely consequences for the natural environment of the River Severn, including any measures which can be put in place to mitigate likely harm.

While I recognise that the development of a Severn tidal power project would create many new jobs in our region, which I would welcome, I have been very concerned by reports which indicate that a Cardiff-Weston Barrage would have a damaging impact on the operation of Bristol Port, with associated job losses (as referred to in the *Severn Tidal Power Feasibility Study Report* published in October 2010).

Bristol Port is hugely important for the local economy and wider West of England region and I have yet to be convinced that a shore-to-shore barrage between Cardiff and Weston-Super-Mare will not seriously harm trade at Bristol Port due in large part to the fact that port traffic would be required to navigate locks, causing delays which could seriously harm the competitiveness of the Port. I have serious concerns about any project which is likely to threaten Bristol Port's viability, leading to significant loss of employment and resulting negative impact on the local and regional economy. I hope these considerations will be taken into account.

Despite my reservations about the current proposals for a Cardiff-Weston Barrage, I would welcome further research and analysis into Severn tidal power options with a view to taking a project (or projects) forward in the near future.

November 2012

Written evidence submitted by the Salmon & Trout Association (SEV51)

1. S&TA was established in 1903 to address the damage done to our rivers by the polluting effects of the Industrial Revolution. For 109 years, the Association has worked to protect fisheries, fish stocks and the wider aquatic environment. In 2008 it was granted charitable status. S&TA's charitable objectives empower it to address all issues affecting fish and the aquatic environment, supported by strong scientific evidence from its scientific network and legal advice from its appointed environmental lawyer. The Association's charitable status enables it to take the widest possible remit in protecting salmonid fish stocks, and the aquatic environment upon which they depend.

2. The S&TA is concerned with the timing of this inquiry, being called before the specific details of Hafren Power's proposal for a Severn Barrage have been published. The lack of clarity, in particular with regards to the potential impacts of this particular Barrage proposal, makes it only possible to answer the questions from a generic perceptive.

3. Overall, the S&TA remains very concerned about a proposed Cardiff-Weston Barrage.

4. The Severn Estuary is a globally unique system and one of the most highly protected sites in Britain. The Estuary is important for migratory fish, for the SAC-designated rivers (the Usk and Wye) and also hugely important for its intertidal habitats, which are vital for birds and fish. The S&TA does not believe the irreversible damage to important habitats and species, which would result from a Cardiff-Weston barrage, can constitute a sustainable solution.

5. While the S&TA strongly supports the Government's commitment to deliver the UK's share of the EU renewable energy target for 2020, the S&TA strongly believes that all means of generating renewable energy must be environmentally sustainable and must not undermine the integrity of important designated sites. The S&TA urges the Government to investigate other options which could increase renewable energy, but at far less environmental risk or cost.

6. In order to help consider the feasibility of other potential options of generating renewable electricity from the Severn, the S&TA believes additional research work must be carried out, including to:

(a) generate greater knowledge and certainty about the ecology of the Severn Estuary, particularly in relation to fish and bird behaviour;

(b) Research the migration routes out from and into the Severn Estuary, especially those of Atlantic salmon, sea trout, shad, lampreys and eels, and model the impact of a barrage on specific species migration routes;

(c) quantify the effects of fish passage through different types of turbines;

(d) improve understanding of the role and significance of the Estuary as a nursery spawning ground;

(e) assess the value of the ecosystem services provided by the Severn Estuary;

(f) assess the hydrological and geomorphological impacts of the different proposed schemes in the Severn Estuary and further afield, particularly in relation to modelling of water levels, sedimentation effects, coastal erosion and flood risk;

(g) assess changes in dilution and dispersion of effluent;

(h) assess predicted impacts on water level management upstream of an impoundment and associated changes in land use, habitats and species; and

(i) improve understanding of the effectiveness of potential mitigation measures.

In answer to the specific questions:

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

7. The proposed Severn Barrage would have a serious impact on fish populations within the Severn estuary, especially as it would create a barrier to migratory species such as Atlantic salmon, sea trout, shad, lampreys and eels, all of which are protected by European legislation. Salmon in particular could become non-viable in important rivers, such as Severn, Wye and Usk. As well as upward migrating adult fish being impeded, the turbines could also potentially kill high numbers of outward migrating juvenile fish.

8. The Severn Estuary is also hugely important for its intertidal habitats, which are designated under the EC Birds Directive, as key feeding and roosting habitats for a wide variety of bird species. It is now widely recognised that these habitats are also vital components to healthy commercial and recreational fisheries, by providing feeding, refugia and nursery areas for juvenile fish.

9. The Severn Estuary is important for marine fish species, including bass, mullet, pollock, sole, flounders and sprat, all of which would be impacted by the loss of intertidal habitat and the physical impediment created by any barrage.

10. Intertidal habitats are dynamic environments, which are utilised by both freshwater and marine fish species, depending on the dominant flow at the time. In addition, intertidal habitats deliver a range of other invaluable environmental services, such as nutrient and carbon storage, and flood and storm defence. Water quality would also be seriously affected, including oxygen levels, turbidity and the build up of contaminants trapped above the barrage, all of which will affect aquatic life in the estuary.

11. Recreating intertidal habitat for small-scale port developments may be a workable solution, but to try and reimburse the destruction of an entire ecosystem is completely untenable.

12. The S&TA believes that it would be impossible to recreate the hugely successful migratory corridors found in the Severn and the associated river spawning habitats of the Usk and Wye. This would also compromise the genetic integrity of salmon populations, which are genetically unique in individual rivers.

13. Whilst the S&TA appreciates the urgent need to address climate change, it does not believe the irreversible damage to important natural habitats and species, which would result from the Severn Barrage, can be considered a sustainable solution to the need to generate more renewable, low-carbon energy

Are the proposals in breach of EU legislation, and if so how will this be addressed?

14. The Habitats and Birds Directives are designed to provide protection for our rarest and most threatened habitats and species. The EU legislation would require a barrage to compensate any damage to habitats. It suggests this could include the creation of new habitat, the restoration of existing habitat, or the recreation of habitats within the site, in other designated sites, or in non-designated sites (and then designating them).

15. It is clear that recreating three of the largest rivers in the UK is simply not possible. Salmon populations from particular rivers are genetically unique and therefore cannot be replaced elsewhere. Therefore we do not believe this breach in EU legislation could be satisfactory addressed, as it would be impossible to mitigate the impact on protected fish species that migrate through the Severn Estuary into their native rivers.

November 2012

Written evidence submitted by the Wales Green Party (SEV52)

1. SUMMARY

- The call for evidence is biased towards the Hafren Power scheme that is being promoted by politicians, specifically Peter Hain MP, with limited and biased information publicly available.
- It asks "Are the proposals in breach of EU legislation?" when they are probably in breach of UK legislation—Habitats Regulations etc. We point out the Hafren scheme cannot claim that socio-economic need over-rides the wildlife interest
- It limits consideration to the "estuary"—normally defined as upstream of the Cardiff Weston line—ignoring impacts downstream in the Bristol Channel, including the operation of Barry docks and erosion of Bridgwater Bay and other sediments in the channel.
- The Green Party in 2007 opposed a continuous barrage across the Severn Estuary and favoured tidal power from lagoons, specifically one in Swansea Bay, depending on favourable environmental appraisal.
- Following the 2010 appraisal for DECC, the Tidal Reef (Minehead to Aberthaw) is a strong contender that the Committee should consider.
- We ask the Committee to include the Reef, Lagoons and Fence in its assessments and we present summary data to help compare to compare the schemes.
- A Cardiff-Weston barrage would significantly detract from the power available for the Tidal Reef, also could strongly change sediment banks in Bridgwater Bay, so that downstream effects need to be studied as well as upstream effects,

1.2 We are concerned that the call for evidence makes no reference to Wales or any Welsh policies or the Welsh role in decision-making; failing to involve the Welsh Assembly is not in the spirit of the devolution settlement. We ask the Committee to find ways to remedy this.

2. BACKGROUND

2.1 The Green Party in 2006 set up a working party to study the various proposals for tidal power from the Severn Estuary and Bristol Channel, heard from proponents including the STPG and debated the issues at conference in March 2007. This resulted in agreed policy to support use of the tidal energy potential subject to sustainability and environmental impact assessments, but that any proposal for a single continuous barrage across the Severn estuary is not acceptable. We supported a tidal lagoon for electricity generation in Swansea Bay, subject to favourable environmental impact study, and in particular a scheme launched by local Green Party members for the Swansea Bay lagoon to be owned and operated for the benefit of local people.

2.2 In 2007–08, many environmental organisations issued reports, and stressed the need for an open public debate in order to help identify the best way of capturing the enormous renewable energy resource of the Severn estuary whilst safeguarding its internationally important combination of species and habitats and bringing lasting benefits to local communities. Hain/Hafren have been preventing proper debate, by with-holding information and using heavy PR.

2.3 Members in the Wales GP have reviewed proposals recently, since the Hafren Power scheme came up, gleaning information on this from presentations to the Severn Estuary Partnership Forum and at Cardiff University (Prof. Roger Falconer who is linked to Hafren Power, as previously to the STPG).

2.4 As a continuous barrage across the estuary, it fails like the STPG scheme because it disrupts shipping, disrupts the whole sedimentary regime in the Estuary and destroys a huge area of tidally washed mud flats.

2.5 This time the innovative floating tidal reef, between Aberthaw and Minehead has stronger supportive studies. Tidal lagoons are still in contention and the tidal fence has progressed with development of submersed tidal current turbines. It is quite wrong for Hafren Power and its political backers to proceed as if theirs is the only option.

2.6 Indeed, a study of the reef concept by consultants Atkins and aero-engine makers Rolls Royce, was endorsed by Government (DECC, 2010). The originators of the concept, Evans Engineering, welcomed this as independent confirmation that their REEF proposal is both valid from a hydraulic perspective and on track to become the most environmentally friendly solution for capturing tidal energy from the Severn: <www.severntidal.com>.

2.7 The *Severn Tidal Power—Feasibility Study Conclusions and Summary Report* issued by DECC in 2010 concluded that a REEF type system from Minehead to Aberthaw could capture up to 50% more energy than the Lavernock-Weston barrage. As it taps energy of the tidal flow, it would not impede shipping and would have little effect on the tidal range in the upper Severn.

3. Re-Assessing options for Severn Tidal Power

3.1 Including the Reef, Lagoons and Fence in assessments is required under Habitats legislation—since the Hafren barrage strongly alters the upper Severn "special area of conservation" (SAC) and could only get legal approval if less-damaging alternatives could not provide comparable tidal power benefits.

3.2 The committee needs to state clearly that ignoring the alternatives as Hain etc. want would lead to a protracted battle through the Courts, right through to Europe, so would only waste time and opportunity for constructive tidal power alternatives.

3.3 Peter Hain has made it clear, as last time, that he sees tidal energy as a sideshow—his purpose is a giant development project to create "greater Severnside". Lord Deben (formerly John Gummer) is another politician involved in the "dodgy Severn barrage" (@Telegraph http://soc.li/4Q4Sn1C). The Corlan Hafren "vision" views the barrage as "enabling infrastructure" to improve the transport connections between South Wales and the West Country. The area immediately around the barrage they see as a city region that capitalises on the barrage and will grow within a clear hierarchy of settlements connected by world class urban transport systems. Their proposals include motorway and rail across the barrage, and building a deep-water port at Port Talbot (for Ultra Large Container ships), yet none of these has been subject to any planning process, in particular Strategic Environmental Assessment and the Wales Spatial Plan. Hain advocates public subsidy for assisting flood protection, but that has not gone through a public appraisal process.

3.4 The Severn Estuary Partnership's meeting on 11 September (in Bristol) heard several objections that the Hafren scheme's proponent (Robert Kirby) was unable to answer:

- the feasibility of providing replacement saltmarsh equivalent to the huge areas lost (5 sq km);
- substantial erosion of the extensive mud/sand deposits in Bridgwater Bay might result downstream of the barrage; and
- power in tidal flows downstream of a barrage would be halved (approx), so undermining a tidal reef and tidal fence options.

4. Assessment as Significant Electricity Input into the National Grid

4.1 The Severn estuary, with a tidal range of 14 metres (the second largest tidal range in the world), could make a significant contribution to meeting renewable energy targets. The barrage and alternatives would generate ~5% of UK electricity, compared with the commitment to generate 20% of the UK's *energy* from renewable sources by 2020 (electricity amounts to only 20% of our energy use).

4.2 However, barrage power peaks strongly with daily tides. The highly peaked output requires not only new National Grid structures (£1–2 billion), but the zero periods have to be filled by "slave" generators.

4.3 There are schemes to use peak power for pumped storage, delivered when needed, but the 2008 studies ignored this. Some pundits expect high powered storage devices, eg. pressurised air, but inefficiencies and technology costs have not been factored in to the barrage scheme.

4.4 Electricity prices under the "pool" are currently very variable depending on timing. Assessments assumed a set (subsidised) price per unit, as for all renewables, but that is not rational as renewables become increasingly important in national electricity supply.

4.5 Though tidal power is predictable, the inflexibility of the awkwardly varying power has to be penalised, compared with more flexible options with inbuilt storage. (The French barrage at La Rance is operated with pumping, to gain some flexibility).

Summaries of the Four Large Projects

updated from those by the Sustainable Dev. Commission www.sd-commission.org.uk
www.theecologist.org/News/news_analysis/269580/severn_barrage_is_there_an_alternative.html

Continuous Barrage—Cardiff to Weston-super-Mare [between Lavernock and Brean Down]

5.1 The STPG scheme had a series of turbines housed in concrete caissons, generating on the ebb-flow only. The tide would flow up the estuary through sluice gates, then the gates are closed to await sufficient water level difference—up to six metres. The water then discharges through 216 turbines.

5.2 The Corlan Hafren variant has two-way generation (flood and ebb tides) for 17 hours per day, using about 1,000 smaller, slower turbines of three metre head. The seasonal changes (spring/neap tides) are strong, and out of phase with winter peak demands for electricity (unlike wind). It destroys much intertidal habitat (5 sq.km, v. 14 sq.km of the STPG scheme). This habitat loss and the big change to the natural state of the *Special Area of Conservation* means it cannot meet the Habitats Directive when alternatives for generating tidal power (below) are practicable—it could not claim socio-economic need over-rides the conservation requirement.

5.3 Tidal range and currents behind the barrage would be reduced and much of the suspended sediments would drop out. With greater light penetration, the biological populations change a lot (as found for the French "La Rance" tidal barrage).

5.4 Shipping locks are needed—the delays were calculated (for Bristol) to affect the comparative economics of ports upstream of the barrage.

5.5 Both scheme envisage a motorway built on top, though a roadway over-flying the shipping locks was found to have such high extra costs that it was counted out.

5.6 Summary numbers:

— Terawatt hours of electricity produced each year = 17.

— Output as a percentage of UK electricity = 4.2 %.

— Size = 15.9km in length.

Tidal Reef —http://www.severntidal.com/

6.1 Halfway between a barrage and a fence, the tidal reef would see an array of floating turbines connected to concrete bases and strung between Aberthaw, Wales, and Minehead in Somerset. The brainchild of veteran hydro engineer Rupert Armstrong-Evans, the reef is estimated to require 10 million tonnes less rock infill than a barrage, and, because it would operate with a water-level difference of just two metres, is predicted to have small impact on the upper estuary's tidal range. Fish should be able to navigate the slow-turning turbines, and ships will be able to sail through "doors" in the reef, rather than using slow and expensive locks. Low-tech components could make the project cheaper than the barrage, and the electrical output would be smoother and more constant.

6.2 Summary numbers:

— Terawatt hours of electricity produced each year = 20.

— Output as a percentage of UK electricity = 5 %.

— Size = 22 km in length.

Tidal Lagoons—www.tidalelectric.com

7.1 Lagoons are artificial enclosures constructed in the estuary with turbines built into the walls. They operate on both the ebb and flow of the tide, as the water fills and then empties from the lagoon enclosure. Because the lagoons don't block the estuary in the same way as a barrage, they would allow the passage of ships and fish up the Severn. But fish would still need to pass in and out of each lagoon.

7.2 Lagoons could be flexible in power generation and coupled in pumped storage mode. There are fears that the "channel" created between the three proposed lagoons in the upper estuary would lead to faster currents, which could bring other problems. The lagoons would also require much greater quantities of aggregate than a barrage, but this could be low-tech sediment-filled geotextile bags.

Information on alternative lagoon types is at http://www.marinet.org.uk/refts/7estuarydebate.html. Arguments over currents, silting and stability would favour a trial construction of moderate-scale, eg. in Swansea Bay or off the N. Wales coast (Rhyl)

7.3 Summary numbers:

— Terawatt hours of electricity produced each year = 6.5–24, depending on scale.

— Output as a percentage of UK electricity = 1.6–6 %.

— Size = a minimum of 82 km of embankments.

Tidal Fence—www.senergyworld.com/

8.1 Unlike a barrage, the fence would not "dam" the estuary, but instead use a string of underwater turbines to generate electricity from the natural flow of the tide, probably downstream on the Minehead-Aberthaw axis where the total flows are higher. There would little affect on the estuary's tidal range and both ships and fish could pass easily. The fence in flexible—can be built in stages and use turbines at various depths—but would generate perhaps a quarter of the mega-barrage energy, but on flood as well as ebb tides.

8.2 Summary numbers:

— Terawatt hours of electricity produced each year = 4.

— Output as a percentage of UK electricity = 1%.

— Size = 9km in length (could be double).

WHAT ARE THE COSTS?

9.1 The cost estimates for the electrical output given by the SD Commission (www.sd-commission.org.uk) are quite unreliable. The costs best known are for the Fence, as marine current turbines are now reaching the commercial stage (10–15p/kWh) but with some reduction for large numbers of turbines. The barrages have such high capital cost (£30 billion) that the power would come ~30p/kWh, depending on the assumed discount rate.

9.2 Lagoons were costed with high spec embankments to put them out of reckoning—the Welsh Affairs Committee *2005–06 third report*** found that errors made by DTI officials had undermined a "highly promising project" for the lagoon in Swansea Bay. The Reef is untrialled, but a short section could be built first as prototype, unlike the barrage where the whole needs to be built before it can operate.

**www.parliament.uk/parliamentary_committees/welsh_affairs_committee/welsh_affairs_committee_inquiry_page___energy_in_wales.cfm

November 2012

Written evidence submitted by the Children's Scrapsore (SEV53)

I would like the following to be taken into consideration regarding the Severn Barrage project. Our objection is based on:

- There would be no overall gain for the economy as the temporary economic gain from the construction of the barrage is balanced by the loss from closure of the ports at Bristol and Sharpness and associated businesses.
- The majority of the capital expenditure would leak outside Wales and the South West as those areas would not be able to supply all the materials, caissons, machinery and man-power for the project.
- The barrage would cause as a minimum a loss of 900 jobs in ports in the operating phase whilst creating around 1,000 operational jobs—a net gain of only 100 jobs.
- The fishing industry of the Estuary will collapse in Wales and the South West with a loss of 60 jobs.
- An estimated 180 jobs would be lost in the nationally strategically important marine aggregates industry. The cost of construction projects particularly in the North West and South Wales would rise as they are particularly dependent on marine-dredged sand from the Estuary.
- The DECC Study estimated that the barrage could create 60 tourism jobs. However, this would be far outweighed by the loss of the attractiveness of the Estuary, loss of ornithological and angling tourism and the damage to marinas.

It is also our opinion that the previous feasibility study outlined significant catastrophic outcomes which have not been fully addressed by the recent application with evidence, but only with conjecture.

As this is a once only decision, I believe it is incumbent on the panel to ensure that environmental and social damage is not acceptable without guarantees of a more solid nature. As those are not available then I believe the least that should be attained is a delay for future reconsideration once this technology has been evolved.

November 2012

Written evidence submitted by Jonathan White (SEV 54)

1. Executive Summary

- The Rance barrage was the first and so far the only tidal barrage constructed in Europe. Commissioned in 1966, it is the only precedent able to provide an insight into the impact of building and operating a tidal barrage over an extended period of time.
- When it was built, the Rance barrage was seen as a trial for a much larger tidal barrage spanning the Baie de St Michel between Cancale and Granville in Normandy. That barrage was never built and Électricité de France ("EDF"), which operates the Rance barrage, says it has no plans to build further tidal barrages in France, instead favouring investment in off-shore wind farms as its preferred source of incremental renewable energy.
- During construction of the barrage the Rance estuary was turned into a freshwater lake, leading to the eradication of all marine flora and fauna.
- Following construction of the barrage, the Rance estuary became a marine basin, with water levels no longer governed by the tides but exclusively controlled by the operation of the barrage.
- The marine basin is very different from the estuary that existed before the barrage. Average water levels have risen by approx. 2.5 metres and tidal range has fallen by 40%, thus reducing the intertidal area from 70% to 50%.
- Following the opening of the barrage, a period of 10–12 years elapsed before a new environmental equilibrium was established. The new environmental equilibrium is quite different from the one that existed before, and is highly dependent upon the operation of the barrage.
- Certain species of fish previously abundant, such as conger eels, flat fish and sand eels, have completely or largely disappeared.

— As there were few if any salmon and sea trout in the Rance prior to construction of the barrage, it is not possible to assess what impact the Rance barrage would have had on salmonid migration, although some evidence suggests that larger fish of other species struggle to pass through the turbines.

— The years since the construction of the barrage have seen a very significant silting up of the basin. It is probable that the barrage has contributed to this phenomenon. The operation of the barrage means that high water can be maintained for as long as eight hours and low water for as long as four hours during a given 24 hour period. Long periods of slack water and therefore low current allow sediment suspended in the water to sink and settle.

— The impact of this silting is such that some heavily silted parts of the basin are being colonised by plants and transformed into salt marsh, thus removing previously fertile nursery areas for fish and feeding territory for birds.

— The issue of silting, and the role the barrage may be playing in aggravating this phenomenon, is currently the subject of significant friction between the communities bordering the Rance and EDF.

— For the Severn estuary, the experience of the Rance barrage shows that, even if during construction of a Severn barrage the colossal destruction of marine life caused by building the Rance barrage were to be avoided, the impact on the environment of operating a tidal barrage is likely to be very significant.

— In this regard, the obvious difference between the Rance and the Severn is the scale of the rivers concerned and range of species affected. The Rance is a small river, which prior to the barrage did not have significant populations of migratory anadromous fish (salmon, sea trout, shad), with a comparatively small estuary. The rivers that flow into the Severn estuary, by contrast, cover a massive watershed, and are home, *inter alia,* to important populations of migratory salmonids, shad and eels.

2. Origins of the Rance Tidal Barrage

— EDF started to consider the construction of a tidal barrage in the Rance in the early 1940's, with the French Parliament finally passing a law to build a barrage in August 1956.

— However, the decision to proceed with construction was delayed by financial constraints and the prospect of cheaper power generation from nuclear. Gaudez[32] quotes M. Jeanneney, French Industry Minister, in early 1960 as saying "It's true that the construction of the barrage would provide work for 2,000 workers for five or six years, but… the State would be better off paying the workers to do nothing… the future is nuclear energy… the electricity produced by the Rance would, as things stand, be more expensive than that currently distributed in Brittany".[33]

— The decision to proceed, finally taken on 29 December 1960 despite Jeanneney's misgivings, reflected both the fact that the project would include a bridge between St Malo and Dinard and General de Gaulle's priorities and vision of France's historical destiny. As de Gaulle said at the opening ceremony on 26 November 1966, "Just as the Rance flows to the sea because her source sends her there, so France is true to herself when she advances towards progress".[34] The Rance barrage should therefore be seen in the same context as other trophy projects approved by de Gaulle in this period, such as Concorde, the liner France and the nuclear power station at Chinon.

— The Rance barrage was originally viewed by EDF as a trial for a much larger barrage across the Baie St Michel between Grouin, near Cancale, and Roc near Granville in Normandy. By the mid 1960's, however, EDF was fully committed to developing nuclear rather than investing further in tidal projects. As M. Massé, Chief Executive of EDF, said at the opening ceremony for the Rance barrage, "The advent of nuclear that we are witnessing today will possibly mean that we will not follow the path opened up by the Rance."[35] Local legend has it that, off the record, de Gaulle put it even more succinctly at the opening ceremony. He allegedly turned to an aide and said, "We have done a bloody silly thing".[36]

— EDF has no plans to invest further in tidal barrages, preferring instead to develop several massive off shore wind farms off the Brittany coast as it seeks to reach its goals for power generation from renewable sources.[37]

[32] Réné Gaudez, Le Barrage de la Rance, Ouest France, 1982, page 10.

[33] "Il est vrai que la construction du barrage procurerait du travail à 2000 ouvriers pendant cinq ou six ans, mais…l'État aurait avantage à payer les ouvriers à ne rien faire…l'avenir est à l'énergie nucléaire…L'électricité produite par la Rance serait, en l'état actuel des choses, plus chère que celle qui est distribuée en Bretagne".

[34] "Tout comme la Rance coule vers la mer parce que sa source l'y envoie, ainsi la France est fidèle à elle-même lorsqu'elle marche vers le progrès."

[35] "L'avènement du nucléaire auquel nous assistons aujourd'hui, dispensera peut-être de poursuivre la voie ouverte par la Rance".

[36] "Nous avons fait une sacrée bétise."

[37] Conversation with Lénaik Derlot, Mission Eau Environnement, EDF, on 28 November 2012.

3. Environmental Impact of the Barrage

— An assessment of the environmental impact of the barrage is made harder by the fact that no environmental study was carried out prior to construction, as building took place 10 years before passage of the Environmental Protection Act.[38] In addition, it should be noted that much of the research produced on the environmental impact of the barrage since construction has been, at least in part, funded by EDF.

— In the early years of the barrage's operation, environmental issues did not enjoy a high priority. Characteristic is Gaudez' book on the Rance barrage,[39] which contains only one sentence on the environmental impact: "The ecological impact appears to be hard to assess, and even more difficult to measure." [40]

— During construction of the barrage the estuary was completely cut off from the sea for three years between 1963 and 1966. During this period the estuary was stabilised at a constant level of 8.5 metres above sea level, salinity dropped to around 10% and significant silting occurred. According to Retière[41] the transformation of an estuary characterised by a high tidal range into a basin with a constant level led to the almost total destruction of marine flora and fauna within the basin.

— Following construction of the barrage, water levels in the basin are dictated by the operation of the barrage in order to optimise the generation of electricity, and are no longer governed by the tide. As a result, water levels are on average 2.5 metres higher than before the barrage, the tidal range has been reduced by 40% and the intertidal area has been reduced from 70% to 50% of the area of the basin.

— According to Retière, it took 10 to 12 years after the commissioning of the barrage to establish a new ecological balance within the basin.

— After the 10 to 12 year stabilisation period, the new ecological balance that emerged in the Rance basin was entirely different from the environment that had existed prior to construction of the barrage. As Retière notes, the Rance had been "profoundly altered".[42]

— Certain species that had been abundant in the Rance estuary substantially or completely disappeared from the basin following commissioning of the barrage. Mauffret's[43] study of the commercial fishery in the Rance estuary prior to the barrage shows the historical abundance of flat fish, conger eel and sand eels. As Stratakis[44] and Bregeon[45] have noted, these species have substantially disappeared from the Rance basin.

— Retière and Stratakis both highlight the extent to which the ecology of the basin is dependent on the functioning of the barrage, with fish populations being vulnerable to sudden changes in water level. For example, they note instances of high fish mortality caused by abrupt drops in water level exposing previously inundated nursery areas for fish.

— The extent of fish mortality caused by migration through the barrage is unclear, as very little scientific research has been carried out. Stratakis believes that there is selection by size, with larger fish being more vulnerable to being killed or wounded by the turbine blades, and points to the fact that fish caught within the basin are of smaller size than prior to construction of the barrage. This conclusion is based on oral testimony given the absence of any environmental study prior to construction.

— Lockwood,[46]a member of MAFF Directorate of Fisheries Research, observed over 150–200 dead fish in the lock and lock pits of the barrage during an informal visit to the barrage in August 1989. This gave rise to a study carried out in the summer of 1991 that had inconclusive results, in part due to difficulty in catching enough fish to conduct a tagging programme.

— Retière and Stratakis both point to indirect fish mortality caused by the turbines, for example as a result of fish shoals being broken up by the extremely strong currents caused by the turbines and therefore becoming vulnerable to predation by birds. In this regard, they note the high concentration of gulls and cormorants in the vicinity of the barrage, a phenomenon that is still apparent today.[47]

— It is not possible to assess the impact of the barrage on migratory salmonids, as these were not present in any significant numbers in the Rance prior to construction of the barrage, probably having disappeared as a result of the canalisation of the Rance upstream of La Hisse in the first half of the nineteenth century.[48]

[38] La loi relative à la protection de la nature (loi du 10 juillet 1976).

[39] Réné Gaudez, Le Barrage de la Rance, Ouest France, 1982, final page.

[40] "Son impact écologique paraît difficilement appréciable et plus encore mesurable."

[41] Christian Retière, Énergie Marémotrice et environnement aquatique, Bulletin Trimestriel de la Société pour l'étude et la protection de la nature en Bretagne, No 160/161

[42] "profondement transformée".

[43] Michel Mauffret, Vie, pêche et traditions de la Rance, Éditions Cristel, 2007.

[44] Sophie Stratakis, L'environnement du Bassin Maritime de la Rance, 1986, p 61.

[45] L.Bregeon, La Rance: étude d'un milieu en vue de sa préservation et de son aménagement, 1973.

[46] S J Lockwood and S M Baynes, Fish Mortality at the Rance Tidal Power Barrage, MAFF Directorate of Fisheries Research, 1992.

[47] 150–200 gulls and six cormorants were observed on the seaward side in the immediate vicinity of the turbines by J M White on 28 November 2012.

[48] Mauffret, Page 42.

4. Silting of the Rance Marine Basin

— One of the most important developments since the construction of the barrage has been the very high degree of silting that has occurred within the basin. This has become an extremely controversial issue between EDF and the communities on the banks of the Rance basin.

— It has been estimated[49] that currently 30,000 m3 of silt are being added each year to the marine basin and that, for example, the level of silt at Mondreuc is now eight metres above sea level.

— François Lang, Chargé de Mission, Mer et Littoral, at Coeur Emeraude, a local environmental protection agency, looked in detail at water levels in the marine basin for the years 1980, 1981 and 1982[50] and found that, in order to optimise power generation, slack water at high water was being maintained for up to 8 hours and at low water for up to 4 hours in a 24-hour period. The long periods of immobile water favour the deposition of sediment, as does the fact that low water seldom drops below 3.5 metres above sea level.

— The effect of this has been to silt up to a great extent the bays within the basin as well large parts of the central channel, covering previously sandy areas of the bottom with a thick layer of silt. Lang has observed that in many areas silting has become so extreme that plants have colonised zones that were previously flooded at high water. This has had the effect of turning parts of the basin into salt marsh, thus eliminating areas that were previously valuable nursery areas for fish and feeding territory for birds.

— Appendices 1, 2 and 3 illustrate the remarkable extent to which silting has occurred within the Rance marine basin.

5. Lessons for the Severn

— Clearly the ecological effects of the Rance barrage are unlikely to be directly transposable to other potential sites for tidal barrages such as the Severn estuary. For example, the level of silting that would occur would depend on the amount of sediment in the water and the way in which a barrage in the Severn would be operated. Equally, the extent of mortality caused by the barrage will depend on the size and fragility of the organisms present and the speed of rotation of the turbines. Given the complexity of the systems involved, modelling and predicting the precise impact is unlikely to be feasible.

— What can be observed, however, is that the experience of the Rance demonstrates that construction and operation of a tidal barrage causes a permanent fundamental change to the ecology and geomorphology of an estuary.

— The obvious difference between the Rance and the Severn is one of size. The Rance is a small river, which prior to construction of the barrage did not have significant population of migratory salmonids or eels. By contrast, the Severn is the longest river in the UK and the rivers Severn, Wye and Usk that flow into the Severn estuary are home to significant populations of migratory salmonids, eels and shad. As a result, the environmental impact of a barrage in the Severn would, in absolute terms, be much greater.

[49] Au fil de la Rance, Rance Environnement, November 2012.

[50] François Lang, peuplements des fonds durs du bassin maritime de la Rance ; rôle fonctionnel de Eupolymnia nebulosa (Annélide polychète),1986.

APPENDIX 1

Viaduc de Lessard in the 1930's (above) and in September 2012 (below).

APPENDIX 2

Pointe du Chêne vert in the 1930's (above) and in 2011 (below).

APPENDIX 3

Plage de la Ville-Ger in the 1950's (above) and in 2012 (below).

December 2012

Written evidence submitted by Don Metcalfe, Bristol Channel Federation of Sea Anglers (SEV55)

During my 60 years plus association with the waters of the Bristol Channel, an area of outstanding beauty ruled by Nature, has already witnessed two human attempts to control its velocity by taming it for Man's greed and profit.

A mixture of coastline comprising rugged cliffs, pebble and sandy beaches, estuaries, peninsulas. extensive mud flats, sandbanks, islands and last to materialise human habitation which has led to industrialisation. But it is the Channel waters that change the scenery twice every 24 hours and produce the world's second highest rise and fall in heights and yield changing speeds of over seven knots on the fortnightly "spring" tides. Because of the carriage of sediments from the many rivers near the terminal ending, many millions of mud/silt lies in suspension and this only terminates near the Somerset/Devon border.

Do not decry the colour of the sea as below the wave's lives of new world of life as any marine zoologist will confirm, not only of the Fishes and smaller marine creatures but Plants as well. I will not even attempt to discuss the multitude of bird life that congregates within the full estuary.

Now it seems that once again for the third occasion there are a limited few who wish to try, repeatedly try, to dominate Nature by placing a barricade across the estuary under the pretence of providing another source of less-expensive fuel by means of taming the waters with mechanical means such as turbines etc.

Business folk and scientists abounding in degrees, surrounded by computers residing mainly in city offices, ones who hardly appreciate the meaning of fresh air, and who have almost lost the use of good eyesight will contest the coastal folk who know the waters, the tides, the weather over countless years of experience.

I have accumulated a hundred and one stories in this connection but use one small incident. Many years ago in my angling weekly column I discussed the lost of major bait grounds if the then proposed barrage was built which would retain permanent volumes of seawater inside or up-channel.

It was read by two Salisbury scientists who fairly criticised my writings and kindly paid me a visit. I explained the area concerned and how they were obtained just over at low water on the bigger tides. My query was what would happen to these creatures if their present residence was permanently covered by some six feet of saltwater? Acute disappointment came with their reply that these worms would simply move further up the beach, in theory this was acceptable, BUT the ground was now solid carboniferous limestone which would have been seen had a visit been accomplished!

Recreational Sea Angling

The waters of the Bristol Channel including Severn Estuary attract recreational sea anglers from all parts of England and Wales. The coastline offers all methods of this sport participation and for the boat angler, Minehead, Watchet, Burnham-on-Sea, Weston-super-Mare and Portishead are departure points for vessels in excess of six metres from the English side. There are 17 licensed boats available for anglers and many smaller privately-owned craft.

Winter months can provide cod, codling, whiting, pouting; Spring will yield flatfish, rays and dogfish followed by conger, more species of rays, bass, sole, huss, dab, mullet smoothound and mackerel as the most commonly-taken fish. Salmon and Twaite Shad move upstream towards the freshwater and are protected. Silver/green eels (Anguilla Anguilla) are now also protected and may only be netted under licence.

This context only refers to the English waters and these writings are only related to the Bristol Channel Federation of Sea Anglers which comprises 26 Fishing clubs and one Welsh sea angling club (total membership approx. 2,500) and venues, species taken are extracted from the BCFSA records. It has been estimated that there are some 20,000 resident anglers within Somerset, Avon and Glos.

Similar figures would be obtained from the Welsh Federation of Sea Anglers governing the coastline from Swansea to the second Severn Bridge. In addition there will be the holiday anglers.

Where once sea fishing was regarded as a simple affair and as a means of catching something for tea; the present day picture gives the gives rise to a major sport with Government figures of approx. two million, and an expenditure of £538 million (*Drew Study* 2004). The earlier *Nautilus Report* (2000) in Wales estimated inshore angling as £ 28.7 million. The *Symes Report* (2002) estimated that inshore angling was worth £140 million.

The latest DEFRA Report on numbers, value etc. virtually confirms the tables set between 2000–05.

Summary

Any changes within the area would have a disastrous effect on sea life where natural channels would be blocked; a much higher density of sediment which would destroy underwater animal and plant life. ie natural feed. Machinery to control any Barrage would result in unaccountable deaths of adult and mature-breeding fishes. There would be changes in current, direction and speeds of the water. The increased risk if pollution within a proposed Barrage confine where no exit existed which would extend far beyond the risk to fish life.

Again natural changes of temperature with the Barrage area with species would be subjected during winter and summer periods.

Finally I have had 52 years of experience in fishing the Bristol Channel—first hand. Add a reasonable scientific knowledge at Bristol University (three years); Practical experience of competence having represented my country and Great Britain for 13 years; Fished in South Africa three x one month; New Zealand two x two months; The Gambia & West Africa 10 years x one month; Kenya nine years x three weeks; Canada four weeks; most of European saltwater.

December 2012

Written evidence submitted by the Avonmouth Community Centre Association (SEV56)

Avonmouth Community Centre is situated in the immediate vicinity of the Bristol Docks area. Our organisation works with local people supporting and delivering various activities, including activities that address local unemployment and health.

We are concerned that the Severn Barrage as proposed would have a detrimental effect on the local economy. After considering information both for and against the barrage, we believe that there would be a net loss of jobs in the area and no overall gain to the economy.

Livelihood in this area is significantly dependant on the fact that this area is a port. We believe that the barrage would damage future options in expanding the port's capacity and curtail future growth. Should the barrage cause a disruption to the local economy, then we believe that community organisations like ourselves will consequently suffer. Higher unemployment, and generally less money coming into the area impacts upon the lives, health and wellbeing of local people. With less money to spend on activities based here, and increased challenges in tackling the subsequent issues leading on from a barrage's negative economic impact, our work will be more difficult, and the organisation less sustainable.

We are also concerned about the impact of the turbine on wildlife and the disruption to the natural ecology of the area. We do not accept that it will increase tourism, and feel that the damage done to the environment may reduce this.

Our organisation is part of a network of local businesses and community organisations that is working hard to secure a more prosperous environment to live and work in, and to secure better outcomes for all. The barrage proposal, in our view, threatens this. We are keen to see investment in greener, sustainable technologies, and believe that there are alternative options that could be explored that do not harm the economy and ecology of the area in the way we believe the barrage will.

December 2012

Written evidence submitted by the Severn Rivers Trust (SEV57)

INTRODUCTION

1. The Severn Rivers Trust is pleased to be able to submit evidence to the Energy and Climate Change Committee Select Committee inquiry into the proposal for a Severn Barrage.

2. The Severn Rivers Trust is an independent environmental charity established to secure the preservation, protection, development and improvement of the rivers, streams, watercourses and water impoundments in the Severn catchment and to advance the education of the public in the management of water and the wider environment.

GENERAL COMMENTS

1. We attach great value to the Severn Estuary for its international importance for wildlife, and for the economic and social benefits that this provides. The Severn estuary has the second highest tidal range on the planet and is rightly protected under the European Habitats directive and as such should be preserved for present and future generations.

2. The Severn Rivers Trust did contribute to the Department for Energy and Climate Change (DECC) feasibility study which concluded with a public consultation in April 2009.

3. At that time the Severn Rivers Trust supported the report produced by the Wildlife Trusts, *Energy at any price?* which coincided with the public consultation: http://www.wildlifetrusts.org/publications. The report examined each of the five short-listed options in turn. The Severn Rivers Trust and Wildlife Trusts did not support any of these five options, and believe that a barrage from Cardiff to Weston would have a devastating impact. We were, and remain, interested in more innovative options which were on the table at the time—none proposed to block the flow of the tide in such a devastating way, and therefore held the most promise for the best technology possible, with the least impact. The Severn Rivers Trust believes that they should still be researched further.

4. Whilst nothing more has been heard about those more innovative technologies, Hafren Power has come forward with a proposal—yet we have not seen a detailed technical proposal to date. As such this evidence is based on the work which we undertook during the DECC feasibility study. Without detailed information on the Hafren Power proposal it is very difficult to assess the impacts and make informed comments. However we remain deeply sceptical that a shore-to shore barrage on the scale of that envisaged can be delivered without unacceptable damage to the Severn Estuary, its wildlife and heritage, and the tourism, recreational and commercial activity that this supports.

Specific Questions

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

1. The Severn Rivers Trust supports the UK's targets to reduce greenhouse gas emissions and the Government's ambitions to tackle climate change and increase the proportion of overall energy generated from renewable sources. We share the sense of urgency in deploying and developing solutions to move the UK towards a low carbon society. However, deployment of large-scale renewables cannot be at the expense of our wildlife, habitats or the environment; it is essential that the right technologies are developed in the right place.

2. The two year feasibility study carried out by the DECC demonstrated that whilst the Cardiff-Weston barrage would have the highest energy production 8.64 GW, with CO_2 savings per year of 7.2mt and cost per unit of energy 12.9p/kWh, it also had the greatest overall impact, with far more intertidal habitat loss than any other option. More than 95% of habitat within protected areas would be lost (20,000ha). The safe passage of fish species to all tributary rivers and downstream through the estuary would be impeded, leading to likely regional extinction of Atlantic salmon and Twaite Shad. In addition the migration of Eels would be adversely impacted, particularly in the early stages of their life cycle, which is in the main passive, therefore any obstruction or delay to their migration could have severe consequences to the Eels' long term survival.

3. As such the proposed Cardiff-Weston barrage would fundamentally change the Severn's ecology, affecting both people and wildlife.

4. We need to ensure that decisions made balance our energy needs against the Estuary's ecological, recreational, social and cultural value. The Severn Rivers Trust believes that any development should respect the intricate natural processes which have developed here over millennia, and at present we do not believe that a Cardiff-Weston Barrage does this.

What risks and opportunities could it pose with regard to flooding in the Severn Estuary, and how might any risks be mitigated?

5. The Severn Rivers Trust believes that there are far more risks associated with the Cardiff-Weston barrage than opportunities, especially with regard to flooding. Far from bringing benefits, a tidal barrage is likely to make our coast less resilient against the effects of sea level rise. In addition to the issue of overland flooding the possibility of ingress of sea water into ground water aquifers on both sides of the estuary, resulting in contamination of freshwater has, as far as we can establish, not been considered in detail. Therefore further research is urgently required into this issue.

6. There has been much talk that a barrage is likely to bring major flood relief benefits due to the reduction in tidal flow and therefore the amount of sediment in the water, which will lead to increased sediment deposition on foreshores. However, lessons arising from both the surge-tide barrage across the eastern Scheldt in The Netherlands and the tidal power barrage at Annapolis Royal in Canada, both silty estuaries like the Severn, have resulted in foreshore erosion, rather than deposition. These examples show how removal of energy from coastlines has unexpected consequences potentially resulting in flood defences being undermined in the long-term as foreshores become less muddy rather than muddier.

7. The ecology and the shape of the Estuary are constantly changing due to the complex interchange of water and sediment. This regime distinguishes it from other estuaries and influences the whole ecosystem. Technology that extracts some of this energy will inevitably affect the way the coast develops. The main impact will be to reduce sediment supply to the coast and to increase sedimentation in the sub tidal area. This means that putting any structure in the Estuary will lead to some degree of erosion. In the long-term this process has important implications for flood defences and other coastal structures such as ports, railway lines and roads.

What risks and opportunities could it pose to wildlife and habitat in the Severn Estuary, and how might any risks be mitigated?

8. The Severn Estuary is an extensive site of international importance for coastal and marine biodiversity, with much of the Estuary designated as a Site of Special Scientific Interest, a Ramsar site (a wetland of international importance), a Special Protection Area and a Special Area of Conservation. Furthermore there are 228 Wildlife Trust nature reserves in the region, totalling 3,450ha, and 17 Living Landscape schemes covering 372,700ha, or 1,400 square miles. Up to 16 reserves would be affected by construction of a barrage, including the destruction of part of the Penarth Coast SSSI, and with it The Lavernock nature reserve, if the proposal was on a similar alignment to the original Cardiff-Weston barrage proposal.

9. It is one of the major estuarine sites for unique invertebrate species, providing irreplaceable habitat for some 69,000 overwintering waders and wildfowl, over one hundred species of fish and a nursery ground for 10 species of commercial fish. Its extensive saltmarsh, mudflats and sub tidal reefs are important features in their own right, with some estimated 10 million tonnes of sediment carried up and down the Estuary on a spring tide—it is the dynamic nature of the Estuary which not only makes it unique but also presents the opportunity to harness energy from the second largest tidal range in the world.

10. In terms of risks and opportunities for wildlife and habitat in the Estuary, the Cardiff-Weston barrage is likely to have significant impacts on this internationally important Estuary and so once more The Severn Rivers Trust believes this poses risks on an unprecedented scale. We do not believe that there are opportunities for wildlife and habitat by extracting energy from the system.

11. With reduced sediment mobilisation the water column will no longer provide sediment onto the mudflats and sand flats resulting in the loss of these habitats. This would have a profound effect on the Severn Estuary's wildlife, including its internationally important bird and fish populations. It is not merely loss of habitat which is represented here, but the total disruption to the ecosystem on which many species depend.

12. The huge productivity within the mudflats of the Severn makes it a winter refuge for white-fronted geese, and thousands of widgeon, teal and pintail, which migrate from Russia. It is also an essential refuelling stop of long distance migrants that winter in sub-Saharan Africa and pass through the UK twice in spring and autumn. Adults and young birds need to put on half their body weight in fat to enable them to make these journeys, therefore biologically rich estuaries like the Severn are vital. A reduction in the area available due to the development of a Cardiff-Weston barrage would have significant impacts on bird numbers and is likely to result in a significant adverse effect on site integrity.

13. The survival of fish populations would also be severely threatened. Fish passage to all tributary rivers within the Severn Estuary, including the improving Wye, and the Usk Special Areas of Conservation (SAC) would be hindered. Salmon for example enter the Estuary system and swim up and return on average 15–20 times before finally making their way upstream. This could mean that a salmon would have to try and pass through the turbines 15–20 times, increasing the risk of mortality. This would have a catastrophic impact on populations of migratory fish and lead to severe decline or local extinction of species such as genetically distinct Atlantic salmon and Twaite Shad. Loss of important nursery and feeding areas could also result. Juvenile Eels without the ability to swim during this stage of the life cycle drift across the Atlantic for between 21 and 28 months and on reaching the estuary continue their migration almost entirely by means of the incoming tide in order to reach the tributaries and the freshwater environment they require to mature into adulthood before returning to sea to spawn. Any impedance to migration could have a catastrophic impact on their survival.

14. The Severn Rivers Trust believes it would be almost impossible to mitigate all the risks associated with a full barrage across the Severn. The DECC feasibility describes the chance of finding like-for-like habitat elsewhere as "impossible". Any habitat creation, it admits, would have to be on an "unprecedented" scale.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

15. When assessing the potential environmental impacts of a Severn barrage it is important that comparisons and lessons learnt are made using examples from estuaries that are similar to the Severn. As detailed above (in relation to flood risk) one of the key environmental considerations is the alteration in geomorphology in the Estuary and as such comparisons needs to be made with similar silty estuaries. Research undertaken during the DECC feasibility study suggests that La Rance is not a suitable comparator for considering possible changes on the Severn. La Rance lies on a rocky coast and its form is largely determined by hard geology. Thus, its overall form is unlikely to change greatly, even though localised changes in sedimentation and erosion will occur. In addition its sediment was mainly sandy—unlike the Severn which is a sink for fine sediments in various locations.

16. The La Rance scheme was built as a pilot for a proposed much larger tidal power scheme which was cancelled due to the devastating impact the La Rance scheme has had on its own estuary and adjacent marine environment during its construction and post build. Furthermore the poor performance and severe adverse environmental impact of the La Rance scheme is the source of ongoing controversy. The construction of a storm surge barrage has had, and continues to have significant impacts on the Estuary ecosystem. There has been significant and ongoing coastal erosion, as predicted for the Severn. This has resulted in loss of important habitat, expected loss of bird populations over the next 50 years as a result, and ongoing cost to the taxpayer to mitigate the increased flood risk.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

17. The DECC feasibility study considered a short-list of five options, which were assessed as part of the study. As we are yet to see technical proposals from any private developer, or otherwise from Government, it is impossible to comment at this stage whether such a proposal is in breach of EU legislation although it is highly likely to do so. We acknowledge that the proposal from Hafren Power is an ebb/flow, low-head barrage to sit across the Cardiff-Weston alignment, however, given the likely magnitude of impacts to European wildlife

sites, including the Severn Estuary and its tributary rivers, and the low confidence in mitigation and compensation measures of the original Cardiff-Weston barrage, we consider it highly doubtful that the proposal could comply with the European Directives.

18. Legal advice which was attained jointly with WWF-UK, the Wildfowl and Wetlands Trust, and the Wye and Usk Foundation in 2010 stated "If compensation cannot be achieved in a broadly like-for-like manner, as conventionally required under the Directive, then the proposals for the barrage as they stand cannot be lawfully fulfilled, because they cannot show the compensatory measures necessitated by Art.6.4 can be attained". (In reference to the Birds and Habitats Directive).

19. As we have seen no proposal of the detail, we cannot give evidence or comment upon how the company propose to address this. However the scale of the impacts of a proposed barrage on the estuary (including geomorphology, hydrology, sea level, habitats and species, landscape and amenity value) must be subject to robust and peer-reviewed analysis. This will require not only an understanding of the impacts of the proposed development, but also of the structure, function, and ecology of the estuary, and is a prerequisite for the identification of potential mitigation and compensation measures.

Are any other proposals for tidal power projects in the Severn Estuary currently under consideration?

20. There are proposals for a tidal lagoon development in the Bristol Channel between Port Talbot and Swansea, the details of which are expected to be published in spring 2013.

21. We understand that Parsons Brinckerhoff also intend to present their proposal for the Stepping Stones lagoon in Bristol on the 11 and 12 December 2012.

December 2012

Written evidence submitted by Dr Richard Brunning, Severn Estuary Levels Research Committee (SEV58)

I am contacting the Select Committee on behalf of the Severn Estuary Levels Research Committee (SELRC), a partnership that brings together the local authorities, national heritage bodies, Universities, heritage contractors and the general public who have an active interest in the historic environment of the Severn Estuary and its adjoining wetlands. The comments below represent the views of SELRC, based on several decades of local experience and long term detailed research, but should not be taken as those of the individual member organisations or individuals.

The Cardiff-Weston barrage proposal entails the risk of serious detrimental effects on very significant heritage assets, both from the direct construction and from the impact of the associated works. The latter were not considered in the recent SEA for the Severn Tidal Energy project. The historic landscape of the Severn coast that will be impacted by the scheme is extremely significant at a European level as an excellent example of early medieval coastal reclamation. The barrage would significantly add to the cumulative impact on this precious landscape resource from existing and planned development and managed realignment projects.

In addition the wetlands on both sides of the Severn and the bed of the estuary contain a wealth of archaeological sites that have remained in a state of exceptional preservation, because of waterlogged character of the deposits. This preservation means that these sites contain a much greater level of information and therefore significance, than archaeological remains found elsewhere.

SELRC believe that because of the international significance of the historic landscape and archaeological remains that will be significantly adversely impacted by the barrage that the Committee should take these considerations into account in your conclusions and recommendations.

December 2012

Written evidence submitted by the Natural Environment Research Council (SEV60)

1. Research Councils UK is a strategic partnership set up to champion research supported by the seven UK Research Councils. RCUK was established in 2002 to enable the Councils to work together more effectively to enhance the overall impact and effectiveness of their research, training and innovation activities, contributing to the Government's objectives for science and innovation. Further details are available at www.rcuk.ac.uk

2. This evidence is submitted by RCUK and represents its independent views. It does not include, or necessarily reflect the views of the Knowledge and Innovation Group in the Department for Business, Innovation and Skills (BIS). The submission is made on behalf of the following Council: Natural Environment Research Council (NERC).

EXECUTIVE SUMMARY

3. The Severn Estuary covers a very large area (approximately 7% of UK estuary space) and is an internationally important site for migratory birds and fish, wading birds and invertebrates. It is a Special Protection Area under the EU Birds Directive, a Ramsar site, a Special Area of Conservation under the Habitats Directive and a Site of Special Scientific Interest. The RSPB estimate that some 85,000 birds rely upon the unique conditions in the estuary.

4. It is therefore important to take a holistic approach to assessing environmental opportunities and risks associated with a Severn Barrage, looking at the terrestrial as well as estuary systems. RCUK and NERC have funded research, including through UKERC, which provides the underpinning science capabilities needed to deliver the complete picture. Going forward, there is capacity to deliver science to achieve much greater levels of confidence on which to base decisions, through a combination of:

- shelf to estuary scale modelling;
- understanding the changes that would ensue in delivery of ecosystem services and their value;
- risk/uncertainty analysis;
- hindcasting; and
- scenario analysis for 2020–50 and beyond.

5. Existing research outputs funded by NERC include barrage impact work led by Alan J Gray[1] and John Goss-Custard,[2] much of which was still being cited in recent years and still provides an authoritative description of impacts.

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

6. Previous investigations (most recently in 2009) suggested that the middle barrage proposal between Lavernock Point near Cardiff and Brean Down near Weston-Super-Mare would produce over 8 Gigawatts of highly predictable clean power, approximately 6% of UK demand. This is considerably less than the 15 Gigawatts possible with a barrage further to the west, but is regarded as a good compromise between cost of construction versus power generated. Other proposals within the estuary using smaller-scale barrage or lagoon and sluice systems produced much less power, a maximum of 1.36 GW.

7. Although a barrage could replace some of the UK's demand on imported fossil fuels, contribute to energy security, and help reduce the UK's greenhouse gas (GHG) emissions, the result is dependent upon managing demand. Demand reduction through improved efficiency and behavioural change offers the UK the biggest gains including job creation, environmental protection and innovation. A highly significant reduction in energy demand could be achieved through stimulating a novel industry to retrofit housing and industrial building stock, to meet new standards of energy efficiency, driven by innovative products and services. However, the provision of clean energy is also essential in meeting the 2050 commitments on GHG reduction.

8. The lifetime of the barrage would be at least 120 years versus 40 years to 50 years for a nuclear power station, and future upgrades and maintenance could prolong the life of the structure by a considerable margin. At a regional level the development of the Severn tidal resource is potentially highly significant, especially when combined with flood protection, transportation infrastructure and other socio-economic benefits.

9. As well as the raw power figures, the barrage would be a highly visible statement of the UK and Welsh Government's intention to move towards a sustainable future.

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

10. Apparent contradictions (as occur also on the subject of water quality) are inevitable when discussing barrages, as there is a lack of empirical evidence and outcomes are likely to vary depending on the characteristics of individual estuaries and the size of schemes being planned.

11. Barrages will alter potential for flooding. In general, it is anticipated that they will mitigate sea flood risk (particularly storm surges) by providing a physical barrier that prevents seawater ingress. It is also possible that fluvial flooding could be mitigated (if there is sufficient warning) because the barrage could hold back the tide, leaving more space within the basin to accommodate increased river flows. Reducing the risk of flooding is becoming increasingly important as sea level rise and climate change may both contribute to higher incidence of extreme events such as storm surges in the future.

12. However, other factors may compound these benefits at a local level. For example, flood risk may be increased as a result of saltmarsh erosion, the restriction of river outfalls by the longer high water stand, and the possible siltation of outfalls as a result of hydrodynamic changes. Flood risk, freshwater supplies and local land use patterns may also be affected by changes to the water table and groundwater flow.

13. It should be possible to mitigate for the potential risk of flooding upstream of the barrage at the design stage but this would require forward modelling of sediment transport, rainfall, runoff, vegetation change, sea-level change etc. There is also a potential risk of down-stream scouring and associated shoreline erosion. It may be possible to mitigate for this with a geologically-based risk assessment.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

14. When addressing the potential risks and opportunities, studies such as the recent one by DBERR have focussed on how different scenarios would affect individual species. However, to enable informed decision making, a more holistic approach is required, using UK excellence, innovative research and long term data sets for the Severn estuary and Bristol Channel to answer the critical questions. As outlined in the executive summary, the science capability to address these questions already exists in NERC centres.

15. After construction of a barrage, the conditions upstream would inevitably change. For example, with reduced vertical mixing and less re-suspension of sediment, water clarity would increase, allowing more sunlight to penetrate. The reduced tidal range and greatly enhanced clarity of the water upstream would cause changes in biodiversity, favouring some species over others and leading in time to a markedly different ecosystem. Risk and potential benefits to wildlife and habitat are outlined below.

16. It should be noted that climate change, sea level rise and ocean acidification will all impact the Severn Estuary over the next few centuries regardless of whether or not a barrage is constructed—the *status quo* will not continue indefinitely.

17. Risks to wildlife and habitats

- physical disturbance (sediment plumes, noise etc during construction);
- obstruction of the passage of mobile and migratory species (with associated collision and mortality risks);
- loss of intertidal habitat;
- redistribution of intertidal habitats;
- opportunities for alien establishment (eg Spartina);
- altered water flows and sediment dynamics; and
- reduced water quality upstream of the barrage: gradual reduction in salinity and potential build-up of contaminants from pollutant sources upstream—for the Severn Estuary, the mixture of nutrients and enhanced light penetration would increase the risk of eutrophication (Langston *et al*, 2010).[3]

18. Potential benefits

- Environmental changes brought about by the barrage might benefit the ecosystem, compensating to some degree for the ecological impacts. For example, reduced turbidity may support an increase in phytoplankton biomass and primary production, which will in turn increase the food supply for the benthos, enhancing the carrying capacity of the reduced intertidal areas for feeding shorebirds. However, this may be counteracted by not only the area available for feeding, but also the time available (Goss-Custard *et al*, 1991).[2]
- There are different arguments for whether or not water quality would be improved by a barrage. Some argue that reduced current flows may reduce re-suspension of contaminants from the estuary's sediments (Prandle 2009)[4] and cause particulate matter, and the associated contaminants, to settle out of the water column. This may improve the situation in the water column, but will impact the benthos. Increased light penetration may also reduce bacterial growth.
- Enhanced water clarity could lead to higher fish population, more food for birds, shellfish aquaculture potential and a less hostile living space suitable for a wider selection of species than is possible at present, but further studies are required to confirm this.
- Work by Wolf *et al*[5] has shown that building a barrage in the Severn has implications further afield, with shifts in the amphidromic points in the Celtic Sea and reductions in tidal amplitude of the Bristol Channel that may help reduce storm surge flooding risks downstream of the barrage. Reduced bottom stress and associated velocities may permit greater bio-diversity on the seabed of the Bristol Channel.

19. Mitigation

- Risks can be mitigated by considering alternative strategies for extracting tidal energy (such as tidal lagoons or tidal reefs) and emerging turbine technologies.
- A recent study shows that members of the general public are willing to pay additional premiums to secure barrage designs that reduce intertidal habitat loss (Hooper *et al* in prep).

— With dual-mode (ebb and flow) generation, loss of mudflat habitat can be substantially reduced and a larger upstream tidal range retained after construction. This is achieved by increasing the tidal range within the basin relative to ebb mode by using the turbines as pumps to increase the head difference prior to power generation, but would increase the cost of electricity generated. However, this needs to be balanced against the potential increase in environmental impacts, including the risk of flooding land that is currently not in the present-day intertidal zone.

20. It should be noted that the impacts of a scheme progress in phases. The operational phase will have clear contrasts to the estuary without a barrage, but the construction phase may be the most damaging and certain ecosystems may not recover from that phase. Similarly, the decommissioning could have temporary but seriously damaging consequences.

What lessons can be learned from the successful development at La Rance tidal barrage in France and other tidal power projects?

21. La Rance power station has operated since 1966 and was only surpassed in terms of generating capacity in 2011 (by the Korean Sihwa Lake tidal power station). The French have invested mainly in nuclear power generation since then but, in recent years, interest in tidal renewable energy has emerged in South Korea, Russia, the Philippines, Canada, China and India.

22. Existing projects (eg Beevers and Pender, 2008[6] and Woollcombe *et al* 2009[7]) have shown that tidal power is generally safe, reliable and predictable. Governments are attracted by the highly predictable nature of tidal energy (availability of peak power is known years in advance) and by the associated benefits of the barrage such as:

— electricity production (not always the main driver, depending on location, but a valuable added benefit);

— calm upstream conditions that can enhance leisure or conditions for aquaculture and farming;

— flood protection;

— provision of a bridge; and

— job creation.

23. However, in terms of lessons learned regarding wildlife and habitats, only limited information is available from existing power plants, and there appear to be no examples of coherent, comprehensive monitoring. There are a small number of peer-reviewed articles about La Rance (eg Frau, 1993;[8] Little and Mettam,1994;[9] Kirby and Retiere,[10] 2009; Le Mao, 1984[11]) which suggest that:

— It took a decade for the ecological balance to be restored (although it should be noted that the construction method used (cofferdams) resulted in catastrophic mortality of marine species upstream).

— Sudden changes in the operating regime (eg from ebb-only to two-way) or irregular operation have also resulted in significant mortality events and organism stress.

— The area occupied by the intertidal zone was reduced from 70% to 50% of the total surface of the basin.

— Areas of the banks have eroded and sandbanks have moved.

— The barrage has also modified: low water height; tidal range; the volume of water exchanged with the sea; and the vertical range of algae.

— The variety of subtidal habitats has increased since barrage construction, with a corresponding increase in species diversity and abundance.

— The estuary remains a nursery area for commercially important fish species.

24. More recently, La Rance estuary was designated a Natura 2000 Site of Community Importance in 2004 and personal communications on the current status of La Rance (Denis Bailly, University of Brest) add that:

— Water quality upstream of La Rance barrage has declined.

— Siltation behind the barrage has increased, and requires dredging.

— The physical barrier provided by the barrage has prevented the spread of at least one invasive species. The upstream areas of the estuary have become a refuge for the European clam, which has been replaced by invasive species in other areas.

25. With regards to risk mitigation, many of the existing barrages were built some time ago (eg La Rance, 1966; Annapolis Royal, 1984) and factors such as construction techniques, turbine technology and environmental impact mitigation measures (eg fish passes) have advanced since then.

26. Routine and representative monitoring of ecological and environmental characteristics of all UK near shore should be started to form an equivalent of the terrestrial Countryside Survey. The impacts of installing devices could then be estimated and set in context against other drivers of change.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

27. Depending upon the scheme chosen, it is reasonable to assume that the construction phase of the barrage would provide employment to a significant number of workers in South Wales and the South West of England, providing a substantial boost to the regional economy.

28. Raw materials can be sourced from quarries in the region, cement from the Aberthaw works near Cardiff, reducing transportation costs and carbon footprint of construction phase.

29. After construction, direct employment by the barrage operators would not be high, with relatively small teams employed for maintenance, lock operations and other support roles. However, the barrage offers substantial opportunities for wealth creation in tourism, additional power generation, transportation links and impacts on existing ports (see *Annex A* for further detail).

30. Any constraints on shipping operations upstream of the barrage could be of benefit to ports at Port Talbot, Neath, Swansea, Milford Haven, and the North Devon coast, which all have excess capacity at present. There are clear economic risks from the silting up of existing port facilities or damage to property from downstream erosion. Modelling based probabilistic risk assessment could be the way to mitigate for this at the design stage.

31. Commercial fishing activities within the estuary are at a relatively low level and any disadvantages are likely to be outweighed by the improved water quality, reduced turbidity and higher productivity (increased sunlight penetration—more plankton, more food for fish) of water upstream of the barrage. Fisheries could be managed within the upstream area to provide a strong recreational or small scale commercial fishery.

32. There is a reasonable concern about access for migratory fish such as salmon through the barrage. Multiple fish by-pass systems will have to be included in the structure, but it is hard to assess exact impact on wild migratory stock.

33. A full life cycle assessment (LCA) of the barrage, including the complete supply chain for materials and the potential decommissioning (even in 140 years) should be performed. It will help illuminate the full costs and benefits.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

34. The construction of a barrage will result in changes to the environment that breach of EU legislation if no mitigating actions are taken. The area is designated as a Special Protection Area under the EU Birds Directive, is a Ramsar site, a Special Area of Conservation under the Habitats Directive and a Site of Special Scientific Interest. Developing a barrage is certain to contravene some aspects of these designations, due to reduction in total area of intertidal habitat and likely changes in water clarity and suspended sediment dynamics, plus disturbance during construction—all of which may affect the local biodiversity to some extent, though it has also been argued that the upstream environment could actually support wildlife in greater numbers and diversity due to removal of the high suspended sediment load from the water column.

35. At the very least, construction will legally require creation of compensatory habitat. In view of the large surface area of reduced intertidal zone (there would still be daily variation of sea level upstream of the barrage) the amount of compensatory habitat required is large, and thus difficult to source. Large amounts of low-lying land have been reclaimed on the south shore of the estuary in the last few hundred years and could provide suitable habitat, though cost of compensation to land owners (mainly this is farmland) would be high. On the northern shore the coastline is dominated by cliffs along the Glamorgan Heritage Coast as far west as the Ogwr river, with no suitable low-lying areas. There is some potential west of the Ogwr for compensatory habitat (Merthyr Mawr—Kenfig Burrows area), however, heading west the tidal range declines, reducing the quantity of available inter-tidal habitat.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

36. In the last round of proposals in 2009 the Government settled on a shortlist of five options:

Middle Barrage, Brean Down to Lavernock Point, peak output 8.6 GW.

English Stones Barrage, peak output 1.05 GW.

Beachley Barrage, peak output 625 megawatts (MW).

Fleming Lagoon, peak output of 1.36 GW.

Bridgewater Bay Lagoon, peak output 1.36 GW.

37. There were an additional five schemes which were not shortlisted in part due to immature technology being proposed such as "tidal fences" and tidal stream current devices, however, since then major companies including Rolls Royce and Alstrom have demonstrated commercial grade systems that can be scaled up to produce power without the need for a barrage structure, but with considerably lower peak electricity production

potential. Typically the new generation turbines are rated at 1.0 to 1.2 MW (examples Alstrom and MCT) so to match the 8.6GW potential of the largest barrage proposal would require an unrealistic number of generators (over 7,000) to be placed in the Bristol Channel, with complex cabling and servicing requirements compared with the "all in one row" approach of a barrage.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

38. It is important initially to understand the bigger picture rather than focus on details of particular sectors. A successful project to extract energy from the Severn estuary, through application of UK research science and engineering capabilities, could potentially kick start global interest in exploiting tidal range resource. This would allow the UK to export innovative design products, advice and services derived from the Severn experience via our international research, consultancy and engineering sectors. This would include technology for energy extraction, as well as electrical infrastructure, flood protection, mitigation of natural heritage assets etc. However, it is necessary to move quickly if this opportunity is to be grasped.

39. To focus on the international context, South Korea has already developed a tidal power scheme at Jindo Uldolmok, (90MW by end of 2013), plus a 254 MW station at Sihwa Lake, and has started construction of the 1.3 GW Incheon Tidal Power Station at Incheon Bay, due for completion in 2017, giving their engineers a strong lead over the UK. Other (smaller) schemes in the UK that could prove a good proof of concept for the Severn, such as those on the Mersey (led by Peel holdings), the Wyre barrage (led by WTE) and the Solway barrage (NB21c) are all on hold seeking the required funding.

40. The Russians have proposed an 87 GW site at Penzhin Bay in the Sea of Okhotsk, however there is a lack of demand from customers in that part of Russia so it has been suggested that the energy be used for the production of energy-intensive products such as liquid hydrogen rather than grid electricity and as yet no construction has started. The Canadians have long examined the possibility of building tidal energy schemes in the Bay of Fundy but so far only one 20 MW installation has been completed, in part because fossil fuel costs are low, especially with the glut of shale gas availability in North America—a plentiful resource not yet exploited in the UK. In the Indian state of Gujarat construction has started on a 50 MW project, and the Japanese are actively investigating using tidal energy to replace capacity lost since the Fukushima nuclear disaster.

Annex A

FURTHER DETAIL REGARDING POTENTIAL OPPORTUNITIES OFFERED BY A BARRAGE

Tourism

Public access/cycleway/footpath across the estuary would afford spectacular vistas across the Bristol Channel and a unique visitor experience, with opportunities for retail, catering and associated sectors, such as boat trips. Other possibilities could be an electric road-train or tram. Such a link could also be of value to commuters between Bristol and Cardiff if suitable public transport connections were available at the ends of the barrage.

Additional power generation

As well as the barrage's submerged turbines, wind turbines and solar panels can be installed on the topside of the structure.

Transportation links

The existing Severn Rail Tunnel was completed in 1886 and acts as a constraint on upgrading the rail network into Wales, particularly for freight operations where the tunnel is unable to accept double-stacked container traffic. Provision of a railway line from the start, or ensuring that the design includes foundations for a future upgrade may provide a possible replacement or back-up to the present tunnel—though a purpose-built bridge near the current Second Severn Crossing could be less expensive than adding a track to the barrage and be more closely aligned with the existing London-Swansea rail route. A road across the barrage would shorten the journey between Cardiff and the M5 but would require a more expensive barrage topside structure.

Impacts on existing ports

Cardiff, Newport and Avonmouth would be the main ports affected with some disruption to smaller operations in the Wye and Severn, including Gloucester and Chepstow and the inland canal network. Locks in the barrage would be required to maintain access to these ports. However, these are not intensively used harbours with frequent 24-hour ro-ro type activities. Sailings are already heavily constrained by the high tidal range of the estuary and locks are required at all of the major ports. The less extreme tidal range upstream of any barrage could actually improve harbour access, though queuing might be required at the locks in the barrage to coincide with correct tidal conditions downstream. Recreational sailors might find sharing a lock with a multi-thousand tonne car transporter rather daunting, but combined operations are possible and for small boat users, the conditions upstream of the barrage will be easier than at present.

References

1. Gray, A Ed. (1992) *The Ecological Impact of Estuarine Barrages. British Ecological Society Ecological Issues* No 3. Published by Field Studies Council, Shrewsbury, Printed by Dorset Press, Dorset.

2. Goss-Custard, J D, Warwick, R M, Kirby, R, McGrorty, S, Clarke, R T, Pearson, B, Rispin, W E, Durell, S, Rose, R J *Towards predicting wading bird densities from predicted prey densities in a post-barrage Severn estuary.* J appl. Ecol 28, (1991): 1004–1026.

3. Langston, W J, Pope N D, Jonas P J C, Nikitic C, Field MDR, Dowell B, Shillabeer N, Swarbrick RH, Brown AR. *Contaminants in fine sediments and their consequences for biota of the Severn Estuary. Marine Pollution* Bulletin 61(1–3) (2010):68–82.

4. Prandle D. Design of tidal power schemes. Maritime Engineering 162 (2009):147–153.

5. Wolf, J; Walkington, I A; Holt, J; Burrows, R; "Environmental Impacts of Tidal Power Schemes" Proceedings of the Institution of Civil Engineers Marine Engineering 162 December 2009 Pages 155–164.

6. Beevers L, Pender G. *Assessing the sustainability of estuarine barrages*. Dohmen Janssen CM, Hulscher S, editors (2008) 1101–7 p.

7. Woollcombe-Adams C, Watson M, Shaw T. Severn Barrage tidal power project: implications for carbon emissions. *Water and Environment Journal* 23(1) (2009); 63–8.

8. Frau J P. *Tidal energy: promising projects—La Rance—a successful industrial scale experiment. IEEE Transactions on Energy Conversion* 8(3) 1993: 552–558.

9. Little C, Mettam C. Rocky shore zonation in the Rance tidal power basin. *Biological Journal of the Linnean Society* 51 (1994):169–182.

10. Kirby R, Reitière C. Comparing environmental effects of Rance and Severn barrages. *Maritime Engineering* 162 (2009):11–26.

11. Le Mao P. Feeding relationships between the benthic infauna and the dominant benthic fish of the Rance estuary (France). *Journal of the Marine Biological Society UK* 66 (1986):391–401.

12. Burrows, R; Walkington, I A; Yates, N C; Hedges, T S; Li, M; Zhou, J G; Chen, Y; Wolf, J; Holt, J; Proctor, R; "Tidal Energy Potential in UK Waters" *Proceedings of the Institution of Civil Engineers Marine Engineering* 162 December 2009 Pages 165–177.

13. Burrows, R; Walkington I A; Yates, N C; Hedges, T S; Wolf, J; Holt, J; "The tidal range energy potential of the West Coast of the United Kingdom" *Applied Ocean Research* 31 (2009) 229–238.

14. Parsons Brinckerhoff. Severn Tidal Power—Scoping Topic Paper. *Marine and Estuarine Water Quality.* Report prepared for the Department for Energy and Climate Change. 2008.

15. Retière C. Tidal power and the aquatic environment of La Rance. *Biological Journal of the Linnean Society* 51 (1994):25–36.

December 2012

Written evidence submitted by the Severn Tidal Power Group (SEV63)

The Severn Tidal Power Group (STPG) carried out the original studies into a Cardiff-Weston barrage in the 1980s, and was instrumental in persuading Government to conduct the DECC feasibility study into a wide range of options for harnessing the tidal energy of the Severn Estuary. STPG is made up of leading British construction and power companies: Sir Robert McAlpine, Balfour Beatty, Taylor Woodrow and Alstom.

We produced a brochure in 2008 which discusses many of the issues affecting a Cardiff-Weston barrage which we would be pleased to send you.

1. *What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?*

The conclusion of the feasibility study published in 2010 and the Government's view is that there is not a strategic case to develop a Cardiff-Weston barrage. We remain of the view that the Cardiff-Weston barrage would be a valuable source of renewable electricity for centuries to come, but recognise that significant questions remain to be answered to satisfy the full range of stakeholders, including cost and environmental impact.

Thus it does not seem that a Cardiff-Weston barrage could make a contribution to UK energy security and climate change objectives in the short term.

We therefore consider that a pathway is needed in which smaller schemes are developed and evaluated so that a decision on a Cardiff-Weston barrage can be more evidenced based. Options should be examined which

can more quickly make a contribution to UK energy security and climate change objectives, without compromising the barrage schemes which would make a much larger contribution.

2. *What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?*

3. *What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?*

4. *What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?*

The Rance barrage has shown that the tidal barrage structure and turbines have successfully operated in the marine environment for over 45 years with no significant deterioration. Some electrical generating equipment was replaced after about 40 years which is an acceptable life for such equipment.

According to the EDF operators of the Rance barrage, there is no clear evidence of environmental damage resulting from the barrage when compared with similar adjacent estuaries along that part of the French coast.

5. *What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?*

6. *Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?*

7. *How does the company plan to engage and consult the community in the development of the project?*

8. *Are the proposals in breach of EU legislation, and if so how will this be addressed?*

9. *Are any other proposals for tidal power projects in the Severn estuary currently under consideration?*

The "Stepping Stones" lagoon concept developed by Parsons Brinckerhoff and Black & Veatch seems to meet the requirements of a first step on the pathway. It has little impact on protected environmental areas, is of a size that can be developed by the private sector (given planning consent), and uses proven technology. Also, it does not interfere with development the larger barrage proposals, nor the operation of the existing ports.

Lessons learned from the construction and operation of such a scheme, including environmental impacts, would provide valuable for evidence-based evaluation of a Cardiff-Weston barrage later along the pathway.

We therefore consider that the merits of developing such a scheme should be carefully considered by the Select Committee.

10. *What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?*

There is great international interest in renewables, and the construction in the near future of a relatively modest project, though still big compared to existing tidal energy schemes, would give UK engineering and UK low-carbon industry an international advantage.

December 2012

Written evidence submitted by Mark Barry (SEV65)

There is a debate, growing in intensity, related to the future economic development of the UK and how all of the country can contribute equitably to GDP, as opposed to the current situation which has seen the UK as a whole become too dependent on financial services and the SE England. Lord Heseltine's recent report on the subject adds further to this debate and strengthens the case for some new strategic thinking.

Underpinning any strategic change in direction must include a realignment of major infrastructure investment to support growth in major conurbations in places liked Leeds, Manchester, Newcastle and yes Cardiff, South East Wales, Bristol and South West England—Severnside.

The concept of a Severnside region did gain some traction up until the 1960s/70s. However, the devolution debate and its implementation put that debate on the back burner and turned its proponents into heretics. However, perhaps with a new maturity from both Welsh Government and civic society and a recognition that on some strategic matters cooperation across the Severn is mutually beneficial, the time for Severnside has come again; not a political entity, but as a means of collaborating and planning strategically for this inextricably linked region to deliver wider economic benefits. This, after all, is a region of five million people containing two Russell Group universities and a broad economic base with potential for further growth and development. It also has, especially in parts of South Wales some serious economic challenges.

The signs are positive; I was involved in encouraging the establishment of the Great Western Partnership, which now includes an alliance of business groups, local authorities and transport experts along the Great Western Line. The GWP has successfully lobbied for the electrification of the GWML to Swansea and has set out a case for further upgrades of the GWML to deliver journey times between Cardiff and London/Heathrow of 80 minutes or less.

There is also growing optimism as regards the Severn Barrage. This transformative project has the potential to create 10,000s of jobs and provide a significant source of dependable, renewable energy well into the 22nd Century. In addition, the Davies commission is once again revising airport capacity and the role and location of a Hub airport in the SE England—this has an impact on us all in "Severnside" given our dependence on Heathrow (more than any other region of the UK).

So, perhaps, now is time to develop a cohesive economic vision for Severnside that sits easily within Welsh Government aspirations for the Welsh economy and is aligned with UK Government and SW England interest, there is much common ground and potential for collaboration.

A strategic Severnside economic vision must be based on the establishment of 21st Century energy and transport infrastructure. This will have the barrage at its heart and dovetail its regeneration and transport connectivity with its undoubted renewable energy capability.

Given the barrage's transport links, then Cardiff and Bristol airports could be only 15/20 minutes on a dedicated rail shuttle. These two airports could effectively operate as one—Bristol on the short haul routes and Cardiff with a runway extension, could service long haul. This could provide part of solution to the capacity issues in the SE England Davies is exploring, by allowing Severnside to retain more of its demand with the region.

A rail link across the Barrage could also enable a high speed Severnside "Circle Service", linking Cardiff, Bristol, Newport, Cardiff airport, Bristol airport and extend to Swindon in the east and Swansea in the west. In addition, The South Wales Metro project will augment the commitments to electrify the Valley Lines and create a truly joined up City Region in SE Wales. The Greater Bristol region is also embarking on a major programme of enhanced regional connectivity over the next ten to fifteen years. In essence, we begin to see the emergence of a connected Severnside region of nearly 5M people that can rival the Bay Area around San Francisco in California.

The construction of the Severn Barrage will also result in Port Talbot having the capacity to become a major container port on western edge of Europe and augment the capacity already offered at Avonmouth. Port Talbot's location on the UK Motorway network and on the GWML main line make this an ideal location develop a new deep water container terminal able to handle the new breed of large container vessels now coming into service.

This is the kind of ambition and strategic approach needed, something that will set the region on a course in the 21st Century, of economic growth and development to reverse what has been a slow inexorable decline in the post war period. A strategic Severnside approach is that; one that combines and integrates a number of projects that can transform the economies of South Wales and South West England.

The creation of the nascent Western Gateway Group of which I am a member is most welcome as a means of developing and advocating such proposals. However, in due course, it will need both the Welsh and UK Government's to join forces to put the meat on the bones to create a Severnside vision that can help rebalance the UK economy.

December 2012

Written evidence submitted by the Renewable Energy Association, Ocean Energy Group (SEV66)

The Renewable Energy Association (REA) welcomes the opportunity to submit evidence to the Energy and Climate Change Committee for the new enquiry into a Severn Barrage. The REA represents British renewable energy producers and promotes the use of sustainable energy in the UK. The membership is active across the whole spectrum of renewables, including wave and tidal, electric power, heat and transport fuels. Members range in size from major multinationals to sole traders. There are over 800 corporate members of the REA, making it the largest renewable energy trade association in the UK.

The REA's main objective is to secure the best legislative and regulatory framework for expanding renewable energy production in the UK. The Association undertakes policy development and provides input to government departments, agencies, regulators and NGOs.

In order to cover sector-specific issues, a number of so-called "Resource Groups" have been set up. The Ocean Energy Resource Group (OEG), comprising more than 100 individuals, covers wave energy and tidal energy. The primary focus of the Group is the progress of energy conversion device and array development to prove the capability and survivability of full-scale projects, and the legislative measures required to support and finance projects in order to bring them to commercial fruition.

The proposed Cardiff-Weston barrage scheme is of fundamental interest to the OEG and may have wide-ranging impacts on development of the tidal energy industry in the UK, as well as the renewable energy sector as a whole. This response to the ECCC enquiry was formulated following discussions at a number of meetings of the OEG and includes input from the REA's experts across the whole spectrum of the renewable energy sector.

The UK Tidal Energy Resource

In 1997, the Marine Foresight Panel reported: "It has been estimated that if less than 0.1% of the renewable energy available in the oceans could be converted to electricity, it would satisfy the world demand for energy more than five times over."

The UK possesses 50% of Europe's tidal energy resource (10–15% of the global resource). Exploitation of both tidal stream and tidal head energy offers significant benefits to the UK, through the supply of a clean, renewable and secure source of energy and by contributing to the UK's 2020 targets for reduction in carbon emissions.

General Comments on the Severn Tidal Power Feasibility Study

The REA welcomes the opportunity to submit evidence to the ECCC enquiry into a privately financed Severn Barrage scheme. We are pleased that the government will reconsider this option for exploiting the UK's unique and significant power resource in the Severn Estuary—on the same order of magnitude as a conventional power station—while at the same time recognising the challenges of mitigating social, economic and environmental impacts of such a project.

We believe that large renewable energy projects, such as a Severn tidal barrage, must become part of the energy mix if the UK is to achieve its ultimate target of an 80% reduction in carbon emissions by 2050. However, it is vital that the government maintains a long-term view, continuing to support and encourage all other forms of clean energy technology. We are concerned that the government may become complacent once such a large scheme has been consented, ignoring the fact that the 15% target by 2020 represents only a staging post to a contribution way over 15% by 2050.

Evidence on specific topics to be addressed by the enquiry

1. *What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?*

As documented in the feasibility study funded by DECC in 2008–10, a barrage crossing the Severn estuary from Brean Down, near Weston super Mare to Lavernock Point, near Cardiff would have an estimated capacity of over 8.6 GW—twice that of the UK's largest fossil fuel power plant—and could generate nearly 5% of UK's current electricity demand.

The 2020 renewable energy target of 15% requires deployment at an unprecedented rate, so the sooner the UK can accelerate development the better. Renewable electricity only makes up around 8% of current electricity production and will require a four-fold increase by 2020 in order to make the necessary contribution of 30% to the energy mix, as estimated by DECC[51].

However, set against this is the fact that even if the largest barrage were to be completed—and it could be counted towards the UK meeting its 2020 target, even if not completed—this still leaves the bulk of the renewables target to be met. The target is mandatory and the Government cannot afford to take its eye off the ball.

2. *What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?*

The REA understands that the potential for flooding may be reduced in the Severn estuary behind the barrage, but there is a danger that coastal flooding may be increased on the seaward side.

3. *What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?*

It is widely accepted that global warming is the greatest environmental challenge currently facing the human race. The REA believes that the benefits of a tidal barrage for mitigation of climate change would outweigh negative impacts on environmental conservation, although within that proviso, we also believe that all available measures should be applied to reduce harm to the environment.

The documented environmental impacts of a Severn barrage include the loss of bird habitat (mud flats uncovered at low tide) and consequent changes to the existing ecosystem, erosion by waves generated within the impoundment area and reduced suspended sediment load, leading to problems with upstream sedimentation.

[51] The UK Renewable Energy Strategy 2009.

Much data on the behaviour of marine mammals and their interaction with turbines continues to be generated through the ongoing monitoring programme for the Seagen tidal power station in Strangford Lough. Although this is a tidal stream (rather than a tidal head) installation, the data is very relevant to the impacts of rotating machinery on marine wildlife. The evidence after three years of monitoring is that no major impacts on marine mammals have been detected.[52]

An interesting beneficial impact of marine construction for wildlife was noted by members of the REA's Ocean Energy Group during a trade mission to New Zealand in 2009. The walls of a fish farm in Marlborough Sound provided an attractive haul-out site for marine mammals.

4. *What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?*

- The REA understands that the road traffic benefits offered by the barrage across the Rance in northern France were not taken into consideration prior to construction, although they are now widely recognised by the local and tourist population. A number of parties have suggested that the possibility of a Severn Estuary road crossing over a barrage should also be considered.
- Both the Annapolis Royale and Rance barrages incorporate a visitor centre, attracting tourists and hence revenue to the region. We believe that this should be taken into account for the social and economic impact assessments of the Severn barrage scheme.
- The Rance barrage has provided a safe area for marine leisure activities (e.g. dinghy sailing and kayaking) on the upstream side, which is enjoyed by the local population.
- The Eastern Schelde storm surge barrage is a useful analogue for predicting the physical and geological impacts of a barrage in the Severn Estuary. A presentation on this subject was given by Roger Morris of Natural England at the REA's WATTS conference in 2008. Further information is presented in his paper.[53]

5. *What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?*

The REA is not qualified to comment on this question.

6. *Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?*

Under current legislation, a tidal barrage of over 1GW in capacity would not eligible for ROCs and the REA agrees that the RO is not an option for a large barrage, given the long term nature of the support needed and the finish of the RO in 2017. However, there is no logic behind excluding it with respect to eligibility for a CfD and we are pleased that the ECCC enquiry will explore this issue.

It is important that the electricity output is subject to the same market forces as other electricity, in order to encourage generation at peak times so that integration with the grid is facilitated. Similarly it is desirable to reduce the cost of capital. Therefore a tariff mechanism that pays a premium over wholesale prices, rather than an absolute tariff, is preferable.

We do not currently hold information about the level of strike price that would be required to make the project economically viable, but if the REA is invited to give oral evidence to the ECCC Committee, we will consult our membership and provide an approximate strike price.

7. *How does the company plan to engage and consult the community in the development of the project?*

The REA has no information on this subject.

8. *Are the proposals in breach of EU legislation, and if so how will this be addressed?*

The most contentious issue for any proposed tidal barrage across the Severn estuary is that of environmental impacts on a site protected under EU legislation, because much of the estuary and surrounding mud flat is part of the Natura 2000 network of EU protected sites. The EU Habitats Directive prohibits projects which have an adverse effect on features of the site, unless:

- No viable alternative is possible.
- Imperative Reasons of Overriding Public Interest (IROPI) is demonstrated.

There is certainly no viable alternative in the UK for a barrage scheme on the scale of a Severn barrage and in view of concerns about climate change and the EU renewable energy targets, arguments in favour of IROPI may well prevail. However, there would still be a requirement for environmental compensation and mitigation

[52] http://www.marineturbines.com/sites/default/files/SeaGen-Environmental-Monitoring-Programme-Final-Report.pdf

[53] *Morris, R.K.A., 2012. Geomorphological analogues for large estuarine engineering projects: A case study of barrages, causeways and tidal energy projects:* Ocean & Coastal Management, June 2012.

measures. If these are considered by the Statutory Nature Conservation Bodies to be inadequate or if they are too expensive to implement, hard decisions must be taken regarding the relative priority of environmental concerns on a global scale (ie mitigation of climate change) and the protection of local features. It is important to bear in mind that in the longer term, global warming may well destroy the beneficial effects of local conservation measures.

9. *Are any other proposals for tidal power projects in the Severn estuary currently under consideration?*

- Pulse Tidal Ltd has been granted an Agreement for Lease of a tidal stream site off Lynmouth, N Devon. The impacts of a barrage on this project must be considered.
- The REA believes that other projects are being considered for the Severn estuary, in particular tidal lagoon projects. We do not have further details at present but will investigate if requested to present oral evidence to the ECCC Committee.

10. *What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?*

No comment.

11. Further comments

The REA remains concerned about the financial and environmental risks of the Cardiff—Weston barrage and believe that a prudent way forward would be to build a small barrage initially, to assess the costs and monitor the environmental impacts, before progressing to a larger barrage.

One way to overcome this dilemma would be to first build a small barrage elsewhere (for example on the Mersey or Solway Firth) and conduct a thorough, practical evaluation of the social, financial and environmental impacts. If the impacts were deemed to be acceptable, a large barrage could be built on the Severn Estuary, utilising the full tidal head resource.

December 2012

Written evidence submitted by Natasha Barker Bradshaw and Professor Graham Daborn (SEV67)

The Bay of Fundy, Canada—lessons learned for tidal power development

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

Executive Summary

The existence of the La Rance tidal barrage may prove that the tidal power technology is viable in itself, but not that it has a viable future in the Severn Estuary. The implications of impounding the Severn Estuary are at a scale that is not comparable with La Rance to inform decision-making here. More relevant comparisons should be drawn from experience in the Bay of Fundy, Canada, which has the highest tidal range in the world. This paper highlights some lessons that can be learnt from the assessment of tidal power potential from the Bay of Fundy where a small tidal barrage has been operating since 1984, but where further or larger tidal barrages are no longer considered viable—due to the outcomes of hydrodynamic modelling, experience from other dams/causeways, community engagement and co-ordinated research. The Canadians have moved on to more benign and reversible technologies.

Content in this paper is also relevant to the questions:

- What risks and opportunities could it pose with regard to flooding in the Severn Estuary?
- What risks and opportunities could it pose to wildlife and habitat in the Severn Estuary?
- How does the company plan to engage and consult the community in the development of the project?
- Are there any other proposals for tidal projects in the Severn Estuary currently under consideration?

1. La Rance compared to the Severn

KEY POINT: Barrage technology has not been proven in a large dynamic tidal environment such as the Severn Estuary.

1.1 The 240 MW La Rance barrage, is around 20 times smaller than an 8,640 MW Severn scheme. It is barely half a mile long, compared to nearly 10 miles, impounds just nine rather than 185 square miles, and generates around 0.64 TWh per year, less than 4% of what the Severn barrage would. The ecology, the geography, and the scheme design itself are all different between La Rance and the Severn and comparisons are of limited relevance (FoE, 2007).

1.2 Claims from La Rance that *biodiversity* may increase (e.g. Kirby, 2006) are probably only valid because habitat *diversity* has increased (and not necessarily productivity). By comparison, the very *high productivity* of

the Upper Bay of Fundy is related to the highly dynamic behaviour of the sediments and the *low biodiversity* that is found there. Changes to the Severn Estuary could cause loss of species that are particularly well adapted to the special environmental conditions: the fact that other species may establish themselves doesn't compensate for that loss.

1.3 Whilst the technology for creating electricity from turbines in a tidal environment has been demonstrated, this does not mean that a tidal barrage across the Severn Estuary is viable. Comparison with more similar tidal environments—in terms of scale and silt concentration, such as the Bay of Fundy—are more relevant. Comparison with the Bay of Fundy illustrates the substantial risks associated with the construction and operation of a large tidal barrage in the Severn Estuary.

2. Annapolis Royal Tidal Barrage, Canada

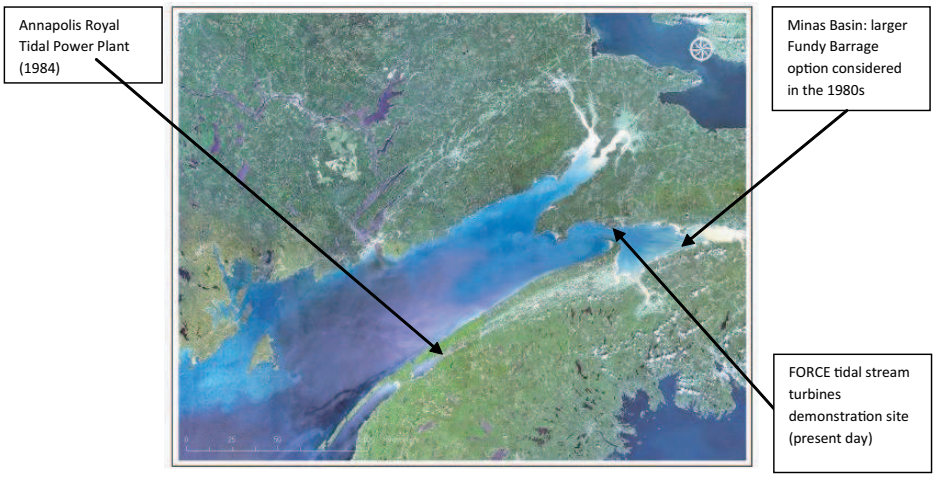
KEY POINT: Annapolis Royal Tidal Power plant was a pilot scheme for larger tidal barrage proposals in the upper Bay of Fundy during the 1980s. It has not led to further consideration of larger tidal barrage options.

2.1 The Annapolis Royal tidal barrage in Nova Scotia has been operating since 1984 on a pre-existing causeway across a tributary river into the outer Bay of Fundy. It's purpose was to evaluate the performance of a single large diameter (7.6m) straight flow (*straflow*) turbine of the kind that might be used in a larger Fundy scheme. The turbine generates electricity for six hours during ebb tide and is connected to the Nova Scotia Power Grid System. The 18MW plant (smaller than La Rance) produces enough electricity to power about 6,000 homes.

2.2 There have been several problems associated with the Annapolis Royal tidal scheme; fish mortality, erosion problems downstream and the health of the river upstream. The detrimental effects on fish populations have been long term.

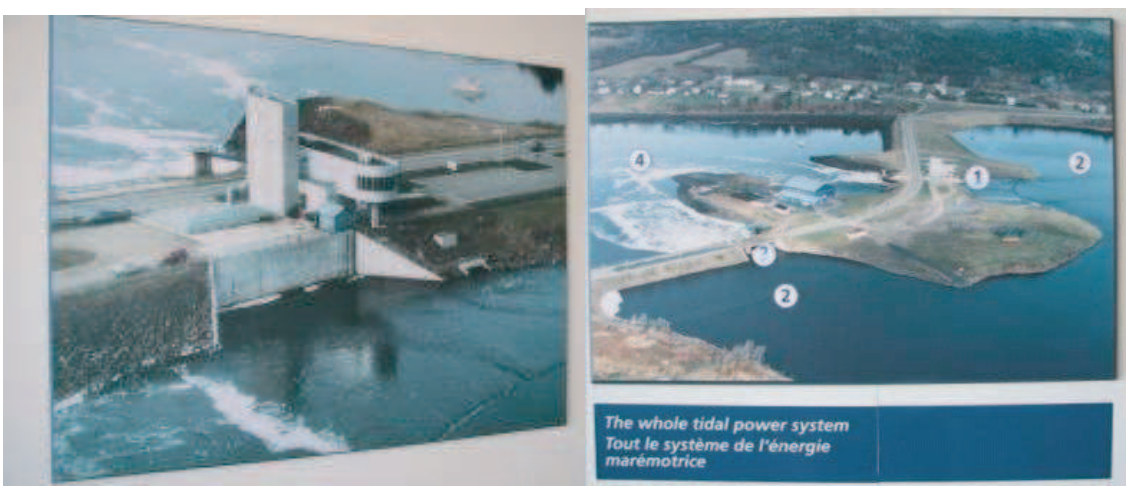
2.3 The Annapolis tidal barrage is situated on a tributary river which flows into the *outer* Bay of Fundy. The silt concentration in this outer area of the Bay of Fundy is different and much less than that of the *upper* Bay of Fundy, where there is a higher tidal range and higher silt concentration.

2.4 As with La Rance, there is therefore limited opportunity to compare this small scheme to a larger scheme as it operates in a less dynamic estuarine environment. It was also realised that it was not feasible to scale-up the effects of a small single turbine installation to a larger tidal barrage.



The Bay of Fundy

Source of basemap: Dr Danika van Proosdij, St Mary's University, Halifax, Nova Scotia.



The causeway across the Annapolis with the tidal power plant; upstream (left) and downstream (right).

3. Larger Fundy Barrage Options

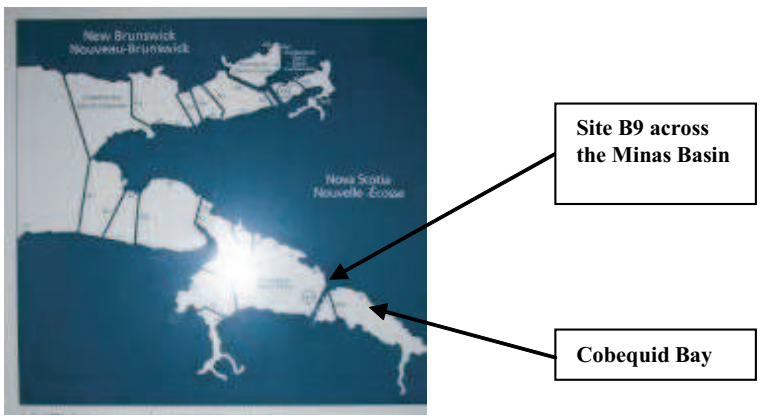
KEY POINT: The predicted impacts of a larger tidal barrage in Fundy were shown to substantially change the tidal regime with largely unpredictable consequences.

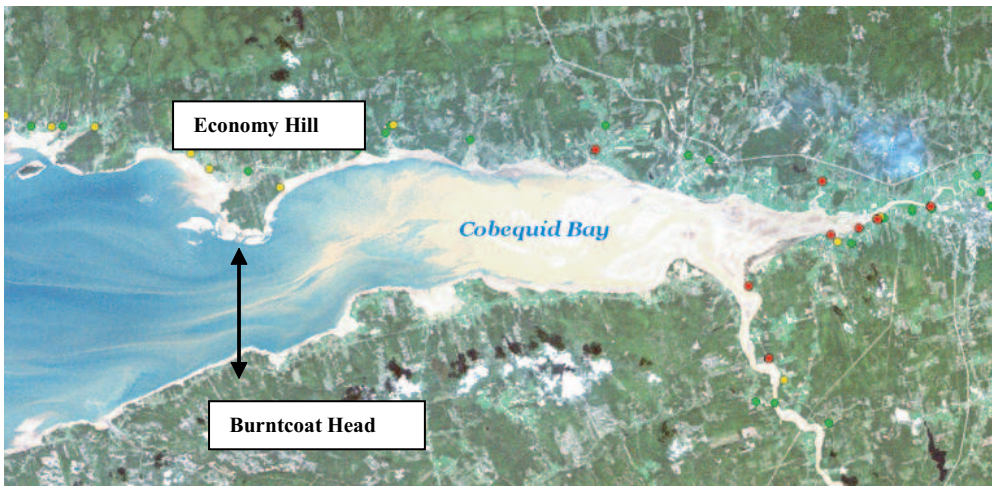
3.1 The potential for generating energy from the Fundy tides was first suggested in 1912. Over the next 50 years there were sporadic and unsuccessful attempts at development.

3.2 The 1960s saw increasing investigations, with the Atlantic Tidal Power Programming Board making the first examination of the tidal resource as a whole and identifying the most promising sites for tidal barrages (Conley & Daborn in *Energy Options for Atlantic Canada*, 1983).

3.3 In the late 1970s, improvements in technology, understanding of the resource and the increasing price of fuel, led to designs for two sites that appeared to be economically feasible.

3.4 The greatest potential was shown by the **Minas Basin-Cobequid Bay barrage** option in the upper Bay of Fundy (site B9 on the diagram). Capacities of 4000–5300 MW were estimated to give an annual energy output of 14000–20000 GWh. It was envisaged that the B9 site would contain 128 turbines in an eight km (five mile) barrage and impound more than 300km^2 (115 square miles) of tidal water in Cobequid Bay in the upper part of the Minas Basin. **This is smaller but more comparable to the Severn Estuary.**





Source of base map: Dr Danika van Proosdij, St Mary's University, Halifax, Nova Scotia.

The upper Bay of Fundy—Minas Basin—showing the approximate location of the preferred tidal barrage site B9.

Minas Basin from Economy Hill looking towards Burntcoat Head, site of the highest recorded tides in the world and the most favoured location for a tidal barrage in the 1980s.

3.5 Investigations during this time illustrated significant potential impacts of a barrage, particularly in relation to changing the tidal regime. Hydrodynamic numerical modelling indicated that the construction of a barrage at site B9 in the Minas Basin was estimated to cause a **13cm rise in tidal amplitude in Boston, New England (USA), more than 600km away.**

3.6 Whilst no environmental assessment was carried out at that time, a considerable amount of research was undertaken. It was realised that large gaps existed in the basic knowledge necessary to predict the environmental consequences of a tidal project. Many individuals and agencies therefore undertook research co-ordinated by the Fundy Environmental Studies Committee to increase understanding, so that the impacts could be better predicted. The conclusions from this co-ordinated research included, for example:

- Removal of energy from the system will modify the physical oceanographic system of the Bay of Fundy-Gulf of Maine-Georges Bank (FMG) system, with unknown consequences on biological resources for North America, from the Arctic to the tropics.
- Altering tidal current patterns leading to changes in the location of mudflats and saltmarsh; questions remaining on the length of time they would take to stabilise and recover biological productivity.
- Tidal upwelling in the important fish, seabird and marine mammal feeding grounds in the outer part of the Bay which is determined by the tidal range.

3.7 Following this work, the emphasis on tidal renewables moved towards tidal in-stream energy devices which carry much less risk. The benefits (EPRI, 2006) were reported as:

- utilisation of an abundant, cleaner & relatively pollution free resource;
- creation of jobs, economic development and improved energy self-sufficiency;
- relatively fewer aesthetic impacts compared to other energy options.

Dr Graham Daborn, Emeritus Professor at the Acadia Centre for Estuarine Research - a world-leading expert on estuaries points out that:

"Estuarine silt can't be modelled in the same way as sand - a non-sticky grain. As a living thing containing many molluscs, bacteria and worms, silt deposits are stickier than sand and do not simply wash away. In fact, silt accumulations could be around 80 times stronger than traditional modelling predicts. He states that, "such accumulations would quickly fill up an estuary".

3.8 In 2006, the government of Nova Scotia established a committee on renewable energy, with particular attention being paid to possible demonstration sites for tidal (sub-sea) turbines. This led to the Fundy Strategic Environmental Assessment for Marine Renewable Energy in the Bay of Fundy (OEER, 2008) with a background report (Jacques Whitford, 2008) and response (Nova Scotia Dept of Energy, 2009).

3.9 Feasibility studies progressed during 2007–08 did not include further assessment of tidal barrage options due to the perceived impacts and risks. The Nova Scotia Marine Renewable Energy Strategy (May 2012) focused on in-stream tidal generation, with the door left open for lagoons or shore-based impoundments, but *not* for barrage-based developments. This contrasts significantly to the work of the UK's Sustainable Development Commission (2007) which focused only on a Severn Barrage, followed by Feasibility Studies by the Dept of Energy & Climate Change (2010) which mainly considered tidal barrages and lagoons.

4. Siltation, flooding and erosion risks

KEY POINT: Tidal causeways/dams across tributaries to the Bay of Fundy illustrate the significant alteration of river systems with rapid, unpredictable consequences and no foreseeable return to a state of dynamic equilibrium.

4.1 Tidal causeways/dams and barrages built for flood/coastal defence or infrastructure purposes across tributary rivers into the Bay of Fundy have caused significant and unpredictable siltation, flooding and erosion. Impacts on the river systems have been significant, particularly in relation to the changes to siltation patterns. This has resulted in a higher perception of the risks associated with larger tidal barrages and any future large tidal power scheme. There has been relatively little experience of the siltation caused by dams/causeways around the Severn Estuary because bridges have been built instead (e.g. across the R. Usk in Newport, and across the R. Avon in Bristol) therefore we have less direct experience of the impact on silt deposition, erosion and flooding risks . This appears to have been a determining factor in limiting further consideration of a large tidal barrage for renewable energy in Canada, but it is receiving less profile in the UK.

4.2 **River Avon Causeway (Windsor)—Upper Bay of Fundy**

Rapid accumulation of mudflats seaward of the causeway, grew to 6–8m above the original sand bar, with nothing growing on them for over two decades after the causeway was constructed. **Ecosystem responses to modifications of these macrotidal estuaries take decades to develop, so the environmental effects are prolonged.** These changes are continuing (albeit at a slower rate) *some 40 years after the construction*. Discussions about replacing the causeway with a bridge concluded that a) it was too expensive; b) it opened up large areas that would be vulnerable to regular flooding (unless even more expensive coastal protection was provided) to deal with post-causeway and future sea level rise; and c) the ecosystem of the estuary will never return to its former state.

4.3 **Petitcodiac River Causeway (Moncton)—Upper Bay of Fundy**

A similar scenario has been experienced on the Petitcodiac River, where a causeway was built in 1968 to prevent agricultural flooding and improve access to the town of Moncton. Whilst the causeway was being built the engineers saw the immediate build-up of silt on the downstream side. An estimated 10 million cubic metres of silt was deposited in the 4.7 km of river downstream from the causeway in the first three years following construction. The causeway restricted the movement of fish and reduced the region's salmon catches by 82% Water quality deteriorated, and the tidal bore (a popular tourist attraction) was eliminated. In 2003, the

Petitcodiac River was designated as the most endangered river in Canada because of these problems. **The dynamic equilibrium of the river and estuary system did not appear to be stabilising, with less predictable flood risk consequences. It was considered better to try and revert back toward the estuary system prior to construction of the causeway over four decades earlier.** In 2010, the causeway's gates were therefore opened permanently as part of a $68 million three-phase project designed to restore the estuary, to be completed by 2015.

http://www.tripsister.com/petitcodiac-river-causeway-gates-opening/#

The road causeway over the R. Petitcodiac at Moncton led to significant build-up of mud flats & salt marsh. In 2010, 42 years after construction of the causeway, gates have been opened to try and restore the original tidal flow upstream.

4.4 In both the Avon and Petitcodiac causeway cases, new large mudflats developed progressively for many years at rates so great that they did not consolidate. They remained so fluid that the typical fauna of bivalves, amphipods and polychaetes was established only decades later.

4.5 There is much public agitation for removing some of the smaller tidal barriers around Fundy, and, following the successful legal challenges that led to the partial opening of the Petitcodiac Causeway, there is discussion about removing the Avon causeway as well.

4.6 These examples show that construction of a tidal barrage is likely to require a very long period for the re-establishment of habitats**. The consequences could be severe for shorebirds and fish but also carry substantial risks to society & the economy, with less predictable patterns of erosion & silt deposition affecting coastal & flood protection.**

4.7 Other major rivers in the world such as the Columbia (USA), Snake (USA), Mississippi (USA), Colorado (USA) and Nile (Egypt) provide stark examples of major downstream effects of barriers ie dams, one or more, on riverine and estuarine systems. Effects have been measured on water quality, the fate of contaminants, fish migration, sediment transport, nutrient transport and the size and condition of their deltas (highly productive biologically and reduced significantly in size), as well as on human health. Ecological effects are extensive and considered largely irreversible (Wells, 1999).

4.8 These results make it worthwhile to compare further the conditions in the Bay of Fundy (and elsewhere) with those in the Severn Estuary. Published studies are available (see Reference list) and there are studies conducted by the Department of Fisheries & Oceans Canada on the River Pedicodiac and St. Mary's University and Acadia University on the River Avon.

5. Community Engagement in Tidal Power Options for Fundy

KEY POINT: The Fundy Strategic Environmental Assessment (SEA) shows how engaging and consulting the community as an inherent aspect of the decision-making process over tidal power options is more likely to lead to outcomes which are sustainable for society, economy and the environment.

5.1 In spring 2007, the Canadians undertook a Strategic Environmental Assessment (SEA) focusing on tidal energy development in the Bay of Fundy. Community input was through forums, workshops, written submissions, an extensive website, monthly newsletter, 24-person stakeholder roundtable and funding for community-based participation and research initiatives.

5.2 Recommendations included the development of a **collaborative research program** for marine renewable energy development to address:

— immediate needs related to demonstration projects;

— longer term requirements for commercial development;

— the understanding, prediction, mitigation and monitoring of far-field and cumulative effects;

— the eventual determination of ecosystem carrying capacity limits.

The priority research areas were informed by workshops that brought together local and national experts to inform the focus on hydrodynamic modelling.

5.3 Recommendations to guide a strategic approach to the development of marine renewable energy included **ten sustainability principles** intended to ensure that marine renewable energy **developments respect ecological integrity and make positive contributions to the social, economic and cultural well-being** of Nova Scotia. They included:

— Commercial application of marine renewable energy developments should go ahead only when a proponent can demonstrate that there will be **no significant adverse effects on the fundamental hydrodynamic processes** of the Bay of Fundy tidal regime (energy flow, erosion, sediment transportation and deposition) or on biological processes and resources.

— Until **near and far-field effects of marine renewable energy are well understood** and deemed to be acceptable, development should take place incrementally, supported by an effective and transparent research and monitoring program. Installations should be removable, and clear thresholds should be established to indicate when removal would be required.

— Research, monitoring and decision making related to marine renewable energy should be carried out in an open and transparent manner. The public should have access to all environmental & resource assessment information, respecting the need to keep certain commercial information confidential. Requests by proponents to keep information confidential should undergo stringent review.

5.4 The SEA recommended **proceeding in a cautious and incremental manner**, beginning with a demonstration program of technologies suitable for application at different scales and locations. The program should initiate **longer term research needed to predict cumulative and far-field effects** in the commercial phase.

5.5 Demonstration projects and any future commercial developments should be designed to be removable, and effects thresholds should be established to determine under what circumstances devices should be taken out of the water.

5.6 Stakeholders felt that sustainability was the key issue with respect to the possible development of tidal energy in the Bay of Fundy where:

— the development of marine renewable energy must not be allowed to significantly affect the complex biophysical systems in the Bay of Fundy or the livelihoods that depend on harvesting renewable resources from the Bay;

— Marine renewable energy development should not be permitted to outpace our understanding of its effects (short and long term, near and far-field) and our ability to mitigate them. A cautious approach is essential.

5.7 The Canadians are forging ahead to test and refine tidal in-stream energy devices to create a commercially viable technology appropriate to the Fundy environment. They have partnered with **Marine Current Turbines Ltd.** (MCT)—based in Bristol, UK—to test its technology in the Bay of Fundy. This has the potential to provide economic impacts in the Atlantic region and position Canada as a world leader in marine renewable energy.

Conclusion

The Bay of Fundy and Severn Estuary are two sites with the highest tidal ranges in the world. At a similar time to the last in-depth studies on the Severn Estuary (1970s and 1980s) there was significant investigation into the economic, environmental and technical feasibility of barrage options for the Bay of Fundy. This led to the building of a trial tidal generating station in a pre-existing causeway across the Annapolis River in Nova Scotia. It provided a valuable platform for research on environmental implications of barrage-based tidal power, especially for fish passage, seawater-groundwater interactions, shoreline erosion, etc. over the past 25 years.

Investigations into the feasibility of a larger tidal generating station in the upper Bay of Fundy, comparable to a Severn Barrage, were carried out in the 1980s. The significant impact predicted from the most favoured location for a larger barrage scheme, were major changes to the tidal regime leading to unpredictable consequences, carrying too much risk.

Experience from the Bay of Fundy on the response of estuaries to the construction of causeways and dams, has raised awareness of the unpredictable consequences where there are high silt concentrations.

The Bay of Fundy represents a much better analogue for the Severn Estuary than does La Rance. In particular, it would be worthwhile to share knowledge of sediment studies, the creation of new habitat and effects on flood & coastal erosion risk management.

This paper illustrates why we must recognise the limitations of comparisons to La Rance tidal barrage: the same technology may not be viable in the larger dynamic Severn environment.

There should be greater evaluation of the impacts of larger scale impoundments in other more similar tidal environments, particularly the scale of change to intertidal sediment regimes and their consequences. Evidence from the Bay of Fundy illustrates the risks of large scale schemes and benefits of progressing tidal technology in a more incremental manner.

The continued focus on a Severn Barrage is distracting from the incentive to identify other potentially more sustainable and truly renewable tidal energy devices for the Severn. Whilst taking a low-risk approach, the Canadians are pioneering commercially viable tidal stream generation utilising technology developed in the UK.

Recommendations

1. Put measures in place to better co-ordinate and support ongoing scientific research, particularly with regard to hydrodynamic modelling.

2. Investigate thoroughly lessons that can be learnt from other (potential) tidal barrage locations including (but not limited to) those in China (Jiangxia plant) and North Korea (Sihwa tidal generating station), dams in Netherlands (Eastern Scheldt) and the Bay of Fundy, Canada.

3. Increase investment in non-barrage tidal power technology that could work more in harmony with the natural dynamics of the Severn Estuary.

About the Authors

This paper is based on research undertaken for a Winston Churchill Memorial Trust Fellowship including a study visit to the Bay of Fundy:

Barker, Natasha (2008) **Managing Tidal Change: Phase 1 Project Report: Bay of Fundy, Canada.**

Natasha Barker Bradshaw has worked in the management and planning of coastal environments for the past twenty years. This has included ten years managing Estuary Partnership initiatives in South-West England and South Wales, co-ordinating community, government and private sector interests to promote sustainable resource use. Whilst working for the Severn Estuary Partnership (based at Cardiff University), Natasha was awarded a Winston Churchill Memorial Trust Travelling Fellowship to study estuaries with the highest tidal ranges in the world—including the Bay of Fundy. This paper does not reflect the views of any organisation Natasha works or has worked for.

Graham Daborn is Professor Emeritus at Acadia University. A graduate of the University of Keele (UK) and the University of Alberta, he was the founding Director of the Acadia Centre for Estuarine Research (ACER), which was established in 1985 to focus attention on estuarine environments, such as the Bay of Fundy. ACER research studies have covered a wide range of topics in estuarine research, and have been carried out in the Canadian Arctic, Europe (Humber Estuary, Venice Lagoon), South America and New Zealand. Most of the research has dealt with the effects of human modifications of estuaries and coastal waters, such as the construction of causeways, the dredging of harbours, the addition of nutrients or contaminants, watershed management issues, and tidal power. From 2004 to 2007 Daborn was the first Director of the Academy for the Environment at Acadia University. From 1996–2004 he chaired the Bay of Fundy Ecosystem Partnership, a virtual institute concerned with increasing cooperation between governments, communities, resource users and industries in development of sustainable futures for the communities and resources of the Bay of Fundy. His current activities relate mostly to the environmental implications of generating renewable energy from the marine environment, especially from tidal currents in the Bay of Fundy, and the potential development of marine protected areas in the Bay of Fundy.

A list of Graham Daborns' references selected to be of most relevance to this submission:

Campbell, L., N. Clark, **G. Daborn**, J. Goss-Custard, A. Gray, M. Hill, S. Lockwood, S. McGrorty, R. Mitchell, S. Muirhead, J. Pethick, P. Radford, R. Uncles, J. West. 1992. ***The Ecological Impact of Estuarine Barrages***. Edited by A. Gray. British Ecological Society, Ecological Issues No. 3. 43 pp.

Daborn, G.R. (Ed.) 1977. ***Fundy Tidal Power and the Environment***. Publication No. 28. Acadia University Institute. iv + 304 pp.

Conley, M.W. and **G. R. Daborn** (Eds). 1983. ***Energy Options for Atlantic Canada***. Formac Publishing Co. and Acadia University Institute. 157 pp.

Daborn, G. R. (Ed.) 1986. ***Effects of Increases in Sea Level and Tidal Range on the Bay of Fundy—Gulf of Maine System***. Publication No. 1. Acadia Centre for Estuarine Research. vii + 133 pp.

Daborn, G.R. 1982. ***Environmental implications of Fundy tidal power.*** Proc. Conference on Hydro and Tidal Power Options for Atlantic Canada. Publ. No. 30. Acadia University Institute. 16 pp.

Amos, C., M. Brylinsky, H. Christian and **G.R. Daborn**. 1994. ***Steps toward a model of cohesive sediment behaviour.*** *In* Coastal Zone Canada '94 : Cooperation in the Coastal Zone. P.J. Wells & P. Ricketts (Eds.) Vol. 4:

Daborn, G.R. and A.M. Redden. 2009. ***A century of tidal power research in the Bay of Fundy, Canada, and the enabling role of research networks.*** J. Ocean Technology IV (4): 1–5.

Daborn, G.R., A.M. Redden and R.S. Gregory. 1982. ***Ecological studies of the Annapolis Estuary***, 1981–82. Publ. No. 29, Acadia University Institute. 80 pp.

Daborn, G.R. 1982. ***Environmental implications of Fundy tidal power***. Publ. No. 30, Acadia University Institute. 16 pp.

Daborn, G.R. 1984. ***Environmental considerations of tidal power***. *In* Conley, M. and G.R. Daborn (Eds). Energy Options for Atlantic Canada. Formac Press and Acadia University Institute. Pp. 107–118.

Daborn, G.R. 2001. ***The Derby Tidal Power Project: An examination of the 1997 Consultative Environmental Review for Environmental Effects that might necessitate abandonment of the Project***. 10 pp.

Daborn, G.R., M. Brylinsky and D. Van Proosdij. 2002. *Environmental Implications of Expanding the Windsor Causeway*, NS. ACER Report No. 69. 108 pp.

Daborn, G.R., and M. Brylinsky. 2004. Fish Population Studies of the Avon Estuary, Pesaquid Lake and Lower Avon River, 2003. ACER Report No. 79. 145 pp.

Isaacman, L., G.R. Daborn and A.M. Redden. 2012. A framework for environmental risk assessment **and decision-making for tidal energy development in Canada.** Final Report to Fisheries and Oceans Canada and Nova Scotia Department of Energy. 50 pp.

OTHER REFERENCES

EPRI (2006) Electric Power Research Institute. **North America Tidal In-Stream Energy Conversion Technology Feasibility Study.** Roger Bedard, Ocean Energy Leader, EPRI, 1 May 2006.

Friends of the Earth (FoE, 2007) **The Severn Barrage** September 2007.

Hawboldt, Stephen (2006) **Tidal Power: A green dream?** *Gulf of Maine Times, Volume 10, Number 12.*

Kirby, R. (2006) **Links Between Environmental Consequences of La Rance and Severn Tidal Power.**

Barrages.https://ice.adobeconnect.com/_a884535394/p45039984/?launcher=false&fcsContent=true&pbMode=normal

Nova Scotia Dept of Energy (2009) Bay of Fundy Tidal Energy—A response to the Strategic Environmental Assessment.

Nova Scotia Dept of Energy (2012) Marine Renewable Energy Strategy.

OEER (2008) **Bay of Fundy Tidal Energy Strategic Environmental Assessment Final Report**. Prepared by the OEER Association for the Nova Scotia Department of Energy. Submitted April 2008. Final Report 92pp.

http://www.gov.ns.ca/energy/resources/EM/tidal/Tidal-SEA-Report-screen.pdf

Pethick, J.S, Morris, R K A, Evans, D H (2009) **Nature conservation implications of a Severn tidal barrage—A preliminary assessment of geomorphological change**. *Journal for Nature Conservation Vol 17, Issue 4, December 2009 pp183–198.*

Van Proosdij & Bambrick (2006) **Spatial and Temporal Variations in the Intertidal Geomorphology of the Avon River Estuary.**

Wells, P (1999) **Environmental Impacts of Barriers on Rivers Entering the Bay of Fundy: Report of an *ad hoc* Environment Canada Working Group.** Atlantic Region 1999, Canadian Wildlife Service, Environment Conservation Branch. Technical Report Series Number 334.

Jacques Whitford (2008) **Background Report for the Fundy Tidal Energy Strategic Environmental Assessment.** 291 pp.

Website links sourced for this research:

Further information about the demonstration site under development: http://www.gov.ns.ca/energy/renewables/public-education/tidal.asp

http://www.gov.ns.ca/energy/renewables/current-activity/tidal.asp

Nova Scotia government news: http://www.cbc.ca/news/canada/nova-scotia/story/2012/09/12/ns-fundy-tidal-power.html

Acadia University research: http://acer.acadiau.ca/FERN.html

Fundy Ocean Research Centre for EnergyFORCE http://fundyforce.ca/

Nova Scotia Renewable Energy Plan http://nsrenewables.ca/about-plan

Nova Scotia Tidal In-Stream Energy Conversion (TISEC): Survey and Characterization of Potential Project Sites http://www.epri.com/oceanenergy/streamenergy.html#reports

http://www.gov.ns.ca/energy/renewables/current-activity/tidal.asp

http://www.gov.ns.ca/energy/resources/EM/tidal/Tidal-SEA-Report-screen.pdf

http://www.gov.ns.ca/energy/renewables/public-education/tidal.asp

River Petitcodiac: http://www.petitcodiac.org/index.php?page=home&hl=en_US

December 2012

Written evidence submitted by South and West Transport Action Group (SEV68)

INTRODUCTION

1. The Parliamentary Energy and Climate Change Committee call for evidence on proposed Severn Barrages invitation, is herewith gratefully acceded to.

2. An important BBC Wales News Report of 5 November 2012 is titled "*Scrapping Severn Crossing tolls would boost economy.*" Insertions in the direct contexts are indicated by [ ].

3. It reveals Wales "First Minister Carwyn Jones said control of the Severn bridges should be transferred to the Welsh Government in 2018."

4. It continued "Mr Carwyn Jones said he wanted [in parallel with the Select Committee] to talk to the UK [Cameron] Government, about what happens when the concession ends [2018], with one option being that full control of the tolling regime is handed over to the Welsh Government.

5. He [Carwyn Jones] said it would be "unacceptable" for the UK Government to retain the income from the tolls, as it would create a "strong perception that drivers coming into Wales were being charged—directly or indirectly—to fund Department for Transport spending in England."

6. I [Carwyn Jones] want to work with the UK Government [and presumably the Select Committee(s)] to achieve a situation where decisions ... [in which] there are a number of options available [for the future including a key option transforming the Second Severn Crossing into a barrage, like at La Rance, St Malo, Brittany, France].

7. "[Although] it is too soon to say what the best situation [advocated here optimally as a multi-purpose barrage on the immediately adjoining seawards side of the Second Severn Crossing] would be."

8. The Department for Transport said it regularly met [including on its parallel responsibilities for Climate Change reductions by 80% before 2050] the Welsh Government, and that conversations about the future [hopefully adequately implementing the barrage advocated herewith] of the Severn Crossings would continue.

AN OUTSTANDING SEVERN BARRAGE

9. The important insertions above highlight the option of transforming the Second Severn Crossing into a barrage by "filling in the gaps." This would follow the **model barrage configuration** of La Rance barrage; by setting in train five key elements of a multi-purpose barrage directly adjoining the line of the Second Severn crossing.

Generally, it is essential that fill to the barrage is derived from South Wales colliery waste, especially Aberfan with the remainder left after 1966. This is to be brought by rail to the Severn barrage construction sites, and used preferably as larger not powdery aggregate. Please note all South Wales collieries are now closed. Barrage power is predictable, like navigators know of tidal flows.

10. Key element **one** is double-acting pump turbines as at La Rance. These generate the cheapest electricity currently in France. This is because debt incurred to build La Rance has been defrayed from large-scale "renewable" power output cumulatively from "free" water. This is especially so because double acting pump turbines allow tidal predictable electricity output to be retimed to coincide more with peak usage.

11. Key element **two** is a rail crossing on the line (but slightly seawards to avoid the piers) of the Second Severn crossing. The Severn Rail Tunnel would continue to be maintained as it would still be used, particularly where the locks for shipping to Sharpness and Gloucester etc were open to navigation and the barrage route closed.

12. The Second Rail Tunnel of 1886 is only 25 feet in diameter, and is not large enough to carry hi-cube and newer larger freight containers. The Severn Tunnel forms part of a key Trans-European Network rail corridor to Southern Ireland, via Fishguard. It thus merits supplementation by a Severn Barrage; both to **power** the railways renewably, and to allow hi-cube and newer larger freight containers to reach South Wales and Ireland; without a lengthy diversion, like road in 1966 Severn Road Bridge times, via Gloucester.

13. When the Severn Bridges Act 1992, was in its House of Lords Bill stages the writer, on behalf of the Railway Development Society Severnside, petitioned Parliament. Although the described future situation was clearly foreseen in a precognitary way, unfortunately the petition was rejected. Five days afterwards, there was the Severn Tunnel Rail Accident of 7 December 1991, 20 years ago. Although, fortunately, no one was killed, still today only one train is allowed in the tunnel at a time; and capacity on an intended to be electrified main line is seriously limited.

14. Readers are asked to make note there is a small railway (for inspection etc) within the structure of the Second Severn crossing. Somewhat similarly there are standard-gauge railway lines used mainly for cranes on La Rance barrage.

15. Key element **three** includes the locks, within the co-ordinated sluices, turbine channels, and fish passes. As highlighted in paragraph 11, the locks would be sufficient to accommodate shipping to Sharpness and Gloucester. However, a more suitable course of action would be to buy out and cease through compensation Sharpness Docks traffic. This would mean less lock use, and also smaller locks would suffice.

16. The locks could potentially impound fresh (potable) water in connected reservoirs. Thus the locks could impound an essential element of a wet west to dry east water transfer grid network.

17. Key element **four** is the road crossing. From the scenario above less lock use also means less disruption to the new Severn Barrage road crossing. The new road crossing would serve both for maintenance and to service the barrage itself with its facilities. It would not be competitive with the Second Severn crossing.

18. Key element **five** extends the basic thrust of elements one and three. A Severn Barrage at the "English Stones" between Studbook and Pilning has been intended since 1933. It was a major interwar regeneration project under the aegis of Lieut Colonel J A Moore-Brabazon MP, who later became Lord Brabazon of Tara after becoming Minister of War Transport in Winston Churchill's Second World War Government.

19. The 1933 Brabazon barrage included a high-head reservoir for pumped storage power at Trellech in the Wye Valley. This is not-on today for scenic reasons; so the high-head adjunct is moved to Hafodyrynys near Pontypool, with both east and west dams. A canal would link the lower Severn north of the Severn Barrage to the River Usk, followed by pipelines to Hafodyrynys. The scheme would resemble the existing Dinorwig high-head pumped storage scheme in North Wales near Snowdon.

20. The Government's 2010 Severn Barrage studies, mainly examined a Cardiff-Weston barrage, costing about £34 billions. However, it also studied a "Shoots" barrage at the English Stones, on the historic line since the 1933 Brabazon barrage in paragraph 18. This Pilning to Sudbrook alignment is parallel to the Severn Rail Tunnel of 1886.

21. There is a DECC/DEFRA letter about Severn Barrage**s** to the European Commission of 18 October 2010, that concludes the scheme option of "a "Shoots" barrage [is] also potentially feasible." In the letter's final paragraph it is set out "In this context, we [the UK Government] would very much like to discuss the findings of the feasibility study [including the "Shoots" barrage] with the [European] Commission." This DECC/DEFRA letter is appended at the end of this report.

22. "Potentially feasible" greatly understates the need for the Severn "Shoots" barrage in contributing to the, parallel in 2008, Climate Change Act 2008 key target to reduce carbon dioxide emissions by 80% not later than 2050.

23. La Rance barrage, at St Malo, Brittany, France has generated substantial (240 Megawatts installed capacity), non-carbon, non-polluting renewable, cheap, sustainable hydro-electric power since 1966. For some unknown reason La Rance barrage is always classed as unfeasible. This may reflect relict Napoleonic disdain, ranged against the upcoming bicentenary of the Battle of Waterloo in 2015. Otherwise the range of unfeasibility attitudes may just mean at the other end of the spectrum, ignorance through no knowledge of speaking French. The Welsh language context is a good parallel—Does anyone in the Committee speak French or Welsh?

24. It is highlighted La Rance barrage is entirely feasible both now, and for as long as approaching a half-century. So the corollary argument expressed here is that perpetrators of the "potentially feasible" canard are trying to mislead the Committee and Parliament; and it is feared that they may be knowingly or unknowingly in the pay of the nuclear industry.

25. Thus, this contribution maintains that a Severn Barrage parallel to the Severn Railway Tunnel of 1886 has been entirely feasible since 1933, and its original devising as a road/rail/barrage power structure.

Severn Estuary Power and Crossings, from Interwar to the Present

26. What has happened since then? Firstly the road crossing is discussed. Please remember there was none before except ferries, transit through the Severn Railway Tunnel on specially adapted wagons, or a long detour via Gloucester.

27. So, 33 years after the Brabazon barrage was devised the first road crossing came to pass instead as the Severn Road Bridge of 1966. It is of two lanes each way, as a dual-carriageway.

28. Sixty-three years afterwards the second road crossing came to pass as the Second Severn Crossing of 1996. It is of three lanes each way, making 10 lanes in total for the two joint road Severn Crossings.

29. Secondly matters of power. The 1933 Severn barrage had a capacity of 800 megawatts in generation terms. Just over this capacity (about 1100 Megawatts) was in fact provided in four nuclear power stations on three sites.

30. Berkeley, of 1962, had a capacity of 200+ megawatts. It began decommissioning in 1989, after a life of 27 years. £3 billions to £4 billions is allocated towards this.

31. Oldbury of 1969 (magnox) had a capacity of 350 megawatts. It closed recently after a life of 41 years. £3 billions to £4 billions is allocated towards this.

32. Hinkley Point had two nuclear power stations. Hinkley "A" was a magnox station of 1966 and closed in 200?, after 30+ years generation. Hinkley "B" is the only remaining operational Severn Estuary nuclear (AGR) Power Station. It is of 1976, and is megawatt capacity. In December 2012 it received a life extension from 2016 to 2023. £3 billions–£4 billions is allocated towards each of the "A" and "B" stations.

The Importance of Decommissioning costs

33. The three closed and decommissioning Severn Estuary nuclear power stations have cost £x millions (adjusted for inflation). They will cost £3 billions to £4 billions each to decommission safely. Please see the paragraph 38 conclusions.

The importance of Nuclear Decommissioning Costs

34. Hinkley Point "C" is proposed by EDF/Centrica. It will cost more than £10 billions plus twice £3 billions to £4 billions to decommission. This is a total of £16 billions to £18 billions, about half that of the £30 billions to £34 billions, of the Cardiff to Weston Severn Barrage.

35. Taking out investment over-optimism, and noting carefully the 41 years longest life of Oldbury nuclear power station among its ilk; The Energy and Climate Change Select Committee is asked to bring forward two endeavours by asking suitable questions to participants.

36. The primary question is, how with only a 40 to 60 years' lifespan at maximum, Hinkley "C" can defray the total multi-billion building, operating, and decommissioning costs safely? There are stated to be **"no"** Government subsidies towards nuclear decommissioning.

37. A parallel question is, if we are paying multi-billions for the so-called safety of society through invisible decommissioning, would this not be much better spent in the **endless** life (including programmed returbining) of Severn Barrage(s) causeways; to protect cities and major towns against flooding—which is both a Climate Change impact and a severe, visible risk.

38. The Energy and Climate Change Select Committee are asked to note that half the Department of Energy and Climate Change (DECC) budget is spent on decommissioning costs. As above the £73 billions to £100 billions future cumulative cost means £3 billions to £4 billions per nuclear power station. This is calculated by dividing out 73–100 by the 24 or so open and closed nuclear power stations in existence.

Furthermore at least three of the five Severn Barrages key elements have been proved essential by the test of time. It would have been comprehensively better, if an integrated major project such as the Severn Barrage had emerged interwar. In the USA, the similar Tennessee Valley Authority (TVA) Major New Deal Roosevelt anti-Great Depression project **did** emerge. In the opposite in Britain we were left with an unsustainable archipelago of components, cumulatively costing **far** more.

New Deal, Roosevelt Returning to Severn Estuary Crossings Aspects

39. Returning to the paragraph 26 context on what has happened since the 1933 devising of a road/rail/turbine power Severn barrage at Pilning to Sudbrook; the rail crossing aspects are now considered.

40. The original 1933 Brabazon barrage there, included a railway crossing. However in 1960 the Severn Railway Bridge of 1879 at Sharpness to Lydney was hit during fog by oil barges; and this bridge was lost through suffering demolished spans. When the Severn Tunnel was closed for maintenance etc; the alternative crossing became Gloucester in 1960, for not just large loading gauge trains (see paragraph 12) but all traffic.

41. On 16 July 2012 there was the announcement of BBC Wales "Railway electrification to Swansea and South Wales valleys welcomed" after "The UK Government agreed last year (2011) to electrify the line as far west as Cardiff, and had faced heavy lobbying to extend the investment to Swansea."

42. Mark Barry, a business consultant who wrote the South Wales [valleys] metro report, told BBC Radio Wales "It is probably the most significant investment in Welsh rail since the Severn Tunnel was opened" [in 1886].

Powering the Future South Wales and wider railway electrification

43. Returning to paragraphs 12 and 19 it is necessary to comprehensively plan the powering of the cumulative South Wales and wider railway network. Paragraph 12 specifies the necessity to power the railways renewably from the advocated Severn barrage in a co-ordinated way. Paragraph 19 moves the 1933 Brabazon barrage high-head pumped storage reservoir from Trellech in the Wye Valley to Hafodyrynys west of Pontypool, in the eastern part of the South Wales Valleys.

44. The latter will be both splendid regeneration, and in direct keeping with the thrust of the South Wales valleys mid-2012 focus of electrification.

45. The previous Government issued "A New Deal for Transport"—The *I*ntegrated *T*ransport *W*hite *P*aper (ITWP), CM 3950 of 1998. The ITWP page 43 paragraph 3.26 foresaw such a "railway renaissance" in the UK.

46. The ITWP page 14 paragraph 1.28 highlighted:

> "We [the previous Government] will put greater emphasis on listening to transport users [such as SAWTAG herewith]—there will be a New Deal for the public transport passenger. ... Through investing in technology, we [the previous Government] will improve the speed [of Severn Barrages provision] and efficiency of customer [electricity] services provided by Government [DECC/DfT/DEFRA] agencies."

A New Deal

47. The New Deal for the public transport passenger (above) is specified in ITWP page 16 paragraph 1.33 (BOX). There are four main indents that apply to the Severn Barrages/Severn Railway Tunnel context highlighted herewith.

48. "More and better trains." Firstly more trains overcomes the Severn Tunnel Annex F page 162 Rail Network pinch-points [bottlenecks] listed in paragraphs 12 and 55—60 inclusive herewith.

49. Secondly in the 1.33 BOX there is "a stronger voice for [SAWTAG in the role of] the passenger." The Select Committee is requested to carefully consider the amalgam of the "New Deal" representations.

50. Thirdly "better interchanges and better connections" are required both in and between South Wales and England.

51. Fourthly and finally" enhanced [railway] networks" require the herewith advocated Severn barrages. This is also given at paragraph 2.45.

Stewardship

52. Continuing in the ITWP, at page 16 paragraph 1.34 it is stated:

> "We will be more effective in our stewardship of [water] natural resources, and are determined to build from the historic turning point of the special United Nations' Conference at Kyoto [Japan], where the developed countries agreed to legally binding targets to reduce greenhouse gas emissions."

53. Going to the ITWP, at page 16 paragraph 1.36 there are three important indents. These are:

> "a major effort to reduce greenhouse gases" [by building the advocated barrages through Select Committee support]
>
> "greener, more fuel efficient vehicles through [renewably electrified trains powered from the advocated barrages].
>
> "better stewardship of the nation's cultural and [water] environmental heritage."

54. Continuing in the ITWP in brief note form only. 2.20:

> "Support regeneration [by Severn barrages] and the vitality of urban and rural areas.
>
> 2.25:—"Respond to the challenge of Climate Change so as to reduce use of non renewable energy sources," or put more simply—by increasing use of renewable energy sources such as barrages.
>
> 2.52:—"The Royal Commission on Environmental Pollution [RCEP—see at their Eighteenth Report—paragraph 8.85] has produced two comprehensive reports on reducing transport's impact on the environment ... key influences on [ITWP in] ... reducing greenhouse gas emissions." In 2.52 BOX, at the end "public transport—targets to encourage more use of public transport."

The Severn Tunnel Bottleneck

55. Further requirements are given in ITWP page 43 paragraph 3.30 where "Other operators [such as Great Western Trains] are constrained by infrastructure pinch-points [bottlenecks such as the Severn Tunnel as highlighted herewith in paragraph 12 and 13] that are already operating at or close to capacity.

56. ITWP pages 43 and 44 paragraph 3.31: sets out Railtrack [now Network Rail] has identified [the Severn Tunnel as a] bottleneck on the rail network together with possible solutions (see map at Annex F). [It is essential in forwarding] investigating the sufficiency of:

— committed plans to deal with bottlenecks on the network [at the Severn Tunnel].

— committed projects to renew and develop [through the announced electrification via the Severn Tunnel of] the network.

— committed plans to meet the requirements of freight [both from Bristol Container Port, and providing a Severn Barrage route for hi-cube large Containers—see herewith at paragraph 12].

57. ITWP page 99 paragraph 4.29 commences with:

> "We [the previous Government] need to take a strategic, network-wide view of the development of the railway ... [and consider, from the second indent] whether Railtrack [now Network Rail] is doing enough to facilitate the progressive [integrated Severn Tunnel and Severn barrage crossings to and from Wales] improvement in passenger services and facilities, and increase in the number of rail passengers, consistent with Government policy."

58. Paragraph 4.29 continues, in the third indent, immediately after "Government policy" to consider the following. "Evidence of bottlenecks [as set out in Annex F page 162 at the Severn Tunnel crossing] on the rail network and the action [Severn barrages as advocated and required] to tackle them."

59. ITWP pages 99 and 100 paragraphs 4.30 to 4.35 inclusive contain the following key words: 4.30 with 1.34, see herein at paragraph 52.

— railway stewardship obligations.

— Few firm commitments to deliver significant [Severn crossings] improvements across the [England/ Wales] railway network.

60. 4.31—additional funds aimed at supporting new [railway] investment proposals.

> 4.32—addressing capacity constraints at key infrastructure "pinch-points" [Annex F page 162 for the Severn Tunnel to Bath] on the existing rail network.
>
> 4.35—disposal of railway land [in 1998 was] suspended. [Also their] "use for transport purposes in the foreseeable future—[has] ample opportunity to bid for."
>
> Planning in 4.165—"Better protection to those sites and routes (both existing and potential) which could be critical in developing [railway] infrastructure to widen transport choices such as .... for water transport.

The Questions

61. Ten Questions are put by the Energy and Climate Change Committee. Question Four asks—what lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal projects? An immediate lesson is that a picture of "La Rance in operation" at the start of the "call for evidence" would have been far more valuable than a supposed weir picture wasting water. At the end of each Question, cross-references give the other paragraph references to the Questions and points involved.

62. **Question 1**—what contribution could the Cardiff-Weston Barrage make to (a) UK energy security and (b) climate change objectives? It is not the purpose of this report to criticise the Cardiff—Weston barrage save in two respects. The first, is concerning the cost of £30 billions—£34 billions, as against a fraction of this—significantly under £10 billions for the "Shoots" barrage, between Sudbrook and Pilning parallel and above the Severn Railway Tunnel of 1886.

63. The second respect is the influences of a Cardiff-Weston barrage on the Port of Bristol. The "Shoots" barrage is above Bristol on the Severn Estuary and will not have the deleterious effects described in Question 5 here.

64. The Cardiff–Weston barrage will supply 5% to 6% of total UK generating capacity. It must be fitted with the best in the world La Rance barrage turbines. Therefore double acting pump turbines, as in Question 4, are essential. This will enable more than ebb generation operation, with requisite pumping to more nearly align operation with peak electricity demands.

65. In these ways both barrages will obviate a great deal of otherwise gas imports for example from Russia; and oil imports from the Middle East including oil from a steadily depleting North Sea.

66. The latter may become separately Scottish after the 2014 referendum on separation with regard to oil prices already currently being at historically high levels of 110 dollars a barrel; this will serve to act as a continued spur to railway electrifications. (See paragraphs 11, 12, 41—43, 53, 54, and 56)

67. Severn Barrages add to energy security in two ways. Firstly they harness home, "free" water, and contingent on this require a causeway containing turbines, sluices, locks, roads, railways and water supply infrastructure.

68. Secondly they utilise the Severn's second highest tidal range in the world. The Severn is second only to the Bay of Fundy, Canada; where there is a test tidal turbine at Annapolis Royal. They efficiently derive electrical energy from tidal flows. This is key regeneration, like in the 1930's when the USA's recovery from

the Great Depression was eased by the Tennessee Valley Authority (TVA) hydro-electric schemes of the New Deal. Please see paragraph 38.

Climate Change

69. The Climate Change Act 2008 requires 80% reductions in carbon dioxide and other greenhouse gases by 2050. One of the few ways of satisfying these criteria is barrages.

70. As the Queen gave the Royal Assent to the Climate Change Act 2008, and foreshore intertidal areas are owned by the Crown, it is vital barrages go ahead to alleviate Climate Change commensurately. Following the Queen's Speech introducing the Energy Bill, this context is a vital recommendation for the Energy and Climate Change Committee to make.

71. Similarly barrage joint infrastructure of turbines/railways/roads are an essential recommendation for the Committee to forward. It is asked that such routeways become integral with barrage causeways; as they were historically, in the Brabazon barrage proposals of 1933.

72. Attention is drawn to barrages both alleviating Climate Change and powering Cardiff and Bristol metros, besides the electrification of the Great Western Railway main lines. There is a direct further outstanding contribution potentially for railways, if they are constructed in one operation integrated with the barrage causeway.

73. This does not have to be on top of the barrage causeway. Thinking laterally, it will be in January 2013 the 150th Anniversary of London's Metropolitan Railway of 10 January 1863, the first underground railway system in the world. A few years later part of the system was integrated with the construction of the Thames Embankment, a quasi lateral barrage. The railway—another first—was under the Embankment from the City to the then new Parliament at Westminster, and supported by Government finance.

74. **Question 2** asks what risks and opportunities could it pose with regard to flooding in the Severn Estuary, and how might any risks be mitigated?

Flooding

75. The Severn Barrage(s) could potentially be the Bristol Region and part of South Wales (chiefly the eastern part) Thames Barrier, as at London.

76. London and the East of England's coast suffered fatalities and severe damage, during extensive flooding on 31 January 1953, following a tidal surge.

77. Three decades later in 1982, the Thames Barrier began operation, to stop flooding in central London. It is believed that some of the Thames Flood Embankments—and not necessarily the Embankment of paragraph 73—are not sufficiently high if the Thames Barrier is overtopped, with Climate Change derived sea level rises and surges.

78. On 13 December 1981 there was a similar to 1953 storm surge, but in the Severn Estuary. There had also been in 1607 a greater surge, that may even have been a tsunami.

79. The Energy and Climate Change Select Committee are also currently examining: the future of nuclear power. Evidence has been given regarding Hinkley Point C proposed nuclear power station of EDF. One of the main concerns is post the sea change of Japan's Fukushima Daiichi nuclear power stations explosions of March 2011, where 5.5 metres high sea walls were substantially overtopped.

80. In Japan a tsunami substantially overtopped the Fukushima 5.5 metres high sea wall defences, and three nuclear power stations there exploded. All the population has been evacuated from an extensive area inland; and not allowed to return.

81. TEPCO, the Japanese utility company owning Fukushima has only been prevented from going bankrupt by multi-billions subventions by the Japanese Government. In all it is a multi-faceted disaster, resulting from sea walls not being high enough. In the aftermath most of the Japanese total of 53 nuclear power stations are still closed for failings to be remedied.

82. At Hinkley Point "C", EDF have told the Committee their sea walls will be below the 1607 Severn Estuary tsunami levels of paragraph 78. Also, they talk of £370 million limits to EDF finance of decommissioning, a minuscule amount of the **average** which is £3 billions to £4 billions from paragraphs 34, 36 and 38.

83. The importance of Climate Change related sea level rises has been shown by Hurricane Sandy's disastrous flooding of New York, inter alia. President Obama's manifesto related to this, and it was a key influence in his re-election.

84. The day of reckoning may or may not be on a hundred years return flood. When Energy and Climate Change Select Committee MP's sign off their Report on the future of nuclear power just make very sure you are not hoodwinked by EDF. Marine Transgressions of the geologist, like time and tide wait for no man.

85. As the Committee is responsible for Climate Change, and it well knows, Hinkley Point is both on the coast and low-lying; so it is subject to the gamut of the Climate Change repertoire. TEPCO, in Japan, were warned of this similar context and ignored it, becoming practically bankrupt and bankrupt of ideas. At Hinkley Point the warning of paragraph 82 is likely to reverberate similarly.

86. There is a National Policy Statement for Nuclear Power Generation (EN1-EN6 etc). However, there is **not** one for Barrages as yet, and the Committee should request its immediate production, with the incorporation of its worthy Energy and Climate Change context.

87. **Question 3**—what risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

88. A brief answer is in two parts. No doubt the other interest groups concerned will try and persuade the Committee. This report will confine itself to two brief points.

89. The Energy and Climate Change Select Committee is asked to strictly apply the theme of the NPPF and the Major Infrastructure Projects recent revisions. This new approach vetoes overly concentrating on wildlife and habitat, and the strong national interest is to prevail.

90. A new wildlife and habitat area was provided at Newport—Uskmouth/Nash for the implementation of the Cardiff Bay barrage. Unfortunately the latter did not have essential turbines, and the Committee should advise the Wales Government that it should.

91. **Question 4**—What lessons can be learned from the successful development of La Rance tidal barrage and other tidal power projects? Much of this has already been set out previously in paragraph 9 to 19, 23, 24, 61 and (here) 91 to 94.

92. The writer is pleased to see the Energy and Climate Change Select Committee recognise La Rance barrage as successful. The Wikipedia parallel entry is enclosed which shows La Rance to be the cheapest power in France. The writer has also been told this both times, on each of visits to La Rance barrage. A quick rule of thumb on power outputs notes the La Rance barrage has 240 Megawatts (MW) from 24 x 10 MW, 5.3 metre diameter turbines. It has a basin size of 24 square kilometres, so the quick calculation is 10 MW of power from one square kilometre of basin impounded size.

93. The Committee is requested to call a witness from EDF on La Rance barrage. This must not be Vincent de Rivaz, as he is not impartial, being overly pro-nuclear. The best expert witness would be a Champion—someone in the senior echelons at La Rance barrage speaking through an interpreter, with translations such as at European Union meetings of Heads of Government (As EU meetings at St Malo 1998).

94. La Rance was built as a smaller version of a potential larger Chausey barrage, further to the north. In this way the thrust of this report is greatly for a Severn Barrage at the "Shoots," English Stones alignment, parallel to the Severn Railway Tunnel of 1886. This would then be like:

La Rance is to Chausey.

This Report is to Cardiff-Weston.

95. **Question 5**—What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

96. This is answered for ports and aggregates, by way of cross-referenced to previous paragraphs 9, 11, 15 and 56. It is most important to realise that the Port of Bristol is unaffected by the preferred barrage line of this report.

97. The two metros powered by renewable hydro-electricity, catalysed on both sides of the estuary will be a boost to local employment and access to main centres. It will also be a stimulus to the regional communities.

98. Penultimately, it is proposed that the ex-Oldbury nuclear power station cooling water tidal lagoon in the Severn Estuary be fitted with turbine(s) to regenerate renewable hydro-electric power.

99. Question 6 is answered previously, in Economic terms at paragraph 9 to 18, 20, 21, 25, 33, 34 and 38. The Energy and Climate Change Select Committee is also directed to their pre*dec*essor Business, Innovation and Skills Committee 2008 companion report on the cost of Nuclear Decommissioning.

100. Question 7, 8 and 10 are not tackled, because of the severe constraints of time and resources.

101. Question 9—Are there other proposals for tidal power projects in the Severn estuary currently under consideration? The short answer is yes, the "Shoots" barrage parallel to the Severn Railway Tunnel of 1886. The entirety of this report is written from the scenario of this alternative barrage. Thus, rather than reiterating many paragraph numbers; it is hoped readers will understand the broad general thrust of this report.

102. Finally there should be several further proposals for tidal power projects in the sub-estuaries of the Severn estuary, including turbines in the Cardiff Bay barrage, as highlighted at paragraph 90.

103. There is not one sizeable low head hydro-electric turbine in all of Britain. The Energy and Climate Change Select Committee must put this right as soon as possible; by bringing in La Rance barrage double-acting pump turbines to Britain. This would do the UK a major service in the renewable, non-carbon, anti-climate change action fields of research.

December 2012

Written evidence submitted by the North Somerset Council (SEV69)

1. North Somerset Council welcomes the opportunity to respond to the Select Committee on the issue of the Cardiff—Weston barrage. The Council is keenly aware of the importance of addressing the contributors to climate change and securing a greater proportion of our energy from renewable sources. The potential of a barrage scheme is of particular interest to this council because any delivered scheme would have a considerable impact on North Somerset both during and after construction.

2. Whilst the Council are wholly supportive of investigating new and alternative tidal energy schemes, which will deliver significant volumes of low-carbon electricity from the River Severn, the current scheme raises the following serious concerns.

Commercial Shipping and Ports

3. The Port of Bristol is a key contributor to the economic strength of the sub-region and also has a national significance, which benefits the residents of North Somerset and UK economy as a whole.

4. The Port employs over 500 people directly and 7,000 indirectly. The Port is the only fully-equipped multi-user dry bulk commodities port south of Immingham, Lincolnshire, capable of handling bulk carriers of 130,000dwt. It is also strategically located close to the major population centres of the UK and is the only UK deep-water port with direct access to North, South, East and West on both motorway and railway networks.

5. The Port handles a wide range of nationally significant cargoes including:

- the second largest steam coal import facility in the UK;
- 27% of the UK's imported aviation spirit;
- 22% of total UK animal feed imports; and
- the leading UK port for deep-sea motor vehicle imports and a major exporter for UK manufactured vehicles including Jaguar Land Rover, JCB, GM, Honda and Toyota.

6. Full consent has been granted and preliminary work is underway for three nationally significant investments with combined value of £1.2 billion—a £600 million Deep Sea Container Terminal and two biomass power stations. These developments depend upon the port's ability to accommodate deep-draught ships, its efficient cargo handling ability and first class inland infrastructure links.

7. The reduction in available water depth upstream of a barrage would make it impossible for deep-draught ships to enter/exit the Port on 80% of tides. This would make the Port realistically unviable for vessels over 70,000dwt without substantial works in dredging and new locks. In addition any barrage would have to include deep-water channel locks to facilitate shipping movements, This would increase costs/journey times and would be highly significant for ship/cargo owners and impair the Port's competitive advantages resulting in the loss of significant revenues. The combined impacts of the barrage would be severe and incapable of mitigation, with the result that the Port could be forced to close.

8. The port is already experiencing a reduced appetite for investment whilst the barrage debate lingers. The Council therefore fundamentally questions whether in the current economic climate it is in the national and regional interest to carry out further investigations.

9. In summary the barrage would not provide a net benefit to the economy. Any temporary gain from the construction employment opportunities would not outweigh the significant value lost from the permanent damage to ports and associated businesses. For example whilst there is a view that a barrage could enhance Weston as a tourist resort due to improved tidal conditions; this is not proven and silting and erosion of the sandy beaches for which Weston is famous could equally result with disastrous consequences for the area's tourist industry.

Alternative Technologies

10. The Council fully support the objection lodged by the West of England Local Economic Partnership (LEP) in particular the need to look at more recent technologies. Feasible alternatives exist to a barrage including tidal range and tidal stream technologies. RegenSW's October 2012 report ("A Balanced Technology Approach") outlined how multiple technologies could be deployed in the Estuary in preference to the barrage to generate energy less damaging to the environment and in balance with other marine uses. This combination of technologies would produce at least as much energy as the large barrage and generate power 24 hours a day (unlike a barrage which would require permanent back-up capacity)

ENVIRONMENT

11. The Severn Estuary is a unique habitat and is protected by several international and national designations, as is some of the adjacent land. The Estuary's sheer scale and extreme dynamic physical environment shapes its ecology and sets it apart from other UK and European estuaries. Any barrage would irreversibly alter those features and have long-term adverse ecological effects on an unprecedented scale.

12. Other organisations are better equipped to comment on the issues relating to the specific biodiversity and ecological systems. However, we consider that the preservation of the special habitat and ecology associated with the great tidal range to be of particular importance and the risk of disastrous unintended consequences is unacceptably high.

13. Another concern is the sourcing of the construction materials and transportation to the site. A robust appraisal of the impact and true cost of construction must be undertaken in terms of environmental damage, carbon footprint and transportation costs.

INFRASTRUCTURE AND PUBLIC SERVICES

14. During the construction phase the influx of plant, machinery and workers would impact on infrastructure and services, possibly to a critical degree. It is essential to include the provision of services and sufficient infrastructure to ensure that existing residents do not suffer reduced service.

December 2012

Written evidence submitted by Sedgemoor District Council (SEV 72)

I am writing on behalf of Sedgemoor District Council in response to the Select Committee's call for evidence on the potential development of a Severn Barrage.

As possible host on the English side for a barrage across the Severn and having a shoreline neighbouring the estuary, Sedgemoor has a particular interest in any proposals. With a population of more than 100,000 living and working within the flood plain or along the estuary and its tributaries, the District also has a strong environmental and economic stake in the wider development of the Severn corridor.

To date, Sedgemoor District Council has taken no formal position on the idea of a Barrage in the Bristol Channel, remaining neutral in its discussions with promoters and objectors. While the District appreciates the potential economic, social and even environmental benefits for the UK and the local area from such a development, it is acutely aware of the challenges it could pose for the community and landscape. The Council believes the project would need to be weighed carefully to seek a balance between its economic potential and its environmental impacts.

As host district for the proposed development of the first new nuclear power station in the UK for 25 years, (Hinkley Point C), Sedgemoor is well aware of the benefits and challenges such large National Infrastructure projects may bring. On the one hand is their contribution to the UK energy mix and wider economy while on the other is their impact on local businesses, traffic, labour market and the environment. Equally, with a Barrage, careful consideration will need to be given to the local implications if any scheme is to be successful and the final decision must be made through an open and accountable process.

We would also suggest that, as a precondition to reaching any decision, certain key issues should be addressed.

1. Given the huge investment for the project and intense consultation involved, a significant degree of certainty on the process and preconditions will be required from Government.
2. Having experienced the Planning Inspectorate's process with Hinkley Point C, we know major projects of this nature can provide a strong focus for developers and communities and the potential for them to work together to get the best outcomes. A crucial barrier at present for a Barrage project would appear to be the lack of any timetable or formal process for bringing forward the scheme. This lack of certainty causes misgivings for potential investors and local communities.
3. As well as providing confidence on the process, we would ask that the Government to support the need for a Planning Performance Agreement, in line with national best practice, to ensure that local authorities can participate fully in the project development, without the costs falling on local tax payers. Given the significance of the likely effects on Sedgemoor, a detailed consideration of options and solutions is vital.
4. Sedgemoor strongly argued, throughout the development of a case for Hinkley Point C, that any nationally significant project should include an element of benefit for local communities. To a degree, this is provided by the economic advantages of the project itself but the very nature of imposing a national scheme on a local area is not always equitable. There is plenty of precedent for local communities which shoulder disproportionate risks and challenges for the wider good of the UK to receive reasonable and fair benefits (through a Community Benefit

Contribution or other mechanism) in recognition of the burden of hosting nationally beneficial energy infrastructure. In the case of the Barrage, given its potential to radically change local conditions and markets, as well as fundamentally alter the environment of the Severn Estuary, there would seem to be a particularly strong incentive to agree an approach to long term community benefit for those communities affected as an integral part of the project. Sedgemoor would encourage the committee to consider the need for a community benefit package arising from a Barrage programme as a precondition, linked to a comprehensive review of the likely local impact. This would provide those communities most affected with a degree of security of outcome, as well as give some certainty for developers over the level of mitigation likely to arise.

Finally, the Council would like to explore the concept of an Enterprise Zone for the area affected, in relation to local priorities for economic growth and regeneration.

I hope the above views provide a useful and constructive input into your deliberations. We would be happy to expand on any or all of the points, should you so wish, and formally request that we are invited to attend.

December 2012

Written evidence submitted by Robbee Smole (SEV 73)

Robbee Smole facilitates SevernNet, an organisation which brings together the businesses and communities from Royal Portbury Dock through Avonmouth, Severnside to Western Approach Industrial Park, crossing the boundaries of North Somerset, Bristol City Council and South Gloucestershire.

Formed from an initiative which began in 2009, SevernNet's focus is on supporting sustainable growth and resource effectiveness across the area, and building on the area's strengths.

Robbee Smole has undertaken extensive research over a number of years into the sustainable development of port industrial areas in The Netherlands, UK and elsewhere. This highlights the importance of the port and its role as a hub attracting other businesses and industries into an attractive and economically vibrant agglomeration. The Bristol Port area in particular has developing strengths and opportunities which are dependant upon the port as a focal point.

Robbee Smole has considerable concern that the development of the barrage would have a damaging impact on both the environment and economy and is not a sustainable solution.

There would be no overall gain for the economy as the temporary economic gain from the construction of the barrage is balanced by the loss from closure of the ports at Bristol and Sharpness and associated businesses.

The majority of the capital expenditure would leak outside Wales and the South West as those areas would not be able to supply all the materials, caissons, machinery and man-power for the project.

The barrage would cause as a minimum a loss of 900 jobs in ports in the operating phase whilst creating around 1,000 operational jobs—a net gain of only 100 jobs.

The fishing industry of the Estuary will collapse in Wales and the South West with a loss of 60 jobs.

An estimated 180 jobs would be lost in the nationally strategically important marine aggregates industry. The cost of construction projects particularly in the North West and South Wales would rise as they are particularly dependent on marine-dredged sand from the Estuary.

The DECC Study estimated that the barrage could create 60 tourism jobs. However this would be far outweighed by the loss of the attractiveness of the Estuary, loss of ornithological and angling tourism and the damage to marinas.

There are alternative options to the barrage which could deliver sustainable energy without such a negative impact upon the existing and developing economy.

The risks of going ahead with the barrage as proposed are simply too great and alternative solutions should be recommended.

December 2012

Written evidence submitted by Bristol Council and the West of England Local Enterprise Partnership (SEV75)

INTRODUCTION

1. The Bristol City Council area covers a significant land area, port facilities and businesses that will be impacted by tidal energy schemes deployed in the Bristol Channel. The location, size and scale of any tidal energy generation scheme will determine the impact on Bristol's environment, infrastructure, businesses and future development—either positively or negatively. A Cardiff-Weston Barrage will have significant negative impact on the area, primarily due to its location downstream of Avonmouth and the port complex.

2. Bristol Port is a major international logistics complex servicing the UK heartland as an import and export facility—it is by far the largest international transhipment port in the South West and Wales with 6.6 million tonnes handled in the last 12 months over 10 times the size of Cardiff, the next largest port potentially impacted by a Cardiff-Weston barrage. Direct port and connected employment was calculated by a South West Regional Development Agency study to be over 7,500. Bristol Port also has plans to expand, with permission to create a new £600 million Deep Sea Container Terminal, creating additional jobs and economic activity.

3. Tidal energy is broadly defined by two sectors—tidal range where the height of the tides is used to produce energy and tidal stream where the flow of water is harnessed. The technologies used in each case are significantly different; Bristol is home to two of the world's leading tidal stream device developers, and along with others in South Wales and an extensive support community (around 120 supply chain, specialist consultancies, legal and financial organisations) it forms a hub of innovative marine energy sector development.

Marine Current Turbines Ltd—a Siemens Company

Marine Current Turbines Ltd. (MCT) is a Bristol-based tidal stream turbine developer now wholly-owned by Siemens. MCT is the world pioneer of tidal turbine technology. The company has an acknowledged global lead in the free-stream tidal market having generated well in excess of ten times the amount of electricity to the grid than the rest of the industry combined. MCT's iconic 1.2MW utility-scale prototype in Northern Ireland has now generated in excess of 6GWh.

Bristol is the home of MCT. MCT's engineering design offices are based at the Bristol and Bath Science Park, and the new MCT Test and Integration Facility is being commissioned in St Phillips in Bristol. This facility has been scaled to produce up to 50 tidal turbines per year once in full production. Currently the company is in the final stages of financing two small tidal arrays; a 10MW array in Wales and an 8MW array in Scotland. MCT has a growing pipeline of future tidal projects which will see the company grow rapidly in engineering design, manufacturing, and production.

Amongst the tidal site prospects for MCT is the Bristol Channel. In fact MCT installed the world's first large-scale tidal turbine, SeaFlow, in the Bristol Channel in 2003. The scale of the site would potentially represent a series of significant-sized projects representing a major source of revenue to MCT and locally-based supply chain companies. The proximity of MCT's engineering team and manufacturing facility would enormously aid implementation of such projects.

4. The Bristol Channel tidal stream resource is also attracting other tidal stream developers as a deployment location such as Pulse Tidal Ltd who have been granted a lease by The Crown Estate for a demonstration project. We are aware of a seabed lease that exists in the outer Bristol Channel to deploy tidal stream demonstration technology. There are other developers looking at tidal stream projects off North Devon using new technologies which are expected to come forward for leasing in the next year. There are also a number if developers looking at tidal lagoon projects on both Welsh and English sides of the channel. All of these projects and investments would be impacted by a proposed barrage scheme.

5. The City Council and Local Enterprise Partnership is fully supportive of the development of marine renewables (tidal range and stream) and has sponsored the development of a Tidal Energy Forum for the Bristol Channel, membership of which has grown to over 60 at the last event, after only twelve months of operation. The Council is also supportive of the South West Marine Energy Park—assisting in its early stage funding. Bristol City Council, along with other key stakeholders and through the tidal forum, has produced a discussion paper outlining an approach to the development of marine renewable energy in the Bristol Channel. This publication is attached to this evidence response.

6. Since the UK government's DECC Severn Tidal Power Feasibility Study that reported in 2010 there has been little debate about a Cardiff-Weston Barrage other than in political/press circles. Very little information about any potential project is available and there has, to date, been no engagement from the proposers of the Cardiff -Weston scheme with the Severn Estuary Partnership, the public forum established over 20 years ago to guide development of the Estuary, with Bristol City Council or the Local Enterprise Partnership.

7. While we welcome the Energy and Climate Change Select Committee's investigation of this issue, in the absence of any firm publicly available project proposals it is very difficult to provide meaningful comment on many on the questions which have been raised and indeed without questioning the terms of reference. It is also very difficult to add to the very thorough investigation previously undertaken that concluded:

"In the light of these findings the Government does not see a strategic case to bring forward a Severn tidal power scheme in the immediate term. The costs and risks for the taxpayer and energy

consumer would be excessive compared to other low-carbon energy options. Furthermore, regulatory barriers create uncertainties that would add to the cost and risk of construction. The Government believes that other options, such as the expansion of wind energy, carbon capture and storage and nuclear power without public subsidy, represent a better deal for taxpayers and consumers at this time."

Summary Position on a Cardiff-Weston Barrage

1. Whilst recognising the clean energy needs of the UK and being very supportive of the development of marine renewables in general, including tidal range schemes, Bristol City Council and the West of England Local Enterprise Partnership are strongly opposed to the creation of a Cardiff-Weston barrage. Our opposition to this particular scheme results from the very significant impacts on the local economy, our broader tidal sector community, potential flooding in the city and the scale of potential environmental impacts.

2. Bristol City Council and the Local Enterprise Partnership also believes that there is a much better approach to generating large scale energy from the resources within the Bristol Channel utilising a mix of technologies—tidal range, tidal stream, wind and wave power—which offers a lower risk and more sustainable alternative. This approach also enhances the UK's position as a leading centre for marine energy technology development and would create more jobs and attract more investment in the longer term. This approach is outlined in the discussion paper "Bristol Channel Energy—A Balanced Technology Approach".

3. We would request that the UK and Welsh Governments work closely with local stakeholders and industry on both Welsh and English sides of the channel to adopt an alternative strategy to harness large scale energy from the Bristol Channel, create sustainable jobs and support export industries, in balance with our unique environment.

4. Each of these issues is described in detail in our following response to the evidence request questions detailed in the Committee's Terms of Reference. Our comments are based on our limited understanding of the potential project, and on previous feasibility studies of Severn tidal power.

Terms of Reference Question Responses

What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

1. Whilst it is acknowledged that a Cardiff-Weston barrage would provide a valuable contribution to low carbon energy generation objectives, we believe that *these can be more appropriately be achieved by multi-technology approach with several projects rather than a single mega-project which has major economic and environmental and impacts.*

2. No new output figures have been provided—The Severn Tidal Power Feasibility Study (STPFS) reported that a Cardiff-Weston Barrage would generate of the order of 16TWh/yr compared to a UK total generation of 368 TW/h of electricity in 2011, whether this level of output is achievable in practice, and using a potential new concept low head turbine would need to be further investigated.

3. Press speculation, in absence of information issued by the potential developers, suggests that the latest proposal is to install an ebb and flow scheme to help minimise environmental impact. Such two-way generation requires low head technology to be developed which it is assumed would be based on initial feasibility studies undertaken as part of the Severn Embryonic Technologies Scheme (2010). This new concept technology would need to be developed from an embryonic level with all the development risks associated with bringing forward new technology. At the scale of this project, these development risks could impact on energy security.

4. On the subject of low head turbines the STPFS concluded that *"Of these, a tidal bar and a spectral marine energy converter showed promise for future deployment within the Severn estuary—with potentially lower costs and environmental impacts than either lagoons or barrages. However these proposals are a long way from technical maturity and have much higher risks than the more conventional schemes the study has considered. Much more work would be required to develop them to the point where they could be properly assessed. Correspondingly, confidence levels on their yields, costs and impacts (including environmental impacts) are much lower at this point."* Given the potential benefits of this concept, and the relative immaturity of the technology, we would recommend that a) more funding is made available for research and b) such technology needs to be properly demonstrated and proven on a smaller scheme such as a tidal lagoon as recommended by the "Stepping Stones"[54] proposals.

5. Conventional, ebb only, hydro-dam technology presents less technology risk, but, as detailed in the STPFS, the environmental impacts are extremely significant.

[54] http://regensw.s3.amazonaws.com/120831_stepping_stones_tidal_lagoon_presentation_for_bristol_tidal_forum_ead4881f6fce116d.pdf

What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?

6. It has been widely claimed in the press and media that the Cardiff-Weston scheme would provide a flood defence—in fact this was not the conclusion of the Severn Tidal Power Final Report, Flood Risk and Land Drainage April 2010.

7. To understand the potential flood impact of a barrage it is necessary to differentiate between two types of flooding—1) *Coastal Flooding* caused by encroaching seawater caused by tidal surges and in the longer term by the expected rise in sea levels caused by climate change and 2) *Drainage* or rainwater flooding (of the type which has been experienced recently in many areas) caused by extreme rainwater, river overflow coupled with poor drainage.

8. In the case of Coastal Flooding it is acknowledged that a barrage—which reduces tidal range/surge—could provide a defence against sea level rises for area upstream of the barrage. However, as documented in the STPFS report, the benefits for areas upstream of the barrage are offset by an increased risk of coastal flooding in areas downstream of the barrage caused by the INCREASE in tidal range in those areas. The extent of the net benefit will depend on the impacts on tidal range upstream and downstream of the barrage, and the type of technology adopted. Several studies have been conducted with various results but all showing a significant downstream impact. The STPFS SEA estimated that increases in water levels seaward of the barrage on the peak spring tides would result in a significant negative effect in terms of a potential increase in flood risk to properties as far as Cardigan Bay, North Devon and the Llyn Peninsula on the West Wales coast. Earlier studies by the University of Liverpool and the Proudman Institute showed small sea level rises in the Irish Sea.

9. There is also a broader question about whether a large scale solid barrage is actually the best option to defend against sea level rises. Best practice would suggest a combination of targeted sea defence coupled with mitigation measures and in some cases managed retreat. In the longer term such an approach is likely to be more effective and cost less than the on-going maintenance of a barrage. Finally if a barrage option is suitable it is likely to be better located far closer to the Avon and Severn Estuary such as the location of the proposed Shoots barrage.

10. In the case of Drainage/rainwater flooding—which is the most common type of flooding in areas adjacent to the Severn and Avon rivers—the analysis of the STPFS was largely negative with an increased level of flooding caused by the adverse effects on the evacuation of water during "tide lock" conditions. Analysis for the STPFS conducted by specialists Black and Veatch[55] concluded that there would be an increased risk and/or impeded drainage affecting up to 372 KM2 of land and over 50,000 properties and 28 critical infrastructure assets.

11. Land drainage outlets are likely to be submerged at low tide, necessitating the installation of pump drainage outfalls to prevent land flooding.

12. The STPFS also identified that coastal erosion and the undercutting of existing defences, caused by the changes in tidal range, both upstream and downstream could be a major factor—it estimates that 448–7 km of flood defences will need to be improved and erosion protection to be established along 134 km (+/-50%) of coastline.

13. The analysis above is based on the STPFS study which looked primarily at a conventional Ebb only barrage. An Ebb and Flood (low head technology concept) would have less impact on the overall tidal range but would potentially increase the impacts on drainage at low water. Much more modelling and research is required to fully understand the hydrodynamic impacts of this technology.

14. NOTE OVERALL—the impacts of a barrage and other tidal range technologies on flooding is not fully understood. Significant risks remain and more research is needed.

What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?

15. The Bristol Channel is an extremely complex hydrodynamic environment supporting a wide variety of habitats and local communities. As the STPFS clearly identified a large barrage would be an extremely high risk project and *"many years of further detailed work would be needed to plan, finance and assess the impacts of such a large structure as a Severn power scheme before a case could be put forward for planning consent"*.

16. For this reason Bristol City Council and the LEP recommends an incremental approach with the deployment of a mix technology of smaller schemes including tidal lagoons and tidal fence technology so that impacts can be assessed and environmental impacts managed.

17. Any potential scheme covering this scale of impounded area is likely to have very significant wildlife and habitat impact. All the schemes considered in the STPFS have potentially significant impacts, but *a Cardiff-Weston scheme has by far the greatest environmental impact, particularly with respect to loss of intertidal habitat*. The STPFS SEA suggests that an ebb only scheme would result in the loss of 11,800–16,300 Ha, Under a more environmentally sympathetic turbine design (bi-directional very low head turbine), the Severn

[55] Severn Tidal Power Final Report, Flood Risk and Land Drainage, April 2010.

Embryonic Technologies Scheme suggested that although reduced, these impacts would still be very significant and considerably greater than all of the alternative schemes considered feasible under the STPFS.

18. Of all the Schemes considered under the STPFS, the Cardiff-Weston project impacted on 30 different bird species—nearly double that of any of the alternative schemes deemed feasible.

19. The impact on fish and fish migration is a particular cause for concern and is not well understood.

20. Considering the scale of habitat loss for a Cardiff-Weston scheme, there must be a significant risk that not enough compensatory habitats could even be found or created in a manner that would not impact on the species they support. Any provision of compensatory habitat on such a large scale would require a significant amount of time to plan and satisfactorily bring to sufficient maturity.

21. The Severn Estuary is a unique and valued ecosystem for people and wildlife that has been afforded the highest environmental protection. As a Cardiff-Weston scheme is likely to have a significant ongoing environmental impact we recommend it be considered with the utmost scrutiny.

What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

22. Bristol City Council and the LEP have not carried out any extensive analysis of the La Rance project to date but our understanding is that—due to the construction methodology—the estuary environment was initially destroyed. More importantly, we note that La Rance is not a good comparator to the Severn owing to significantly different scale, sediment and habitat conditions. It is noted that the focus of French government is now on the development of Tidal stream technologies.

23. More recent examples from the Netherlands such as the storm barrier erected across the Oosterschelde estuary in the 1980s have shown significant environmental impacts and loss of habitats, mudflats and saltmarshes and damage to shell fish fisheries. We refer to " in the late 1980s"—a report by Erik van Zanten and Leo Adriaanse on behalf of Netherlands government.

What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

24. The Cardiff-Weston Scheme being an extremely large civil engineering project will produce economic benefits overall—2.4 billion GVA (Gross Value Added), under a base case according the STPFS Economic Appraisal). However, the economic benefit as a proportion of capital expenditure is much poorer than other tidal range projects considered by the STPFS, or other marine renewable technology deployment considered by the ORRAD project conducted by the SW RDA (2010). A good comparison is Bridgwater Bay lagoon option studied in the STPFS which produces a net regional GVA of £2.3 billion with a project capital cost estimated at about half that of a Cardiff-Weston scheme.

25. *This poor economic return for a Cardiff-Weston scheme is in large part due to the negative impact on Bristol and in particular the port*, as a result of it being inside the barrage basin. Of all the projects considered as part of STPFS a Cardiff-Weston scheme has the biggest impact on Bristol port, the largest of all ports in the scheme area with over 7,500 employed directly or as a result of port activities. During the construction phase of a Cardiff-Weston scheme it is estimated (STPFS) that employment will be 2,100 lower each year than it otherwise would have been. Should the Deep Sea Container Terminal be in place, this job reduction would increase to 2,500 during the construction phase. During the operational phase, annual employment would be 700 lower than it would have been, and if the Deep Sea Container Terminal was in place, job reductions increase to 900. The STPFS Regional Economic Impacts Study concluded that the overall *port-related lost GVA is likely to be between £0.9 billion and £2.9 billion, or £1.1 billion and £3.6 billion if the Deep Sea Container Terminal is in place.*

26. The development of alternative tidal range schemes (Barrage or Lagoon) which do not impound the port will have far less impact on port related employment—indeed an alternative balanced technology approach to development of marine renewables in the Bristol Channel could potentially increase port economic activity.

27. Job reductions in the fishing sector as a result of a Cardiff-Weston project have been estimated (STPFS) at 40. In the aggregates industry job reductions are likely to be approximately 180. Whilst the job losses associated with fishing activity are likely with all the feasible options in STPFS, *the 180 job losses associated with the aggregates industry are unique to the Cardiff-Weston scheme.*

28. In addition to the above negative economic impacts, the development of a Cardiff- Weston barrage would also impact on the burgeoning tidal stream technology hub based around the Bristol Channel. Technology developers present include Tidal Generation Limited and Marine Current Turbines based in Bristol, as well as Tidal Energy Limited based in Cardiff—all global leading (top 10) companies in the evolving tidal stream industry. Moreover there are others globally who already have an interest in the resource including Pulse Tidal Limited, and VerdErg Renewable Energy Limited. These technology developers are also supported by locally expanding supply chain and leading support organisations including consultants, lawyers and finance specialists. It is estimated that there are over 120 organisations linked to the offshore renewables sector in the

Bristol City Region. Creation of a Cardiff-Weston barrage would negatively impact on the tidal stream resources in the inner and outer Bristol Channel—making it far less attractive as a potential deployment location. *The removal of this potential deployment location would significantly inhibit the growth of this sector in and around the Bristol Channel.*

29. The negative economic impact of a Cardiff-Weston barrage could be avoided by consideration of more holistic development approach in the Bristol Channel using potentially all the marine energy technologies in a more balanced manner as presented in discussion document "Bristol Channel Energy: A Balanced Technology Approach". As well as creating more sustainable jobs, across a wider geography on both Welsh and English sides of the Channel—this approach would also enhance the UK's position as a leader in marine energy technology development.

Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

30. Currently all marine renewable energy technologies require additional support above the market price for electricity. However most technologies will have a downward cost trajectory as volumes grow and learning takes place if they are to survive. The government is encouraging tidal stream and wave deployment using the Renewable Obligation Certificate (ROC) support mechanism until 2017. However this is only available for limited cumulative installation capacity of 160MW. The benchmark for most marine renewables is driven by the cost of offshore wind, which has target of around £100/MWh by 2020. The STPFS estimates the levelised cost of energy of a Cardiff-Weston scheme to be just over £200/MWh (assuming an internal rate of return of 10% and a write-off period of 40 years). *A high level of support (against a wholesale market price of £405–0 per MWh) for around 5% of the UK's electrical power supply will have a significant impact on consumer bills in the medium term.*

How does the company plan to engage and consult the community in the development of the project?

31. No significant scale energy scheme of any technology in the Bristol Channel will succeed without a strong support from stakeholders on both the English and Welsh sides of the channel. It is essential therefore that a consensus is established about how to balance the need to generate green energy with the wider environmental, economic and social interests that will be affected.

32. One of the most disappointing aspects of the project to date is the singular lack of engagement with the community, in its widest sense. The Severn Estuary Partnership exists as a vehicle for serious debate on the strategic development of the Severn Estuary but to date has received no direct approach from the project sponsors. Indeed it seems surprising that a project can gather such political interest, with such paucity of information in the public domain.

33. There has been a lot of press coverage about a Cardiff-Weston Barrage–coming from proponents and political supporters which until this point has been wholly one-sided and contrary to the spirit of Localism.

34. BCC and the LEP would welcome a much more inclusive and open dialogue which will enable government, industry, environmental groups and local stakeholders to work together to utilise new technology which will generate significant low carbon energy and sustainable jobs.

Are the proposals in breach of EU legislation, and if so how will this be addressed?

35. Bristol City Council and the LEP have not considered any project implications on EU legislation at this stage.

Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

36. Bristol City Council and the LEP are aware of a seabed lease that exists in the outer Bristol Channel to deploy tidal stream demonstration technology. There are other developers looking at tidal stream projects off North Devon which are expected to come forward for leasing in the next year. There are also a number if developers looking at tidal lagoon projects on both Welsh and English sides of the channel. All of these projects and investments would be impacted by a proposed barrage scheme.

37. More broadly the Bristol Tidal Energy Forum (a largely private sector forum) is, along with other stakeholders, considering an alternative strategic approach to the development of marine renewables in the Bristol Channel. A recently published discussion document is attached to this call for evidence.

38. Bristol City Council and the LEP support this "balanced technology" approach as it promotes a more Channel-centred holistic strategy which maximises economic development (avoiding the negative impacts of a single large barrage), enables significant deployment of all technologies, and allows management of environmental impact.

What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

39. A Cardiff-Weston barrage would potentially allow the UK to develop a new range of turbines suited to tidal range installations (rather than conventional hydro dam turbines) and so open up a new international offering. However, advanced tidal range turbines are only at the conceptual stage (as evidenced by the Severn Embryonic Technologies Scheme) and there are better ways to develop this technology through smaller projects such as Tidal Lagoons.

40. Tidal Barrage technology may have a limited market—there are no other sites we are aware of for a barrage being planned in the UK nor any plans for a barrage in Europe. Tidal Lagoons and Tidal Fence technologies are likely to have a wider export market.

41. The tidal stream industry focused around the Bristol Channel, who have devices applicable to the global market already at the full-scale prototype stage. *Installation of a Cardiff-Weston scheme will make the down stream resource unattractive to tidal stream developers and hence potentially hinder the development of the Bristol Channel cluster and ultimately its place in the global marketplace.*

December 2012

Written evidence submitted by the Wye and Usk Foundation and River Wye Preservation Trust (SEV76)

1. The Wye and Usk Foundation (WUF) and River Wye Preservation Trust (RWPT) are registered charities with specific concerns for the Wye and, in the case of WUF, the Usk.. These organisations had representation on the 2010 Strategic Environmental Steering Group of the Severn Tidal Power investigation. This investigation looked in depth at the effects and benefits that five (from a short list of ten) Severn estuary projects might have in respect of economics. It also looked at negative side effects as well as the likely outcomes for the protected habitats and species.

2. The Severn Estuary has some of the largest concentration of listed sites: Severn Estuary; River Wye and River Usk Special Areas of Conservation (SACs). The intertidal zone is a Ramsar listed site for migratory birds.

3. However, the initial selection process for the shortlisted five rested solely on their cost benefit: the cost of construction in relation to power output. No attempt was made to identify "showstoppers" at this stage such as (to name three examples):

- Adverse flooding effects.
- The problems of impoundment (sediment/water quality).
- Damage to the listed species and habitats.

4. During the assessment of the shortlisted five projects, determination was made of these other effects. On the discovery that all five would cause of extinction of *all* the migratory, EU listed fish species (Atlantic salmon, Allis and Twaite shad, River and sea lamprey plus the European eel and several UK Biodiversity action plan species), investigation into the possibility of finding other habitats to compensate the loss of these Natura linked sites revealed that the IROPI (overriding public interest) clause of the Habitats Directive could not be met.

5. It was not possible to "fudge" this by using compensatory habitats of a different type and robust legal opinion has been sought to rebutt any such attempt.

6. None of the five shortlisted projects, which included the Cardiff to Weston Barrage (CWB), produced enough power to justify their constructional cost were the government to undertake the project ie there were cheaper alternatives available to meet generation and decarbonisation targets. It was noted that the although predictable, the intermittent nature of Severn tidal power generation presented problems as the non generation period of time (which varied on a daily basis) would need to be met with generation from other sources.

7. The substantial power output of the CWB for that short period would challenge the grid system leading to additional costs that were not included in the assessment.

Conclusions of WUF and WRPT

1. During the previous investigations, sight of plans for the CWB afforded the opportunity to make a proper assessment. This is not the case now.

2. La Rance is a very poor example of Harnessing of tidal flows and both French and Canadian (Bay of Fundy—the world's highest tidal range) experts agree that barrages are a high risk environmentally.

3. There is a view that the CWB could bring economic prosperity to South Wales and elsewhere. It should be remembered that it is investment that brings prosperity and not necessarily the project.

4. The political incentive for economic regeneration could cloud the decision in respect of the UK's power needs and Climate Change measures. It should be clearly understood that all NGOs support decarbonisation and green energy production. The need for both is urgent and neither will be met by the CWB.

5. Very little investment has been made into methods for converting tidal range into power generation. We hope the conclusion will be that other forms of green energy (Tidal flow, Photo Voltaic, Micro Hydro, wind etc) will be pursued alongside low carbon schemes (Nuclear, possibly gas) to solve the immediate short term problems concurrently with development of environment friendly tidal range schemes for deployment in the longer term.

December 2012

Written evidence submitted by E.ON (SEV79)

SUMMARY

A large scheme like the Cardiff-Weston tidal barrage would make a significant contribution towards meeting the UK's climate change targets, although it would almost certainly be too late to contribute to meeting the UK's target under the EU Renewables Directive. It would also provide a more predictable source of intermittent generation than wind, which would have some positive benefits for the operator of the scheme.

However, whether the investment is worth supporting through Government policy depends on the answers to two principal questions:

(a) whether the investment represents value for money for the consumer compared to alternatives sources of low carbon generation, particularly as the total funding available to support low carbon generation will be subject to continuing limits under the Treasury's levy control framework, and constraints on available private sector capital; and

(b) the extent of the local environmental impact, whether these can be mitigated and whether the project can comply with EU and UK environmental legislation.

An economic analysis of the scheme would need to consider in more detail the impact of the scheme on the wholesale power market and other power generation investments. The Severn Barrage would also need to demonstrate that it can be built at lower cost than other low carbon technologies which would otherwise be needed to meet the UK's climate change targets, and offshore wind in particular. As offshore wind currently sets the maximum price for support for low carbon technologies in the UK market, the Severn Barrage would need to generate at lower cost to be considered an option.

More work would also need to be done to improve understanding of the environmental impacts of any new scheme and compliance with the EU Habitats and Birds Directives in particular.

A Severn tidal scheme would require significant financial support. The proposed Contract for Difference under electricity market reform would appear to be a suitable vehicle for this in principle. However, we note that the Government wish to move from the latter part of this decade to a technology-neutral approach to minimise costs to consumers so the Severn Barrage would again need to be competitive with other technologies eligible for CfDs.

Q. *What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?*

If a Severn tidal power scheme generates whenever it can, as dictated by tidal flows, then in effect the demand shape for other electricity generation operating in the wholesale power market is changed. An assessment would be required of the impact on the wholesale market compared to alternative low carbon generation investments, and on the consequences for more flexible fossil plant needed to maintain security of supply as well as on nuclear and intermittent sources of generation.

For example, there are limits on the extent to which it is economically viable to deploy both intermittent "must-run" renewable and nuclear plant on the system as the combined output may in time exceed available electricity demand, which would lead to output from these plants being curtailed.

A Severn Barrage project would not reduce the UK's total requirement for generating capacity as it could not be relied upon to be generating at times when the requirement for capacity is highest, that is when wind generation is low and electricity demand is high. While it would displace generation from fossil plants and the UK's requirement for imported coal or gas, so would the other low carbon generation options which a Severn Barrage would displace given the limited funding available.

A Severn Barrage could of course make a significant contribution to reducing the UK's CO_2 emissions and to achieving a decarbonised power sector by 2030. However, the issue is really whether it can do that at a cost to customers which is lower than alternative sources of low carbon generation, as available funding will be limited under the HMT Levy Control Framework and there will be limits on available sources of funds from utilities or financial markets. Were it to be more competitive than other sources, then it could have a net positive effect on carbon reduction as more low carbon generation could be delivered for the same cost. As

offshore wind currently sets the maximum price for support for low carbon technologies in the UK market, the Severn Barrage would need to generate at lower cost to be considered an option.

Q. *What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated? Are the proposals in breach of EU legislation, and if so how will this be addressed?*

The Severn Estuary is classified as a Special Protection Area (SPA) for birds under the EU Birds Directive and is also a Special Area of Conservation (SAC) under the EU Habitats Directive. The SPA area is also designated as a wetland of international importance under the Ramsar Treaty. There are significant populations of a number of rare or vulnerable species which require protection under the Birds Directive. The Severn Estuary supports a range of marine and migratory fish, providing feeding, spawning and nursery grounds for a number of species.

For any tidal barrage to go ahead the project would need to ensure that it can comply with EU and UK legislation. The relevant statutory advisors to the Government—the Joint Nature Conservation Committee and member organisations—and any potential developer are best placed to comment on this matter further. The significant impacts of harnessing its tidal power, on local, national and internationally important habitats and species, were covered in the DECC Severn Tidal Power Feasibility Study.[56]

Any project would also need to comply with the UK's National Policy Statements (NPS) for energy Infrastructure. The current renewable NPS does not cover tidal projects and the Government has said it would consider either revisions to that NPS or separate NPSs to cover such technologies, were they to be considered economically and technically viable.

Consideration would also need to be given to the impact on other generation projects in the Severn Estuary including the proposed nuclear plants at Hinkley Point and Oldbury, in terms of cooling water availability and flood protection, for example.

Q. *Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?*

It would require support under a CfD but we cannot comment on the strike price. It would need to be competitive with the price of offshore wind as a minimum. In October 2007 the Sustainable Development Commission published some cost estimates and commented[57] that "the high capital cost of a barrage project led to a very high sensitivity to the discount rate used. At a low discount rate of 2%, which could be justified for a climate change mitigation project, the cost of electricity output from both barrage proposals is highly competitive with other forms of generation. However, at commercial discount rates of >8%, these costs escalate significantly, making private sector investment unlikely without significant market intervention by Government."

We agree that the discount rate would be a key issue in assessing the project cost and strike price. However, it seems unlikely that the project could be funded from other than private sources of capital for the foreseeable future. This would suggest that private sector discount rates would need to be applied to the project. These would need to take account of political and regulatory risk and the potential for cost overruns as with any major low carbon project. Investors would also need to be found who were prepared to commit very large capital sums for some years without seeing a return.

December 2012

Written evidence submitted by the British Association for Shooting and Conservation (SEV80)

EXECUTIVE SUMMARY

1. The Severn Barrage proposal will directly affect approximately 200km of shooting on the Estuary foreshore. Most of this shooting is secured by Crown Estate leases and is regulated by Natural England consenting. If the scheme goes ahead it is likely to jeopardise the majority of this shooting.

2. This 200km of land is managed by seven BASC affiliated wildfowling clubs.

3. This 200km of land is of high conservation status, providing important habitat for birds and wildlife.

4. BASC recognises Fossil fuels (coal, gas and oil) are a finite resource, it is therefore essential to find renewable alternatives. BASC understand that as part of a renewable energy strategy tidal energy is one of a number of possible options.

5. BASC does not oppose the development of tidal energy as such, recognising the importance of sustainable energy. However, it is evident from the limited information available from the developers that the proposed Severn Barrage would threaten nationally and international important habitats for birds which BASC objects to.

[56] http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/renewable%20energy/severn-tp/621-severn-tidal-power-feasibility-study-conclusions-a.pdf

[57] Turning the Tide: Tidal Power in the UK

6. BASC recommends that the government commissions a thorough and independent report into the proposal before considering this scheme any further. As with any development proposal there should be a comprehensive analysis of environment damage with the aim to keep this to a minimum which this scheme appears to have overlooked in favour of commercial gain.

About BASC

7. BASC was founded in 1908 as the Wildfowlers Association of Great Britain and Ireland and is the UK's largest shooting association. BASC is constituted as an Industrial and Provident Society and has a membership in excess of 130,000. BASC is the representative body for sporting shooting in the UK and the largest field sports organisation. It aims to promote and protect sporting shooting and the well-being of the countryside throughout the UK and overseas. It actively promotes good firearms licensing practice, training, education, scientific research and practical habitat conservation. BASC believes that all who shoot should conduct themselves according to the highest standards of safety, sportsmanship and courtesy, with full respect for their quarry and a practical interest in wildlife conservation.

8. BASC's expertise in shooting matters is widely recognised and it is routinely consulted by a variety of government departments and agencies (including the Home Office, Welsh Assembly Government, Defra, LANTRA & The Health and Safety Commission) and other statutory and non-statutory bodies.

9. BASC represents approximately 165 affiliated wildfowling clubs in the UK with a total membership of around 15,000 individuals. Wildfowling clubs manage more than a quarter of a million acres of land (104,000 hectares) in the UK, 90% of which is designated as sites of special scientific interest (SSSI). In England, Wales and Northern Ireland BASC affiliated wildfowling clubs lease some 700km of foreshore from the Crown Estate.

10. Wildfowling is the pursuit of quarry species of ducks, geese and waders with a smoothbore gun, principally on estuaries and coastal marshes but also on large wetlands further inland. Wildfowling is usually a solitary activity and in England and Wales takes place from 1st September to 20th February on the foreshore and ending 31st January inland. Wildfowling is a recreational benefit for local communities and wildfowling clubs provide a focus for wardening of land, monitoring of wildfowl and habitat protection and improvement. The Birds Directive (1979) fully recognises the legitimacy of hunting of wild birds as a form of sustainable use. Wildfowling is an activity that provides significant social, cultural, economic and environmental benefits in the UK.

11. Management of the wildfowl resource by local communities is integral to the management of wildlife on our coasts and an important aspect of our coastal heritage. Land managed for wildfowling often plays an important role in local flood management risk strategies and wildfowling clubs are well placed to deliver continued benefits to such strategies, especially in the management of land involved in managed realignment projects. Wildfowling clubs manage land involved in Environmental Stewardship and Higher Level Stewardship schemes. BASC encourages more clubs and members to participate in such projects. We recommend greater empowerment of local communities in the management of land as a long-term strategic benefit to flood risk management.

12. BASC recognises the importance of the coastal environment and the need to balance different user needs. The Severn Barrage inquiry should recognise the long standing and culturally important activity of wildfowling and the sensitive nature of the habitats over which wildfowlers shoot.

13. The Severn Barrage proposal will directly affect approximately 200km of shooting within the Estuary. This land is managed by seven BASC affiliated wildfowling clubs.

14. In 2004, an estimated 2.6 million work days were undertaken on habitat and wildlife management as a result of sporting shooting in the UK. This is the equivalent of 12,000 Full Time Equivalent jobs.

15. As a result of sporting shooting, £250 million was spent on conservation activities and that shooters themselves contributed 2.7 million work days, the equivalent of 12,000 full time jobs. £8 million alone was spent on tree planting. The total value of sporting shooting to the UK economy in the same year was £1.6 billion. (Source 2006. PACEC. Economic and Environmental Impact of Sporting Shooting in the UK. Available online at www.shootingfacts.co.uk).

16. Given the level of involvement shooting has within the Severn Estuary, we hope that the inquiry will recognise the important contribution shooting makes to the environment, and that the activities of those involved will not be inadvertently restricted by any Severn Barrage proposals.

January 2013

Written evidence submitted by Ravensrodd Consultants Ltd (SEV81)

Having seen on our local TV on Thursday 10 January 2013 the consequences of your Select Committee interviews, and read the evidence given by wildlife groups and others at the hearing, I would be grateful if the committee could consider the enclosed as a written submission because it is clear that the evidence given so far could be construed as misleading. Should it be the Committee's desire, I would, of course, be happy to be questioned on it.

May I point out a major omission in your procedures to date. This is, namely, that you have failed to engage with the academic community with whom scientific knowledge of the Severn Estuary resides! My colleagues and I span the physical evolution of the system, the shore birds, fish and invertebrate communities. Our comprehension arises from fieldwork begun in the early 1970s which, as it turned out, was a golden, honeymoon period for British marine research. I am an oceanographer and former government researcher at our Institute of Oceanographic Sciences (now NOC) responsible for 24 shipboard research investigations costing, maybe, £10 Million to repeat today. Since our laboratory closed I have worked equally intensively on the foreshore. Over 40 years I have written more than 60 scientific papers on the Severn, 15 on various barrage prospects. I have participated in every tidal power investigation (4) of the modern era and, with a French professor, am a Thomas Telford Premium Award Winner from our Institution of Civil Engineers in Westminster for our work comparing ecological consequences of The Rance and a Cardiff-Weston Severn Barrage.

My colleagues at Plymouth Marine Laboratory (ex-IMER) have worked even more extensively in the estuary (52 shipboard research investigations on 1 topic alone). I rely on them for knowledge of the important microfauna, invertebrates and many other issues.

The British Trust for Ornithology has undertaken yearly bird counts in the estuary extending back now 40 years, and my fish biology colleague is the actual person who makes and records the monthly counts of fish catches on the cooling water screens of all our estuary power stations.

It should be clear to your committee that these long biological time series, involving huge amounts of data, render the Severn data-rich and with a sound base of scientific knowledge. The unambiguous trends these show lead all of us to be "profoundly unsettled" in respect of the galloping pace of climate change we detect. We have an equal commitment to the wellbeing of the Severn as our conservation colleagues, but our training and high level life's work drive us to a different view. Instead, we pose the question "What will become of the ecosystems of the Severn without a Cardiff-Weston barrage?".

Furthermore, from our forecasts and experience at similar schemes elsewhere, we don't doubt a barrage can be built without causing the damage these colleagues insist is inevitable. Just one issue you might reflect on is that in spite of the passage of 40 years and in the meantime the huge amount of knowledge gathered, we haven't even managed to reach an agreed description of the ecological status of the estuary with the conservation lobby.

This jarring discrepancy may owe something, or indeed everything, to the current parlous state of British maritime science compared to adjacent mainland Europe and the USA. This manifests itself detrimentally in a number of ways. I have tried unsuccessfully in the past to alert Richard Benyon MP of Defra and The Chancellor, George Osborne, to these matters when they have touched upon these disciplines.

Because the work of my colleagues and I is in peer-reviewed, high impact factor scientific journals, I can summarise briefly the status of the Severn and consequences we have determined of Cardiff-Weston. (see below). So you understand it, I currently have no commercial link to anyone promoting a tidal energy scheme.

SEVERN ESTUARY AND IMPLICATIONS OF CARDIFF-WESTON BARRAGE

1. Executive Summary

(a) Over the last 40 years the Severn has become data-rich and well understood.

(b) It is clear that Cardiff-Weston would reduce threats of flooding from seaward or the Severn Catchment.

(c) A contrasted appraisal of the Rance Barrage to that offered by the conservation movement is provided based on intimate experience.

(d) Tidal power barrages can readily be built which don't kill birds and mince fish—witness Rance.

(e) The water body of the Severn is barren, as are intertidal and subtidal sands, subtidal mud and much of the muddy foreshore.

(f) The shorebird density is low and declining rapidly. Water temperature is rising and, without a barrage, becoming critical for fish such as Salmon.

(g) The higher muddy foreshores are populated from time to time by a highly restricted range of dwarf invertebrates typical of normal estuaries. There are no species typical of highly stressed regimes, such as deserts.

(h) In future the already suppressed dissolved oxygen levels are threatened with further deterioration by climate-induced factors.

(i) This justifies a line of thought that only a Cardiff-Weston barrage, depending on how it is configured, could save the Severn.

2. The evidence provided by the Conservation Pressure Groups, Martin Spray, Kate Jennings, Simon Prior and Martin Salter is often focussed on "the estuary is too complex to meddle with", "this or that is unknown"—all without any reference to the highly evolved state of knowledge of the system. In the course of the DECC study published October 2010 contributors were asked two or three times whether there were gaps in knowledge which were holding back progress. On each occasion all agreed there were none. The Energy & Climate Change Select Committee has received evidence on shipping, flooding, and ecology, which should properly be addressed on the basis of the above knowledge.

3. In respect of shipping, Simon Bird expresses concern with regard to siltation. Depending on what is built, this can't be a problem. He mentions ship locks and loss of high water height. Ship locks will be needed whatever is built and water depth is a genuine issue with the Hafren Power scheme. He doesn't raise it, but the closure sequence and its long duration is a real challenge for all concerned. A barrage would reduce storm surge height to seaward and also reduce flooding risk. In respect of high rainfall in the Severn catchment, it is axiomatic and simple engineering to manipulate the basin waters of any barrage in order to keep the levels depressed by way of raising bed gradients to accelerate discharge of flood waters. It is well established that there is about a two day delay between heavy rain in the Welsh uplands and a flood peak at Gloucester. In this manner height regulation can be readily anticipated. (See also STPG evidence from penultimate study). By the same token, owing to its upstream location, Slimbridge is above the zone directly influenced by changes in the tide. In respect of conservation evidence, it is not true that all barrages kill birds or that turbines inevitably mince fish.

4. It is not true that, as alleged, the Rance barrage "doesn't work" or that the French have no data prior to the 1980s. The Rance barrage is the most visited industrial tourist attraction in France. Since commencing operation in 1966 it has enjoyed a high serviceability rate (average ca. 0.75% downtime/year). It still looks brand spanking new, uses the original turbines and produces enough electricity to heat, power and light a city the size of Rennes. Laboratoire Maritime of Muséum National d'Histoire Naturelle (MNHN) was set up in 1883 on a bluff looking down on what is now the barrage. Over the last 130 years it has assembled a library full of works on Rance and elsewhere. In my joint paper with Prof. Retiére in 2010 I have pre-barrage sediment maps for 1889 and 1956, and post-barrage maps for 1971, 1976, 1994 and 1995. Were any other discipline to be studied, historic material will be in this library too. The Rance barrage does not mince fish. Its fish fauna is more abundant and bio-diverse than either before 1961 or in adjacent, comparable French estuaries in the same zoogeographical area. Its turbine speed is 94rpm compared to 50rpm for a STPG Severn barrage. French marine biologists are (arguably) more sophisticated than ours, they have learnt to use the basin waters and bed as nursery areas to seed, grow, transplant and repopulate zones on the French continental shelf degraded by dredging, pollution, etc. The UK currently has no such option. The avian fauna is, similarly, more abundant and bio-diverse than it was prior to 1961.

5. The claim was made that a Severn barrage would be intrinsically damaging to fish and birds. Arising from the extreme tides and high fine sediment load, which cycles fortnightly between Springs and Neaps, there is no daylight as well as inhibited dissolved oxygen levels in the water body—hence there is no photo-synthesis—the basic building block underpinning any food chain (Williams, 1984). Ditto, there are no diving birds. A further notable feature of the estuary is that the fish fauna lacks a benthic (bed)-feeding component (Henderson, 2007 & others). Migratory and indigenous fish are largely confined to the estuary margin. In recent decades water temperature rises in the Severn have led to new warm water fish species invading the estuary at the rate of one every 15 months. In respect of Salmon, our local waters are now within 1°C of permanently excluding this species. Our indigenous fish, including Salmon, are highly adapted to living in waters fully saturated in dissolved oxygen, which these water no longer routinely are (EA data). Similarly, were it not for interbreeding with escapees from Salmon farms, this species would no longer even occur in the estuary today. Bearing in mind these three factors, the future of Salmon in the estuary looks extremely bleak without a barrage.

6. Separately from the largely barren water body, the intertidal and subtidal (below LW mark) sand bodies are presently barren or very nearly so (Cefas 1999 & 2000). The much-vaunted intertidal mudflats are eroding progressively. Elsewhere in the natural world derived fines from this erosion are carried away in suspension leaving behind a "winnowed" deposit of the heavier shell fragments from long dead burrowing invertebrates at the tidal flat surface, which are swept by currents to form large shell banks. Notably, eroding, over-consolidated tidal mudflats in the Severn lack such shell banks, testifying to their long-standing barrenness (1000s of years). This absence is unrelated to pollution but owed, instead, to the hostility of the environment. By the same token, subtidal mud patches are also barren (Kirby & Parker, 1980). Higher inshore mudflats do from time to time exhibit a restricted fauna of the invertebrate prey-species of fish and birds—*Nereis, Corophium and Hydrobia*—all dwarf in size. These are termed depauperate (impoverished) examples of "normal" estuarine communities. Were the Severn to hold any species typical of highly suppressed environments, as do deserts, it might properly be termed "special" but it doesn't. There is virtually no reproduction in the Severn. Where present, following advective spat input from the productive Bristol Channel to seaward, such invertebrate colonisation is vestigial and ephemeral. There is a logic to biology, ensuring that this favours predation by Dunlin, a species small at adulthood. The sediment regime almost entirely precludes filter-feeding organisms. These severe constraints contribute to the shorebird fauna existing at a density one third to one twentieth of "normal" muddy estuaries in UK (British Trust for Ornithology—BTO).

7. Furthermore, the reality is significantly worse on grounds that since the early 1970's the abundance of seven bird species has crashed—in the case of Dunlin to one third of its earlier reduced level (BTO)—at a

time when sewage and industrial discharges have improved, along with water quality. This crash, from its already minor levels, is entirely due to climate change, the very thing installing a tidal power barrage is designed to offset. From the above description it is unambiguous that large parts of the existing Severn can't even be a "habitat" let alone one which can be "damaged" by a barrage. These facts are disconcerting to the academic community.

8. The issue of the dissolved oxygen status of the Severn is a focus of future concern. Temperature rise induces two detrimental effects on dissolved oxygen (DO) status. As temperature rises sea water can hold less dissolved oxygen and, moreover, the oxygen consumption rate by micro-organisms increases. In the oceanographic world there is acute concern, amongst several factors, with the oxygen status of the world's oceans. The Severn is renowned intrinsically for its vulnerability to DO sags (EA data). Separately from the two temperature-related factors, above, increases in tidal range and height are leading to raised current velocities and increases in suspended sediment concentration. Organics in the high sediment load use up DO. Furthermore, long time series of tidal flat elevation measurements indicate an association between deeply erosive events and positive excursions in the Index of the North Atlantic Oscillation which are known to bring severe gales over southern Britain. Such episodic erosion also inputs large increments of fine sediment into the system. Some climate modelling suggests such positive excursions will increase in future. As far as timescale to wider system-deoxygenation is concerned, remember 2007. Where any faunas occur at all these two water temperature and two suspended sediment trends due to climatic deterioration threaten further the already highly depauperate estuary.

9. The findings of academics from the most prestigious government research institutes in the UK and France contrast starkly with the case made by the conservation lobby. Academic concern is often focussed on how, in future, without the right tidal power barrage, we can resist the detrimental consequences already happening to birds and pending for fish. Our findings derive not from occasional observation but, instead, from huge, expensive, scientifically-robust endeavour. Over-riding everything for the estuary and its prospective barrage, the sanctity and integrity of the ocean sciences underpinning decisions must be paramount.

January 2013

Written evidence submitted by The Severn lake Co. (SEV82)

REPORT PURPOSE

To lend support with recommendation to Hafren Power and a privately financed Energy Causeway between Wales and England.

BACKGROUND

1. The poem, The Severn Lake, was written in 2004 and published in the book "The Grumpy Old Welshman" that year, since republished 2012 in hardback. It is a scathing attack on local councils and the Welsh Assembly Government for the treatment of small business in Wales.

2. To balance the argument, my vision and innovation for jobs was included. The possible 32,000 jobs created by building an Energy Causeway seemed more important than bus passes. The "Energy Policy....." booklet in 2002 and published by the Coal Authority clearly showed an energy gap.

3. To my astonishment, I discovered that apart from 14,000 plus documents on the "barrage" website, no-one and no single company had actually kicked it off.

4. On 1 March 2006, I placed a "change of use" planning application with the Vale of Glamorgan and Sedgemoor Councils. The application was to change the Severn river by placing an Energy Causeway that would create a 145,000 hectare. The Vale of Glamorgan returned the application with recommendations on planning needs. Sedgemoor sent the application to the DTI at 1 Victoria Street London. The journey up to the present time and nine Energy Ministers down the line, will also be written in a book "The Severn Lake".

5. In July 2006 The Severn Lake website was launched and has been the "News on the Severn" "With a strong following, including HM Government Departments". The very first home page is shown as Fig.1.

6. As part of the journey, we have had discussions and Open Days with Sedgemoor Council and the public, The labour Party at Clevedon, The Friends of the Earth, The Green Party at Bristol, and many other smaller meetings to provide our vision for this project and to listen to their fears and suggestions. I have never been asked to supply any information in Wales.

7. The biggest surprise to this project is the huge support from the South West for this scheme. We have had financial offers to buy shares from elderly residents in the hope of regenerating jobs along the Eastern shoreline for their children. Another surprise was the vociferous argument against a road or rail links citing a rat-run to Cornwall from Wales!, and finally, we discovered that most of the environmentalists we have met ie Friends of the Earth, The Green Party and others are wholly supportive of this project. We consider at least 90%, but their leaders do not reflect this! It might be an idea to have a large open convention with an open vote to gauge the true feeling for this project.

8. The forming of the company, Hafren Power, by businessmen and entrepreneurs should be applauded and supported. Despite press reports ignoring the recommendations of the November 2006 Energy Review, in that any energy supply should be privately financed, it is encouraging to see Victorian values and projects back on the agenda. The country as a whole do not understand the delay.

Recommendations

(a) *Overall*. The Severn lake vision was for a complete ribbon development to include not just the Energy Causeway, but all the commercial and tourism activities. That can be introduced. Care should be taken in design to accommodate these much needed activities. Shipping channels for small and large craft safer areas on the lake and approaches to the scheme must be thought through as a "whole" development not a "bolt on" later.

(b) *Power Plant Technical*. It is our opinion that only tried and tested turbine technology centred in the deep area of the Severn venturi will capture tile power effectively and efficiently. The Tri·Wall Tri-Pod single direction bulb turbine system can only be the safe way to collect the energy. A UK Patent held by one of the Worlds foremost leaders in turbine technology, Mr. Alexander Gokhman of California USA has been configured to specifically meet the needs of this project. His paper has been published (Alexander Gokhman, Severn Estuary ideas for development, International Water Power & Dam Construction. Vol. 63, No. 2 (2011)) and is with HM Government. Our concerns regarding the Hafren Power House proposals are as follows:

(i) The Tri-dam Tidal Power Plant concept needs only one set of one-way turbines for generating power during both ebb and flood tides. It uses frequency converters which permit the turbines to work at their optimal operating regime for the entire variation of head during both ebb and flood tides. It also uses bypasses passing water parallel to the power house at the ends of ebb and flood cycles. These three features allow use of commercially available and tested in the field Voith bulb turbines equipped with axial fixed-blade propeller runners. As a result. the turbines of the Tri-dlam Tidal Power Plant always work at their peak efficiency and without pulsations or vibrations. These turbines also have high discharge capacities that result in the fact that only 64 turbines with 9 meter diameter runners can provide 5% of the UK's annual energy consumption.

(ii) In order to provide the same 5% of UK's annual energy consumption, Hafren Power's proposal uses 1064 not tested in the field bidirectional VLH turbines. Since in Hafren Power's proposal there are no frequency converters, the bidirectional VLH turbines must work at variable heads at constant speed. As a result, these turbines work in both directions mostly off their optimal operating regime with very low efficiencies and, therefore, with high pulsations and vibrations. Also, there are no bypasses in Hafren Power's proposal.

(iii) Danger to fish passing from the basin to the Bristol channel via turbines caused by runner blade adjustments:

— Tri-dam proposal—reduced danger. This proposal uses fixed-blade propeller runners which have no gaps between blades and hub and between blades and runner housing which can trap fish.

— Hafren Power's proposal—significant danger caused by 1064 units with adjustable-blade runners containing fish-trapping gaps.

(iv) Change of physical, chemical and biological conditions in the basin on the inland side of the barrage caused by the reduction of the tidal range on that side. This includes adverse effects on wetlands and beaches:·

— Tri-dam proposal—insignificant adverse effect, because, due to the bypasses and the variable speed turbines, the tidal range is almost unchanged from natural conditions.

— Hafren Power's proposal—significant adverse effect, because, the tidal range on the inland side of the barrage is significantly reduced from natural conditions due to the inability to bypass sufficient water to equalise the tidal range.

The Severn lake Company has, through the length of this project, acquired the expertise of many of the World's experts in this field, and it is part of our mission to give full support to Hafren Power to resolve these complex and technical issues.

(c) *Shipping Movement*. It is certain that the commercial shipping and dredging companies have a valid reservation to this scheme in any delays encountered. Hafren Power will have the ability by the end of February 2013 to licence a Free Flow Shipping Channel Patent (currently before the Patent Office) which allows the free flow control of shipping by way of variable lock. and gating systems and depth control. The final design of the device should be done with the input of the Port of Bristol Authority, Associated British Ports, local Marinas and other interested parties. It should also be noted that this patent implementation naturally allows for fish pass.

(d) *Construction*. (Further innovation and vision):

(i) *Wave and Power*. Consideration should be given to grid supply within the Causeway to allow wave farms to be set up downstream to capture further energy and to console and calm the waters prior to entry into the Causeway turbine houses.

(ii) *Islands*. The provision of 12 Woodham Islands on the English and Langdon grounds with a dual purpose. *Purpose 1, Waste Disposal*. The construction process will create huge volumes of rock sediment and construction waste. The building of the islands can absorb all the waste during construction within close proximity to the scheme. *Purpose 2, Private and Tourism*. The 12 islands (more or less) wouuld have the following title and use:

The Woodham Islands—North to South

1. One eel island.
2. Four private islands.
3. Newman island Studios (sponsored).
4. Yachting. Sailing, lifeguard island (most Eastern side).
5. Schools, innovation. invention centre, nautical tests, government funded.
6. Bird island RSPB. The largest and floating island (most Western side).
7. Island fort visitor centre with seabed restaurant (sponsored).
8. Fishing islands (with wrecks).
9. Diving island [and habitat] (most Southerly island).

All the islands will be self sufficient on water and power.

CONCLUSION

The Secret of success is "luck and timing·. Power from the Severn was always going to happen. The time is right re: demand. The brave businessmen with the finance re: supply and logically HM Government re: sentiment. The job is big, but construction itself is easy.

Let's Do It!

January 2013

Written evidence submitte by Tidal Lagoon Swansea Bay (SEV83)

OVERVIEW OF THE TIDAL LAGOON SWANSEA BAY PROPOSAL

We believe that tidal lagoons should form a significant part of our future energy mix and can help us achieve greater security of supply while reducing the cost of electricity to consumers. Our proposed project in Swansea will be a flagship for the UK and Wales, generating cost effective, predictable and fully renewable power from the tidal range in Welsh waters. We therefore welcome any support for the development of tidal lagoons as part of Wales' energy mix.

Tidal lagoons offer the first renewable form of baseload electricity generation which encompass the predictability of tides and generation periods. Developments provide a low risk, low cost renewable energy source without significant innovation. They hold the potential to harness significant power from a natural resource widely available from an island nation and in close proximity to population centres for low loss distribution. This renewable energy source is also able to be plugged into the national grid without requirement for additional balancing fossil fuel driven capacity.

This development project will be the world's first man-made tidal lagoon, producing enough sustainable and predictable electricity to power over 107,000 homes—the equivalent of Swansea's entire domestic electricity use—saving over 200,0000 tonnes of CO_2 annually. It is estimated to represent a £550 million investment. It is also a significant opportunity for Wales to take the lead in the tidal industry for the UK as we work towards driving a critical change in the UK's energy mix with low cost, low carbon electricity sources that are sustainable long-term. Importantly, we believe that this power plant has the potential to be connected to the Grid by 2017.

The project is expected to have an installed power capacity of 200MW, making use of four tidal movements per day to produce around 400GWh of renewable electricity per year for over 100 years. This level of generation qualifies the proposal as a Nationally Significant Infrastructure Project (NSIP), and as such the associated planning application will be considered by the Planning Inspectorate and determined by the Secretary of State. Separate applications may be made to the City and County of Swansea for some elements of the scheme, in addition a marine licence will be required from the Welsh Government.

The lagoon will comprise a "land attached" impoundment sitting between the dredged channels of the Tawe and Neath rivers. With landfall points situated at either end of Associated British Ports' owned Swansea Docks, the lagoon will not obstruct the entrance to any rivers or marinas, nor adversely affect the operation of the port.

Permission will be sought for: the construction of a c.10km breakwater wall extending out from the Port of Swansea to enclose c.10km² of tidal area; sand dredging within the lagoon perimeter; the construction of turbine housings, sluices and a visitor centre on the lagoon wall; plus associated onshore amenities. The total height of the wall will be 11m (rear) and 19m (sea). The visibility of the wall at low water will be 11.3m, at high water it will measure 2.8m.

Swansea Bay has been chosen as it offers the necessary conditions for building lagoons—the water must be shallow and the tidal range must be large. The Severn Estuary holds the second highest tidal range in the world and Swansea Bay reaches a range of up to 12m. As well as benefitting from this key characteristic, Swansea has a site of gently sloping seabed (suitable for this construction method) and proximity to a population centre, such that transmission losses are minimised from the electricity produced.

In addition to clean energy production, we believe this project will facilitate wider regeneration objectives in Swansea and South Wales, creating a new visitor attraction comprising an education centre, an iconic art and cultural venue, a mariculture resource, and a national sports centre suitable for sailing, canoeing/kayaking, rowing, triathlon, open-water swimming and running events.

Environmental Impact

We recognise that any development of this size will have an effect on its environment. We are committed to minimising any adverse impacts of our build programme and operation through comprehensive assessment and understanding of potential impacts, thorough consultation, analysis and appropriate design tuning. Between early 2011 and autumn 2012 we produced a full Environmental Impact Assessment (EIA) scoping report that outlines our proposed approach and areas of inclusion for EIA. This was submitted to the Planning Inspectorate on 15 October 2012 and is available to view through the link on their website. This document covers the proposed scope for a wide range of investigations, including coastal processes, sediment changes and sands, water quality and visual impact. From the outset of the project we have sought informal feedback from statutory consultees such as the Countryside Council for Wales, Environment Agency Wales and the local ports authorities.

We are now in the process of assessing baseline scenarios and setting up our hydrodynamic model with which impacts can be measured, employing a team of independent experts to carry out our assessment process. Additionally we aim for our lagoon to have a net positive affect due to the creation of a 10 km sea reef and the creation of oyster beds and mussel beds.

Finance and Partners

Swansea Bay Tidal Lagoon is being driven by Tidal Lagoon Power Limited. Our focus is the development of a series of tidal lagoons to generate renewable energy from the rise and fall of the considerable tidal range to be found in Welsh and UK waters. The vision of the business is to deliver 10,000 MW of power from tidal range in the UK and thus change the energy mix to home-grown, low carbon energy that creates local jobs, cheap power and local long term amenities for the communities who host the lagoons.

Tidal Lagoon Power is privately funded and founded by Mark Shorrock, CEO. Mark is a pioneering entrepreneur in renewables who has founded four companies including Wind Energy, a Scottish based developer of wind farms. Mark grew Wind Energy Ltd into the largest independent developer of wind farms in the UK with over 650MW of wind farms moving through the planning process. In 2006 Mark founded Low Carbon Investors, investment manager of the AIM listed Low Carbon Accelerator fund which he also founded. In 2008 he founded Low Carbon Solar Holdings, a private investment vehicle currently investing in solar power plants in Spain. Prior to founding Tidal Lagoon Power, Mark was a founder of Low Carbon Solar which in 2011 developed and funded the deployment of £70 million of solar energy, totalling 28MW.

Core members of Tidal Lagoon Power's consortium are Atkins Engineering, responsible for design of the lagoon, Van Oord, responsible for construction, Costain, construction of caissons and future Operations and Maintenance, Sgurr Energy, responsible for financier's technical assessment, GKL Consulting, responsible for Environmental Impact Assessment work and a series of coastal process and oceanography consultancies including Intertek Metoc, ABPmer and Titan Environmental Surveys.

Consultation

Adopting an informal, early consultation approach we have aimed to ensure as much collaboration with all stakeholders as possible, seeking feedback on early proposals and including concerns raised within our approach to assessment. So far we have held audiences with over 100 stakeholder organisations.

Informal consultation to date as had provided the blueprint for our strategy for community engagement and plans for community benefits. We plan to set up a community fund, offer a local community share and provide a local electricity tariff. This is also an opportunity to support existing local community regeneration organisations, employment and apprentice schemes and environmental and arts initiatives.

We will begin formal consultation in May 2013 with full project detail, subject to design readiness, with the view of submitting an application for development consent to the Planning Inspectorate in Q3 of this year, between July and September.

If you would like us to arrange a meeting in the near future please contact Lucy James Tel: 01242 308043, lucy.james@tidallagoonpower.com.

More details are available on our website, www.tidallagoonswanseabay.com, where you can also register for updates as the project progresses. We look forward to keeping you informed as we reach key stages of the development.

January 2013

Written evidence submitted by Brian Catt (SEV84)

I hope this evidence will be useful to you in your deliberations on a Severn Barrage arising from the Select Committee of 10th January that I have just watched, and all topics relating to assessing the relative economic and environmental viability of energy generation modalities, whether blessed as renewable or alternative by policy or not. Thanks for including this ex post.

I am a professional electrical engineer, physicist and MBA retired businessman, interested only in what can work best for the UK to maintain the affordable, controllable and sustainable electrical energy supply through the end of fossil.

We have to maximise the competitiveness of the energy supply that drives our economy, in a world where use of cheap intense energy is directly proportional to prosperity, investment in future generating infrastructure has to be both affordable and sustainable (i). I apply these criteria to barrages below.

Background: Our generation will need to be 2 (2050) then 3 (2100) times current levels simply to replace the uses of primary fuel in heating and transport and maintain today's levels of GDP with no growth, the doubling is based on DECC DUKES figures and is a factor the DECC also uses, the trebling by 2100 is from the IPCC. Not less. 2 then 3 times more. How will that be done?

Not by conservation. Conservation is a small offset to this massive essential increase which must also be as cheap as possible, not least because the simple replacement of primary gas combustion for direct heat by electrical energy will cost four times direct gas at today's relative rates per kWh, never mind any other premium. 400%.

Quadrupling the cost of that part of energy supply will cause serious energy poverty without any subsidies for barrages, other alternatives and renewables!

The crucial test of a barrage for the UK economy is, I suggest, "Will a barrage help as a more cost effective and decarbonising investment long term than the current fossil and nuclear mix?".

The facts are well established by modern science, straightforward and controlled by the physics and its consequences. No opinion is required. We have two centuries of experience and research since inherently inadequate wind, water and Bio Fuel energy sources were dropped in favour of coal that had far superior intensity and controllability, hence lower costs, necessary to create the first industrial revolution.

So can a tidal barrage better deliver the objectives of energy policy?—adequacy, affordability, contollability and sustainability—while decarbonising our generation overall?

Capital Costs are Very High per GW

The capital costs of barrages are greater than nuclear power per GW and the operating costs low but not as low (RAE). It appears there is reasonable concensus that costs are likely to be similar to offshore wind. Three times fossil and nuclear generation. To paraphrase wind, only the gravitational potential energy is free, everything else sitting in a very aggressive martime environment is not.

Uncontrollable and Output Falls to Zero twice day, Fossil Dependent for 100% of output twice a day

Assuming this must be a bi-directional tidal barrage the output is cyclicaly variable and goes to zero twice a day, so, like other policy alternatives, barrages depend uttterly on fossil generation for 100% backup and are effectively obsolete without it.

Overall the output is relatively weak per unit resource compared to base load coal, gas and nuclear, and the environmental impact far higher.

So, as with wind power and all other alternatives subsidised by policy to date, barrages are very expensive, and are dependent on, and not a true alternative to, fossil generation, simply replacing its cheaper controllable generating capability with more expensive energy by law when its there, with little effect on emissions, and economically and practically pointless without this fossil backup.

Spending our money on ever more expensively subsidised modalities that are too weak and variable to deliver our future electrical energy requirement on demand when fossil has gone is clearly a bad idea, on one with such massive environmental consequences its even worse.

We can meet our needs much more cost effectively and sustainably by more intense, decarbonising and controllable gas or nuclear with minimal environmental impact.

Environmental Impact: The best alternative, of nuclear replacement for fossil energy, has the smallest environmental footprint, and requires no new grid lines or extensions with their incremental costs and additional enviromental damage where it directly replaces fossil power, as it ultimately must as fossil becomes first economically then physically unsustainable. New nuclear's environmental footprint is as small as CCGT, no cooling towers are required, just modern house-height low profile cooling arrays as at Didcot B, so a small environmental impact per unit output. By far the best environmentally.

It is essential we minimise electricity costs and maximise the value of investments made in energy generation on our behalf using our money, whether gained through direct taxes or the privatised taxation that is ROCs. And our solutions must be competitive with other nations adopting the most economically effective solutions for themselves.

The scale of the economic consequences of these decisions at a critical time for our economy is massive. Base load energy and ROC subsidies at c.£50/MWh costs us c.£1B pa for each 1GWYear of electrical energy for 25 years, or £50 per household. Each ROC adds another £1B pa per GWyear to the energy poverty resulting from subsidised generation. Most of it is unproductive and short term economically obsolete, as this would be.

CO_2 Emissions: It has now been clearly shown that alternatives as prescribed by policy have at best a marginal effect on CO_2 emissions for their 100% or 200% grid subsidies because of the impact on the emissions of their fossil backup, and they are self evidently 100% dependent on displacing the output of cheaper controllable fossil power to exist. Not sustainable without fossil. If dangerous global warming exists, energy policy prescriptions to date are making it expensively worse by their subsidies for the weak and uncontrollable energy sources of history and the highly emissive renewables.

As with the relatively weak and diffuse energy sources of wind, wave and solar electricity the "fantastic power" of this barrage compared to real alternatives such as gas and nuclear is again a simple political delusion. It is, in clear fact, uncontrollable and more expensive per unit to collect compared to better economic alternatives. Only the Tidal energy is free. Capturing it costs too much and isn't necessary to best meet policy's objectives.

This barrage fails all the key policy tests of adequacy, affordability, controllability and sustainability (as part of its reliance on fossil to maintain its output)—in comparison to better gas and nuclear investments that meet all the policy objectives unsubsidised.

Damming The Severn Estuary at massive cost to generate yet more uncontrollable electricity very expensively until the end of fossil, when the whole thing is obsolete without fossil backup, is simply compounding the negative consequences of current energy policy. The jobs argument is utterly bogus, we want people working on what works best that we can also export, not what a rational purchaser without our ideology blinkers would run away from.

(i) Hans Rosling is good on the direct causal linkage between electricity use and GDP, less is less, this is a simple and clever animated visualisation over time. Note the scales are logarithmic, so each main division represents a factor of 10 increase. Play and enjoy. Note the size of circles is CO_2 emissions and can be represented using other parameters. There are other corroborating academic studies.

Less is less. Planning less, more expensive electricity is clearly a mistake when we need more cheap electricity, and conservation is simply a sticking plaster delaying the inevitable.

http://www.gapminder.org/world/#$majorMode=chart$is;shi=t;ly=2003;lb=f;il=t;fs=11;al=21;stl=t;st=t;nsl=t;se=t$wst;tts=C$ts;sp=6;ti=2008$zpv;v=0$inc_x;mmid=XCOORDS;iid=phAwcNAVuyj1jiMAkmq1iMg;by=ind$inc_y;mmid=YCOORDS;iid=tiVeyAJd7iRWorOwl_ARWEQ;by=ind$inc_s;uniValue=8.21;iid=phAwcNAVuyj1NHPC9MyZ9SQ;by=ind$inc_c;uniValue=255;gid=CATID0;iid=pyj6tScZqmEfbZyl0qjbiRQ;by=grp$map_x;scale=log;dataMin=294;dataMax=76977$map_y;scale=log;dataMin=5.6;dataMax=50083$map_s;sma=58;smi=1$cd;bd=0$inds=

There are other corroborating academic studies. And should they be required I wil reference them, also expand on the science and data behind this evidence as required.

January 2013

Written evidence submitted by a Coalition of NGOs (SEV86)

A coalition of NGOs,[58] with a shared interest in the Severn Estuary and shared concerns regarding the potential impacts of barrage proposal met with Peter Hain MP and with Hafren Power in October 2012.

While each of the NGOs reserves the right to take their own position regarding Hafren Power's Severn barrage proposal once full details emerge, we have a number of shared concerns at this early stage. Those have previously been provided to Peter Hain MP and to Hafren Power in the form of a briefing, and are presented below as evidence to the Select Committee Inquiry.

The current position of the NGOs on Severn barrage proposals in general, and the Hafren Power proposal in particular, can be summarised as follows:

- We attach great value to the Severn Estuary for its international importance for wildlife, and for the economic and social benefits that this provides.
- We see climate change as the greatest medium to long-term threat to biodiversity, and we support the deployment of renewable energy as an essential element of the steps required to decarbonise the UK economy and maintain our electricity supply. We also acknowledge the potential of the Severn Estuary for renewable energy generation.
- That said, we recognise that, like all forms of development, inappropriately designed and/or sited renewable energy developments can cause serious, irreparable and unnecessary harm to biodiversity.
- To date we have not been presented with sufficient detail on the current proposal, or any assessment of the impacts on the impacts of that proposal, which would allow us to consider the extent to which the impacts of the current proposal would differ from those of the completely unacceptable high head Cardiff to Weston barrage (especially in the long term).
- However, we remain deeply sceptical that a shore-to-shore barrage on the scale of that envisaged can be delivered without unacceptable damage to the Severn Estuary, its wildlife and heritage, and the tourism, recreational and commercial activity that this supports.
- We acknowledge that the Severn Estuary is a highly dynamic ecosystem that will change over time (and has done so in the past). The very nature of the estuary means that all devices installed to generate electricity from it will in some way affect that ecosystem. We wish to see an approach to the development of renewable energy proposals that delivers maximum energy yield for minimum environmental impact. If current technologies cannot achieve this, then efforts should be concentrated on the development of less damaging alternatives.

THE KEY CONCERNS OF THE NGOS REGARDING THE IMPACTS OF A SEVERN BARRAGE ARE

- Impacts on the geomorphology—including long-term changes following construction of a barrage structure;
- Impacts on hydrology and sea level—including near and far-field effects, impacts on flood risk, water quality, wave climate, land drainage and groundwater;
- Impacts on estuarine habitats—including both habitat loss at the time of construction, and that associated with changes in geomorphology and the tidal regime following construction;
- Impacts on birds including those associated with habitat loss and change;
- Potentially fatal impacts on rare and highly protected fish species populations including direct and indirect (cavitation effects) mortality through collision with turbine blades (a risk exacerbated by with multiple passages through the turbines), delays to fish migration, enhanced predation, changes in water quality and salinity, and the loss of fish nursery habitat. Most of these fish populations are already well below "Favourable Conservation Status" and are therefore particularly vulnerable to further pressures; 90% of the world's Twaite Shad population risks extinction and 25% of England and Wales' salmonid habitat could be excluded by a barrage;
- Evidence from around the world showing that hydroelectric dams and barrages themselves create barriers to sustainable fish spawning runs even where fish passes are installed;[59]
- Impacts on coastal and terrestrial habitats, including those associated with changes in sea level, hydrology and water quality;
- Impacts on the landscape, seascape, archaeological and amenity value associated with both the construction of a barrage and associated impacts and infrastructure.

[58] The Angling Trust, CPRE, The Salmon and Trout Association, The Severn Rivers Trust, The Marine Conservation Society, The RSPB, The Wildfowl and Wetlands Trust, The Wildlife Trusts and WWF.

[59] *"Dams create a largely impenetrable barrier for fish even when installed with specially-built passages, according to a new study in Conservation Letters. The scientists found that migrating fish largely failed to use the passages in the U.S., resulting in far fewer moving through the state-of-the-art hydroelectric dams than had been promised. The researchers say that their findings are a 'cautionary tale' for developing nations. 'It may be time to admit failure of fish passage programs...'"*
http://news.mongabay.com/2013/0117-hance-dams-fish-us.html
Ref: Jed Brown *et al* (2013), Fish and hydropower on the U.S. Atlantic coast: failed fisheries policies from halfway technologies. *Conservation Letters* http://onlinelibrary.wiley.com/doi/10.1111/conl.12000/abstract

Key Challenges for Hafren Power:

We believe that there are five key tests which must be satisfied by proponents of any tidal barrage or other renewables technology proposal in the Severn Estuary before any scheme could be considered for consent (whether via a hybrid bill or any other mechanism):

1. The assessment of the nature and scale of the environmental impacts of the proposed barrage on the estuary must be robust and subject to rigorous peer-review based on terms of reference agreed with NGOs in advance. This will require not only an understanding of the impacts of the proposed development, but also of the structure, function, and ecology of the estuary (eg fish behaviour within the estuary). A robust assessment of impact is a prerequisite for the identification of potential mitigation and compensation measures;
2. To achieve this, all technologies must have been developed and adequately tested, in conditions which accurately mirror those found in the Severn Estuary;
3. Environmental impacts on geomorphology (including intertidal habitat loss), birds, fish, water quality and adjacent terrestrial habitats over the full life of a barrage structure[60] must—as a minimum—be demonstrated to be within the realms of what it is practically possible to compensate for on a like for like basis within the UK;
4. It must be demonstrated that required "like for like" compensatory measures can be secured and delivered in advance of construction, and will be effective in the short, medium and long term;
5. Impacts on jobs, land drainage and flood risk etc, along with the costs of compensatory measures, will need to be factored into any analysis of the economic feasibility of a proposal, and will need to demonstrate that the proposal would provide a good deal for taxpayers AND consumers.

Application of the Habitats Directive Article 6(3) and 6(4) tests will act as a litmus test for the viability and acceptability of any proposal. These require that the nature and scale of impacts on all Natura 2000 sites affected[61] (SPAs, SACs and (as a matter of UK Government policy) Ramsar sites) be thoroughly assessed. If it is not possible to ascertain that the development will not have an "adverse effect" on one or more of these sites, it may only be consented if it can be demonstrated that there are no less damaging alternative solutions that could deliver the same public interest, that there are imperative reasons of overriding public interest why it should proceed in spite of its effects on the integrity of Natura 2000 site(s), and that sufficient, adequate and effective compensation can be secured to maintain the coherence of the Natura 2000 network of SPAs and SACs in the short, medium and long term.

Recent Developments since the Meeting in October 2012

In November 2012, RegenSW and partners published a new discussion document, "Bristol Channel Energy: A Balanced Technology Approach",[62] which outlines most of the known ideas for marine energy generation from the Bristol Channel/Severn Estuary system and proposes adopting a multi technology approach. The report's authors highlight that the key advantage of this approach would be to enable the incremental roll-out of a series of large scale energy schemes as technologies are proven and their environmental impacts can be properly managed. We welcome this discussion document and the approach it advocates, which could facilitate a better understanding of the impacts of tidal energy generation at much lower risk to investors, the environment, and the wider business and resident communities.

Summary

We support the deployment of renewable energy as an essential element of the steps required to decarbonise the UK economy, and acknowledge the potential of the Severn Estuary for renewable energy generation. However, we believe that renewable energy deployment can and should be delivered without unacceptable impacts on the environment. To date we have not been presented with sufficient detail on the current proposal, or any assessment of the impacts of that proposal, which would allow us to consider the extent to which its impacts would differ from those of the completely unacceptable high head Cardiff to Weston barrage (especially in the long term). That said, we remain deeply sceptical that a shore-to-shore barrage can be delivered without unacceptable impacts on the environment. Given the likely scale of the impacts of such a development, and the associated environmental, social, technical, legal and investor challenges and risks, we believe that an approach which focuses on smaller-scale deployment, sited and designed to maximise energy output whilst minimising environmental impact, is more likely to deliver an acceptable solution in a timescale compatible with the urgent need to address climate change and maintain electricity supply.

January 2013

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[60] It must be assumed that a barrage, once constructed, would never be removed.

[61] The impacts of any barrage development would be expected to extend far beyond the boundaries of the Severn Estuary SPA, SAC and Ramsar site. The Severn Tidal Power Feasibility Study concluded that a high-head Cardiff to Weston barrage would have adverse effects on 19 SACs, 5 SPAs, and 5 Ramsar sites, and was unable to conclude that there would ne no such effect on a further 96 SPAs and 84 Ramsar sites.

[62] http://regensw.s3.amazonaws.com/bristol_channel_energy_balanced_technology_approach_20121127_c541010d0b3719f8.pdf

Written evidence submitted by the Marine Conservation Society (SEV87)

1. Background

1.1 The Marine Conservation Society ("MCS") is the UK charity dedicated to the protection of the UK's seas, shores and wildlife. MCS campaigns for clean seas and beaches, sustainable fisheries, protection of marine life and their habitats, and the sensitive use of our marine resources for future generations. MCS produces the annual Good Beach Guide, the Good Fish Guide on sustainable seafood, organises volunteer projects and surveys such as Beachwatch, the Beachwatch Big Weekend and Basking Shark Watch and works closely with the UK Government and devolved administrations on the development and implementation of marine laws and policies.

1.2 MCS is strongly supportive of renewable energy, in particular offshore wind, as it will lessen our dependence on fossil fuels, and make a significant contribution to meeting the UK Government's legally binding target of at least an 80% cut in greenhouse gas emissions by 2050.

1.3 However, MCS is firmly of the opinion that the proposed Severn Barrage is the wrong option in the wrong place for generating electricity. Although the tidal range in the Severn estuary is considerable, building a 16km concrete barrier from South Wales to Somerset is not a credible option; the environmental risks simply far outweigh the commercial benefits. For example, fish and eel migratory routes will be severely inhibited, if not blocked completely; approximately 14,000 hectares of inter-tidal habitat of European importance will be lost upstream of the barrage; due to the high suspended sediment levels within the water, it is doubtful whether the lifetime of the barrage would be anywhere near as long as the projected 120 years; and the barrage could severely damage the viability of ports such as at Avonmouth.

1.4 At a projected cost of up to £34billion, the barrage will generate—at most—5% of the UK's energy needs. MCS would far prefer to see a diverse approach taken to the generation of renewable energy, identifying the most suitable option that is fit for purpose in each location. The range of energy generation options includes on- and offshore wind turbines, tidal lagoons, and wave and tide turbines all of which need to be sensitively located and undergo full environmental impact assessments.

2. Introduction

2.1 Over the past few months there has been a lot of conjecture and opinion published in local, regional and national media regarding the revised design for a Severn barrage being promoted by both Hafren Power and Peter Hain MP; MCS therefore welcomes the Energy and Climate Change Select Committee's ("the Committee") inquiry into "A Severn Barrage?". MCS feels this is timely and will help promote a reasoned, objective debate through the media and between the various stakeholders and interested parties about both the advantages and the disadvantages.

2.2 We would, however, raise the challenges faced in submitting evidence when Hafren Power still has not published a detailed proposal relating to this latest version for a Severn barrage. We have therefore based comments on the previous so-called Cardiff-Weston barrage (promoted by the then Severn Tidal Power Group) which was considered in detail by the Department of Energy and Climate Change's ("DECC") seminal report "Severn Tidal Power: Feasibility Study Conclusions and Summary Report" which was published in October 2010 ("the October 2010 report").

2.3 Furthermore, we note Hafren Power's website (www.hafrenpower.com) was not established in time for the Committee's deadline for submission for written evidence, and still (as at January 2013) does not contain a detailed proposal that can be subjected to rigorous, external, objective scrutiny by third parties.

2.4 Although we are aware some research has been undertaken by Professor Roger Falconer of Cardiff University on Hafren Power's behalf, this research has yet to be published in a peer-reviewed journal or released in detail by other means to the scientific community for external, objective scrutiny (although we do acknowledge that Professor Falconer has given numerous presentations throughout the UK and other countries on the proposal to extract energy from the Severn estuary, although we believe most of these presentations are based largely on the previous barrage proposal).

3. Questions Posed by the Select Committee

3.1 The inquiry has directed interested parties to address some or all of the following 10 questions:

(1) What contribution could the Cardiff-Weston Barrage make to UK energy security and climate change objectives?

(2) *What risks and opportunities could it pose with regard to flooding in the Severn estuary, and how might any risks be mitigated?*

(3) *What risks and opportunities could it pose to wildlife and habitat in the Severn estuary, and how might any risks be mitigated?*

(4) What lessons can be learned from the successful development of La Rance tidal barrage in France and other tidal power projects?

(5) What risks and opportunities could it pose to local employment and community, and how might any risks be mitigated? In particular, what are the consequences for current ports, fishing and aggregate extraction industries in the estuary?

(6) Would the project require support under the proposed new Contracts for Difference mechanism? If so, approximately what level of strike price would be required to make the project economically viable?

(7) How does the company plan to engage and consult the community in the development of the project?

(8) *Are the proposals in breach of EU legislation, and if so how will this be addressed?*

(9) Are any other proposals for tidal power projects in the Severn estuary currently under consideration?

(10) What could be the wider international implications of the scheme for UK engineering and UK low-carbon industry?

3.2 Of these 10 questions, three fall wholly or mainly within MCS's remit, and these have been highlighted for ease of reference.

4. Response to Question 2

4.1 Because a detailed proposal still has yet to be published by Hafren Power, and the research it has commissioned to date still hasn't been released to the scientific community for rigorous, external, objective scrutiny, MCS can only respectfully direct the Committee to the findings of the October 2010 report.

5. Response to Question 3

5.1 To reiterate a quote from the October 2010 report, "the evidence base [which was published with the report] is extensive, particularly the Strategic Environmental Assessment of Severn tidal power". To date, MCS has not had sight of any credible evidence that would challenge any of the key conclusions of the feasibility study; we therefore accept, support and commend the findings of the report.

5.2 A number of the key conclusions on page 5 of the October 2010 report are of direct interest to MCS. For ease of reference, the relevant key objectives are reproduced below:

(1) The scale and impact of a scheme would be unprecedented in an environmentally designated area, and there is significant uncertainty on how the regulatory framework would apply to it. The study has considered ways in which to reduce impacts on the natural environment and also how to provide compensation for remaining impacts on designated features. It is clear that the compensation requirement would be very challenging, however defined, and require land change within the Severn estuary and probably outside it also;

(2) A scheme would produce clearer, calmer waters but the extreme tidal nature of the Severn estuary would be fundamentally altered. This means that some habitats including saltmarsh and mudflat would be reduced in area, potentially reducing bird populations of up to 30 species;

(3) Fish are likely to be severely affected with local extinctions and population collapses predicted for designated fish, including Atlantic salmon and twaite shad. This could mean the loss of twaite shad as a breeding species in the UK as three of the four rivers where it breeds run out into the Severn estuary; and

(4) Water levels would also be affected and in order to maintain current flood protection levels in the Severn estuary additional flood defences would be required; these costs are included in the cost estimates for each scheme.

5.3 The October 2010 report also clearly states the environmental and nature conservation value and status of the Severn estuary, which is of international, European and national nature conservation significance. On page 28 the report states that it is:

(1) A Special Protection Area under the Birds Directive for the number of water birds that use the Severn estuary;

(2) A Special Area of Conservation ("SAC") under the Habitats Directive for the unique and highly dynamic conditions and the special range of habitats and species this supports, including sandflats, mudflats, saltmarsh and rare marine life; and

(3) A Ramsar Wetland of International Importance.

5.4 On page 29 the report also states that the Rivers Wye and Usk, which flow into the Severn estuary, are also designated as SACs. Together, they represent around 1.3% of all the UK's designated SAC habitat. These rivers provide important spawning habitats for species of migratory fish, including five species protected under the Habitats Directive (allis and twaite shad, sea and river lamprey and Atlantic salmon) which travel up the Severn estuary on the way to these spawning grounds.

5.5 Elsewhere on page 29 the report also states that the area also contains Sites of Special Scientific Interest ("SSSI"), Scheduled Ancient Monuments and Areas of Outstanding Natural Beauty. A Severn tidal power

scheme would impact significantly on natural and historic conservation sites both upstream and downstream of any scheme. The landscape and seascape of the Severn estuary would be significantly altered with the addition of a scheme.

6. Response to Question 8

6.1 MCS is extremely concerned that Government continues to support proposals by private companies to develop a Severn barrage as well as barrages in numerous other estuaries, rather than opposing such proposals as being unsustainable and likely to be in contravention to at least three EU Directives (the Habitats Directive, the Marine Strategy Framework Directive and the Strategic Environmental Assessment Directive), as well as the Government's commitments to halt biodiversity decline.

6.2 MCS supports the generation of electricity from sustainable renewable sources such as offshore wind, wave and tidal currents as essential components of reducing greenhouse gas emissions provided they are sited and developed sensitively with appropriate mitigation to minimise impacts. However, a barrage in the Severn would not be sustainable and would adversely affect this internationally important ecosystem, at a time when we ought to be making ecosystems more resilient in the face of climate change, not decimating them.

6.3 The Severn estuary is a conservation site of international importance as its vast dynamic estuarine complex is unusual at the European level as well as national, and its various environmental designations have already been mentioned in Section 5 of this submission. In addition, it supports a large mosaic of habitats including mudflats, sandbanks, biogenic reefs, rocky platforms and saltmarsh and internationally important populations of wildfowl and migratory fish.[63] Its demise would hence be a disastrous loss to European conservation as well as national conservation. While limited compensation of some parts of its habitats may be possible the complexities of the Severn's ecosystem are not just due to the sum of its parts but due to the unique interactions between them.

6.4 The Severn barrage would have an adverse affect on the integrity of the Severn estuary as it will radically alter the estuary's natural physical processes. The proposed inner Severn barrage would have the effect of reducing the tidal range in the inner Severn estuary by approximately 50% of the existing range.[64] The tidal prism, sedimentation, tidal inundations, the size of the intertidal zone, subtidal zone will all be irreversibly altered.

6.5 *The Marine Strategy Framework Directive:* The Severn barrage could compromise the UK's ability to meet our Marine Strategy Framework Directive (MSFD) requirements of Good Environmental Status, especially under Descriptor 7 (hydrographical conditions) since even DECC's Energy SEA 2 acknowledged that barrages would cause effects potentially detectable over the whole continental shelf. We are concerned that the Department of Environment, Food and Rural Affairs has not made either DECC or the developers aware of the legal environmental requirements under the MSFD and the fact a Severn barrage would likely cause infraction. In a meeting with DECC (held on 15 May 2012) we raised this issue and they have suggested such environmental impacts would be considered as a requirement of the EIA process, but they seem to believe that an EIA will actually address such an issue, whereas we believe that the MSFD is insurmountable.

6.6 *The Habitats Directive:* A barrage would have an "adverse affect on site integrity" under the terms of the Habitats Directive and hence cannot be consented unless there are not more suitable "alternatives", it is a project of "over-riding public interest" and "compensation" can be provided. MCS does not believe it will be possible to meet all these criteria. There are a number of alternatives, most notably nuclear power and offshore wind. Ecosystem health is as much of public interest as is electricity supply. It would be completely impossible to compensate for all the lost intertidal and sub-tidal habitats as a result of a barrage, due firstly to the scale and nature of the habitat creation necessary and secondly, because it is not possible to replicate the Severn and the loss of the rare twaite and allis shad and this important Salmon river, the sabellaria reefs, and the intricate and unique biodiversity of such an estuary.

6.7 *The Strategic Environmental Assessment Directive:* Article 1 of the SEA Directive states the aim is "to provide for a high level of protection of the environment" is met. DECC's Energy SEA 2 makes clear that tidal range developments (generally tidal barrages) lead to the destruction and modification of whole estuaries, bays and inlets permanently.

7. Stepping Stones Tidal Lagoon

7.1 As an alternative option for the Severn estuary, we would like to bring to the Committee's attention the Stepping Stones tidal lagoon proposal that has been developed by Parsons Brinckerhoff in association with Black and Veatch.

7.2 However, in doing so, we must emphasize it is still MCS's view that any proposed marine renewable energy option must be sensitively located and undergo full environmental impact assessments. Even though the proposed tidal lagoon is significantly reduced in scale when compared to the proposed Severn barrage it would still be the largest tidal plant in the world, which we can only infer means there will still be a significant impact on the marine environment. For example, it impact on the East Aberthaw SSSI.

[63] Natural England, 2007. Natural England response to Sustainable Development Commission report on tidal power.
[64] Pethick, J, 2007. Severn Barrage Proposal: Assessment of Geomorphological Impacts. Report to Natural England.

7.3 It is encouraging that, according to Parsons Brinckerhoff, the objectives of the proposal are:

(1) To demonstrate that tidal power can be generated from the Severn estuary with acceptable cost, environmental and social impacts and build UK confidence in ocean energy;

(2) To be informed by the October 2010 report research and add to that research base through full scale demonstration; and

(3) To be financeable in the private sector but developed in partnership with the public sector.

7.4 MCS does not have a view on the Stepping Stones tidal lagoon until we see a full environmental impact assessment but we respectfully suggest the Committee views the Stepping Stones tidal lagoon as an example of a smaller, tidal renewable energy option.

8. Conclusions

8.1 Because only high-level statements and information have been released by Hafren Power to date, we urge them to release a detailed proposal supported by robust scientific research which can then be subjected to rigorous, external, objective scrutiny by third parties. Until this is done, MCS can only respond on the basis of information contained within the October 2010 report published by DECC, the key conclusions of which we accept, support and commend to all relevant stakeholders and other interested parties.

January 2013

Written evidence submitted by Supervawt Ltd (SEV88)

This paper makes it plain that there is a further design for tidal generation in the Severn Estuary beyond Hafren and Evans Engineering proposals. A floating tidal farm that has the least impact on the Severn Estuary, won't disrupt shipping and leaves fish unharmed.

The current state of the art in technology will be disrupted by Supervawt Ltd's new design for a fluid turbine. It stands on its head a number of presumptions about lift based vertical axis designs and is not an incremental improvement in design. Testing has already demonstrated that a number of textbook facts for lift based vertical axis designs do not hold true for the supervawt design.

The patent application, which can be made available, makes it clear how the design operates.

As has been mentioned the design produces more power than any existing vertical axis design.

Why is the vertical orientation important? A vertical turbine does not have a tipping point and so is suitable for floating platforms. This is why floating tidal turbines have not been considered before, because the existing tidal turbines are horizontal axis turbines which are not suitable for floating platforms.

The vertical axis design is also advantageous as the central shaft allows the generating equipment to be out of the water which reduces the complexity of the design, construction and maintenance.

The supervawt design has a simple mechanism that allows the orientation of the turbine to match flow direction and speed.

It takes a visionary to see that whilst a barrage must be arranged in a linear development, a tidal farm can be arranged over a larger area with a consequent increase in power generation.

There would be no need to construct a barrage and so no need for a tidal lock and the consequent disruption to shipping. Fish are unlikely to be affected by the turbines.

January 2013

Written evidence submitted by Cardiff Council (SEV89)

Firstly thank you for affording Cardiff this additional time to submit evidence regarding the Hafron Power Severn Barrage proposals to the Energy and Climate Change Committee. It has been identified by both UK Government and Hafren Power that the proposals are incomplete, Hafren Power will release more information if they receive Government commitment to the scheme. This brief report cannot make any clear conclusions until further information on tide cycles, impoundment heights and turbine design are provided however, the following comments are provided on a best available information basis.

Key matters considered:

— Climate Change objectives.

— Flood risks and opportunities posed.

— Ecological impact and opportunities.

— Economic opportunities and impacts and Other tidal opportunities.

— Community engagement.

Climate Change Objectives

It is widely recognised that the development of a Cardiff to Weston barrage traversing the Severn estuary could produce 5% of the UK energy requirements and would support the challenge to reduce carbon and greenhouse gas emissions by 80% by 2050. Clearly this is a significant single contribution to renewable clean energy resources, which is very welcomed, notwithstanding the carbon cost of this major construction which should not be underestimated.

Flood Risk & Opportunities

If the retained upstream tide height is increased, then: A longer period to reduce sea level during ebb condition would result in a longer tide-lock at Cardiff Barrage, hence re-modelling will be required. This may be mitigated by large pumps or an additional sluice may be needed to discharge flood storage during extreme conditions. In essence the permanent Severn Estuary retained level needs to accommodate highest river flows in Cardiff Bay and the retained level may result in a longer retention period of required flood storage in Cardiff Bay.

Evidence presented by Hafren Power indicates that the level of water above the proposed barrage may have a lower peak height but the retained period at a high level may be longer. It includes several options and therefore it is not possible to really identify the impact on the Cardiff Barrage at this stage of the project as there does not seem to be one fixed design with definitive water levels. However, clearly the Severn Barrage would offer an overall improved defence for eastern Cardiff, it is the interface with existing structures that is the question and how the higher retention level affects the Rhymney and it's tributaries.

The designed water levels for the barrage will need to consider the impact on the Cardiff barrage so that the flood defence afforded by Cardiff Bay Barrage and established ecology are not compromised.

A Severn Barrage built between Lavernock and Weston (Brean Down) may result in a retained level of sea water that will impact on Cardiff Barrage and the Bay, therefore the retained level height is crucial to impact and opportunity. At the present time no firm information is available on how the Severn barrage will operate. A higher than current spring tide allowed upstream of Severn Barrage will have a High impact.

Cardiff also has concerns regarding the River Rhymney which is still a tidal river and therefore will be affected by raised tidal levels and the knock on effect that would potentially have have on Roath Brook and any increased river flow coming downstream during high rainfall events.

Increased ground water levels pose a risk that will require careful assessment to understand the impacts on the Internal Drainage Board (IDB) and the levels, Cardiff bay water quality—ecology impacts, impacts on the local farming community due to changing soil conditions and salinity, discharge levels, flooding risks and erosion of infrastructure and greater risk of over topping in eastern Cardiff.

Other concerns would be regarding coastal erosion and whether or not this would increase with a higher level of water in the estuary. Also would the building of the barrage negate the predicted rise in sea levels due to climate change and hence add to the protection of the Wentlooge Levels or would the drainage of the land be affected would need to be assessed.

Navigation

Navigation through locks will not be affected with a retained level in the Severn Estuary provided retained level is greater than -0.5mAOD. Navigation through the locks could be quicker as the retained level increases between -0.5 and 4.0mAOD. Increased dredging may be needed due to increased deposition of silt in the lead-in channel to the outer harbour.

Environment & Ecology

If there is an increase in saline intrusion this could affect the ecology of the Cardiff Bay. It is not expected to affect the passage of fish through the existing Fish Pass, assuming fish are able to reach Cardiff Bay through the Severn Barrage.

Since impoundment, Cardiff Bay has been invaded by a wide range of nuisance or invasive species, this will need to be considered. Some of these were predicted, such as the Chironomids or Non-biting Midges. Although not an environmental problem as such, they caused a significant nuisance problem to residents and businesses, requiring large financial and technical input to resolve.

Impounding the Severn Estuary could lead to a slight reduction in salinity. This may be low enough to allow salt tolerant midge species to thrive. However, the operation of the Barrage may be such that any population would be washed out during each generating cycle. This will be clearer when more information is provided by Hafren Power. Equally flora species that help prevent coastal erosion may be removed due to changes in feeding habits by animals/birds or the increase salinity, so accelerating the issues above. Impacts on the current sites of special interest would require careful consideration their loss being heavily considered against other gains. There is a risk that flora species that help prevent coastal erosion may be rapidly eroded or removed due to changes in feeding habits by animals/birds or the increase salinity, so accelerating the coastal erosion issues

we face, strengthening the sea wall will need to be a consideration for further infrastructure to accompany the barrage.

Economic Opportunities and Impacts and Other Tidal Opportunities

Hafren Power claim that the project will create 20,000 new jobs during construction phase, and 30,000 additional jobs which will be a vital a huge boost to regional employment as well as Cardiff's local economy.

It will contribute towards vital energy resilience for British industry and for citizens and compliment Cardiff's own growing energy agenda.

The components will need to be manufactured near the construction site. Port Talbot is earmarked by Hafren Power for this an investment that will create highly skilled jobs in the local economy.

If accompanied by a transport link it will bring Bristol, the South West and Cardiff much closer together, bringing major economic benefits to both cities abd the Esturine Region as well as supporting the Welsh City Region and Metro.

The barrage would position Cardiff as a world leader in green energy, attracting inward investment, public and private sector R & D, and tourists.

Water leisure use could increase significantly as there will be a large more protected water body available. Although the designs could include transport links it is understood these would need additional funding. If provided this could increase economic activity in the areas close to the barrage. The barrage would impact significantly on the Docks upstream of the barrage including Cardiff Docks as vessels would have to transit at least two locks.

However, Bristol and Associated British Ports see the project as damaging to Avonmouth port they put forward that it will result in 60% job losses at Avonmouth.

The barrage will rely on a massive public subsidy (in the shape of a guaranteed energy price). Some consider that a persuasive argument is that this public funding could be much better spent, for instance on a major housing retrofit project which would create local jobs, reduce energy bills (in particular for those in fuel poverty), drive innovation in localised energy production and reduce CO_2 emissions.

Community Engagement

In additions there are other options to consider of smaller, less.

Capital intensive tidal lagoons could operate with much smaller and limited impact on local ecology, existing industry and ports and may be deliverable to faster timescales. Cardiff would wish governments to consider all opportunities. Given the challenges such a major infrastructure project would entail it is essential that all affected communities of the barrage are consulted widely, not just those that may have historical established forums, the project must establish strong and cooperative communications from the outset.

March 2013

Written evidence submitted by Blue Marble Sustainable Solutions Ltd (SEV90)

Having researched tidal barrages and Severn tidal power options in some detail since 2007, we would like to take this opportunity to make the case for the new Hafren Power proposal, which appears to be a realistic and timely development of previous less environmentally friendly schemes.

TOPIC 1: *Is a complete enclosure of the estuary necessary or would a partial closure be sufficient?*

1. *Questions 35–39 (Dr. Whitehead)* asked whether an *"incomplete barrage"* might suffice because *"turbines are bi-directional and therefore do not require water retention and therefore do not require a barrage"*.

This question implies that impacts on ports and the environment would be reduced by the presence of a gap in an "incomplete barrage", whilst its functionality as an energy-capture device would not be compromised.

Response

1.1 Maintaining a permanent gap would mean loss of hydraulic head and therefore ability to harvest the extreme tidal range of the Severn. The result would be an expensive tidal stream device, with only 1/20th the power output of a fully enclosed barrage (confirmed by DECC 2010,[65] which concluded, "*It is not possible to generate strategic amounts of electricity in this way. In turn, this puts the energy costs at the extremes of the renewable envelope"—£226/MWh,*).

[65] DECC 2010: Severn Tidal Power Feasibility Study Conclusions and Summary Report. p.66

1.2 The only viable approach to a partial enclosure appears to be a double tidal fence of approx. 780 bi-directional ebb-flow turbines placed across the estuary, leaving a shipping gap of 800–1000m, having a peak output of 390MW and generating 0.88TWh/y (STFC).[66]

1.3 To reduce energy loss turbines would need to be housed in concrete caissons[67] to prevent water escaping past them, rather than mounted on steel piles. This would be a barrage without lock gates.

1.4 It has been suggested by Regen SW 2012[68] and by Mr Gowdy (Q.252), that a hydraulic head could be generated through "flow blockage". Although it has been proposed by some that this would boost output to 1.8GW peak and 3.3TWh/y, this has been demonstrated to be incorrect.[69]

Modelling (Giles *et al*, 2010[70]) has shown that flow blockage from turbines and associated support structures would not generate a hydrostatic head and therefore would not boost generation output. It would instead create a current flow along the face of the tidal fence, leading to considerably accelerated flow velocities (2.3 times) through the shipping gap.

The maximum outputs from a double Aberthaw-Minehead tidal fence with a 1000m shipping gap were shown to be 390MW and 0.9TWh/y. At spring tide, the velocity through the proposed shipping gap was shown to be 3.5m/s (6.8 knots) at this location. However, with a Lavernock-Brean tidal fence these shipping gap velocities would be likely to be even higher.

1.5 This concern about tidal current velocities in the shipping gap was raised by Simon Bird on behalf of Bristol Ports (Q.107): *"The issue that will concern us.....would be a potential funnel effect on the tide and current going through a much smaller area (*and*) its impact on ship handling and ship manoeuvrability".*

Conclusion: By comparison with a tidal fence which has a shipping gap, a barrage enclosed by lock gates would perform three essential functions:

— *The output would be 20x the output of a tidal fence in the same location.* A barrage with lock-gates would therefore capture and not waste the unique tidal range resource provided by the Severn estuary at this location. It would generate a *baseline minimum* electricity output of 16.5TWh/y (before any pumping gains) compared with less than 1TWh/y from a tidal fence.

— *Lock gates would prevent accelerated tidal velocities* which would otherwise occur through an open shipping gap for most of the ebb and flood periods. Lock transit could be carried out at any state of the tide, with completely unimpeded passage at slack water. Locking delays during flood and ebb could be programmed into passage planning far in advance as part of normal port approach procedures.

— *Lock gate enclosure would protect upstream locations against sea level rise (SLR), storm surge and marine induced flooding* and secure all the ports upstream (not just Bristol) from this long-term risk.

TOPIC 2: *Regen SW report. Does the Regen balanced approach exclude a barrage?*

2. *Q.42 Dan Byles* asked, (with reference to the Regen SW discussion document[71]), whether, instead of a barrage, "an alternative, balanced, multi-technology approach including a combination of tidal wave and wind technology could produce double the amount—14GW of energy".

Response: does the Regen "*balanced approach"* exclude a barrage?

2.1 The Regen SW discussion document is widely cited as providing an *alternative* to the conventional high head barrage. However, Regen SW *do not exclude* the idea of a barrage, but include 5GW of tidal range capacity in their 14.25GW multi-technology approach.

2.2 The Regen SW analysis provides a broad spectrum of options and installed capacities. However, it does not give any estimates of annual electricity output for the different options (now amended 04.03.13). This means that a valid comparison of the total annual energy outputs and regularity of output of different technologies cannot be made from the Regen analysis, in the context of national energy requirements.

2.3 Mr Johnny Dowdy, speaking on behalf of Regen SW, explained (Q.252) that the Regen document discussed an holistic approach to energy options for the Bristol Channel after the Severn barrage was shelved in 2010 (DECC 2010[72]). He explained that Regen is *"not anti-barrage"* (Q.254) "*because I believe we need large-scale projects"* but was looking at a multi-disciplinary approach. In fact the Regen balanced approach includes tidal range (barrage and/or lagoons), together with tidal stream, tidal fence, offshore wave and offshore

[66] STFC 2010, *Final Report*, v.3.1: Severn Embryonic Technologies Scheme, p.2 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69847/24._Severn_Embryonic_Technology_Scheme_-_Final_Report_-_STFC.pdf

[67] Regen SW 2012: *Bristol Channel Energy A Balanced Technology Approach,* see Fig.p.8 http://regensw.s3.amazonaws.com/bristol_channel_energy_balanced_technology_approach_20121127_e8d9ace7549e3afb.pdf

[68] Regen SW 2012: *Bristol Channel Energy A Balanced Technology Approach,* pp.8 and 13.

[69] Giles *et al* 2010: *An Innovative Tidal Fence Development for the Severn Estuary*, UK. p.4

[70] Giles *et al* 2010: *An Innovative Tidal Fence Development for the Severn Estuary*, UK. p.4

[71] Regen 2012: *Bristol Channel Energy, A Balanced Technology Approach*.

[72] DECC 2010: *Severn Tidal Power Feasibility Study Conclusions and Summary Report*, p.8

wind. Mr. Dowdy was careful to explain (Q 252) that this represents a *potential range* of installed capacities—it could be as low as 5GW or as high as 14GW.

2.4 Regen SW is clearly not presenting an either/or situation with regard to a barrage, although many commentators are certainly choosing to interpret it this way. The Regen objective of 14.25GW of installed capacity is clearly predicated on 5GW of tidal range (Regen 2012[73]). To achieve this, it would mean including in the mix either a 5GW barrage, or 5GW of lagoon capacity, or a 1GW Shoots barrage + a substantial allocation of lagoons.

To achieve 5GW capacity through lagoons, it would be necessary to impound an area similar to that of a Lavernock-Brean tidal bar, ie approx. 500 km2, and address a similar range and scale of environmental impacts. Although port access would not be obstructed by lagoons per se, navigation in the accelerated tidal streams resulting from partial narrowing of the estuary by any lagoons sited upstream of the Lavernock-Brean line could become much more difficult in these already challenging waters. Furthermore, protection from flood, storm surge and sea level rise would be severely diminished by comparison with the tidal bar.

Conclusion: The Regen SW 14GW renewable objective for the Severn estuary includes 5GW of tidal range. In other words, the Regen 14GW target includes a major barrage (or major lagoons of equivalent total plan area, resulting in similar environmental impacts, all of which would require similar mitigation and compensation measures).

TOPIC 3: *Are there are other better alternatives to the HP barrage which would be less damaging to the environment*

3. *Other and better alternative technologies:* many objectors to a barrage across the Severn are actively campaigning for "*other, better, more modern technologies"*, without giving sufficient reasons why they consider these better. Specifically, they provide no quantitative analysis of energy outputs, although this last point is now being addressed by Regen in its 4th March submission to the ECCC.

NGOs appear to agree on the need to harvest the energy potential of the Severn as an appropriate alternative to other more polluting or hazardous[74] energy sources and say they *"….are not naïve enough to think that you can extract tidal power from an estuary with having an impact"* (Kate Jennings RSPB, Q76).

The RSPB also say that they are not against the barrage itself, but that they are against the potential environmental impacts unless the conditions of the Habitats Directive can be met (Qs.79–81). They suggest that the incremental approach of Regen SW should be followed, allowing technologies to be tested and then rolled out (Qs.77 and 81).

Response

3.1 This question highlights three issues:

- What are the alternatives to the HP barrage and are there better "alternative" schemes which would be supplanted by its construction?
- Are there other schemes or technologies which would be complementary to the barrage?
- Is an incremental roll-out of technologies realistic or practicable?

3.2 *Alternatives to the HP barrage*—which schemes would be supplanted?

The Lavernock-Brean barrage would be incompatible with only a few alternative options either upstream of the barrage, in the same location, or close by. None of the "alternatives" would be impact-free, and all would generate considerably less electricity than the barrage. These alternatives are listed in Table 1 below.

Table 1

TIDAL TECHNOLOGIES DISPLACED BY A LAVERNOCK-BREAN BARRAGE

Alternative technology	*Installed capacity GW*	*Annual Output TWh/y*	*Impacts/comment*	*Flood, SLR, storm surge protection*	*Timeframe or priority*
Tidal Fence along barrage line[1,2] and[3]	0.3–0.4	0.88	— Acceleration of tide in shipping lane — Some possible fish impacts — Slight suppression of tidal range and intertidal areas — Change in currents and sedimentation	None	? 2022 onwards

[73] Regen 2012: *Bristol Channel Energy, A Balanced Technology Approach,* p.21.
[74] Though see answers to Qs 65–71concerning nuclear power

Alternative technology	*Installed capacity GW*	*Annual Output TWh/y*	*Impacts/comment*	*Flood, SLR, storm surge protection*	*Timeframe or priority*
Tidal stream Mackenzie* shoal (inside barrage)[4]	0.07	0.082	— Unsuitable location because of depth constraints and shipping	None	? 19th in tidal stream deployment sequence
Tidal stream—Barry * (downstream)[4] and[5]	0.14	0.147	— Identified as marine resource with minimal impact	None	? 23rd in tidal stream deployment
Shoots barrage[6]	1.0	2.7	— Restriction of navigation upstream — Significant impacts on fish, intertidal areas, birds	Only up-stream	? 2023 onwards
Lagoons: Beachley and Welsh Grounds[6]	Approx. 0.70	1.2 and 2.6	— Acceleration of tide in shipping lane — Impacts on tidal range, intertidal areas and birds — Potentially major impacts on migratory and resident fish	Mainly behind lagoons	? 2023 onwards

Table Notes:

[1] Giles *et al*, 2010: An Innovative Tidal Fence Development for the Severn Estuary, UK. p.4

[2] STFC 2010, Final Report, v.3.1: Severn Embryonic Technologies Scheme, p.2

[3] DECC 2010: Severn Tidal Power Feasibility Study Conclusions and Summary Report. p.66

[4] Carbon Trust 2011: UK Tidal Current Resource and Economics pp.44, 23 http://www.carbontrust.com/media/77264/ctc799_uk_tidal_current_resource_and_economics.pdf

[5] WAG 2011: Marine Renewables Energy Strategic Framework (MRESF) Approach to Sustainable Development. pp.66–67 http://wales.gov.uk/docs/desh/policy/110317energymarinesustainabilityen.pdf

[6] DECC 2010: Severn Tidal Power Feasibility Study Conclusions and Summary Report. p.59

*Barrage displacement of tidal stream (Mackenzie and Barry sites), represents only 2.5% of total UK tidal stream resource generation displaced (Carbon Trust, 2011[75]). Both have a very low priority for deployment (19th and 23rd in UK tidal stream deployment).

Conclusion: alternatives to the HP barrage

Alternative technology options displaced by the HP barrage would clearly generate considerably less electricity than the barrage. The energy produced by them would cost more (or considerably more) per MWh and the operational deployment dates would generally be no sooner to be of consequence.

There would still be a wide range of adverse environmental impacts depending on the scale of the technology used. Flood/sea level rise/storm surge protection would either be very limited or non-existent. "Alternatives" to the barrage would therefore represent wasteful use of the un-paralleled tidal energy resource of the inner Severn estuary.

3.3 *Other technologies or schemes which would be complementary to the HP barrage.*

Regen SW propose that other technologies including those either in current commercial use (offshore wind), or in development (tidal stream and wave), would be fully compatible with a barrage on the Lavernock-Brean alignment. These complementary schemes are listed in Table 2 below.

[75] Carbon Trust 2011: *UK Tidal Current Resource and Economics* pp.44, 23

Table 2

OTHER TECHNOLOGIES OR SCHEMES WHICH WOULD BE COMPLEMENTARY TO THE HP BARRAGE

Other technologies or schemes which would be complementary to the HP barrage					
Complementary scheme	*Installed capacity (GW)*	*Annual Output TWh/y*	*Impacts/comment*	*Flood, SLR, storm surge protection*	*Timeframe or priority*
Tidal stream—Minehead[1] and Lundy[1]	0.61	0.68	Low environmental impact. May be partially suppressed by barrage.	None	15th in deployment sequence 2015–2030 onwards
Wave—Lundy/outer Severn + N. Cornwall and Devon coastal[2]	0.62*	2.0[3]	Low environmental impact.	None	2030 onwards
Offshore wind—outer Bristol Channel[2]	1.50**	5.8[4]	Low environmental impact	None	2015–2030
Lagoon Bridgewater Bay[5]	3.60	Up to 6.2	Potentially significant localised environmental impacts	Significant local benefit	? 2023–2025
Swansea Bay lagoon[6]	0.25	0.40	Potential localised environmental impacts	Local benefit	? 2022
Stepping Stones lagoon[7]	0.6	1.2	Potential localised environmental impacts	None as it allows overtopping	2022–2023?

Table Notes:

[1] Carbon Trust 2011: UK Tidal Current Resource and Economics pp.44, 23

[2] PMSS 2010: Offshore Renewables Resource Assessment and Development (ORRAD) Project Technical Report, pp.29–31, 35–39 http://www.wavehub.co.uk/wp-content/uploads/2011/06/2010-October-Offshore-Renewables-Resource-Assessment-and-Development-Report.pdf

[3] Carbon Trust 2011: UK Wave Energy Resource, Introduction http://www.carbontrust.com/media/202649/ctc816-uk-wave-energy-resource.pdf

[4] http://2050-calculator-tool.decc.gov.uk/assets/onepage/4.pdf

[5] DECC 2010: Severn Tidal Power Feasibility Study Conclusions and Summary Report. p.59 and 62

[6] Swansea Bay lagoon http://www.tidallagoonswanseabay.com/

[7] Stepping Stones lagoon http://regensw.s3.amazonaws.com/120831_stepping_stones_tidal_lagoon_presentation_for_bristol_tidal_forum_ead4881f6fce116d.pdf

* The ORRAD study indicates considerably less than Regen's 2–5GW for wave

** Regen give a range of 1.5—>3GW.

Conclusion: schemes complementary to the HP barrage

The HP barrage would provide a very high core output contribution (16.5TWh/y) to a balanced renewable marine energy programme for the Severn estuary and Bristol Channel.

A further 16.3TWh/y, which could include up to 6.2TWh/y of tidal range from a Bridgewater Bay lagoon, could possibly be added to this baseline generation capability over time. *This assumes that all the complementary renewable technologies, some of them embryonic, could be economically deployed in the locations indicated by the Carbon Trust and the ORRAD Project.*

It would also be essential for any Bridgewater bay impoundment to have fully fish friendly bi-directional turbines (c.f. Swansea Bay and Steeping Stones, see 3.4, below) before it could be considered a viable proposition.

Note re Swansea Bay Lagoon: the estimated annual output of the Swansea Bay lagoon (which is not a competitor but complementary) is 250MW and *not* 10GW (or 10,000 MW) as suggested during the 3rd evidence session (28.02.13). The annual output of 0.4TWh/y indicated[76] would equate to just 2.4% of the annual output of the HP barrage.

[76] Swansea Bay lagoon http://www.tidallagoonswanseabay.com/

3.4 *Is an incremental roll-out of renewable energy generation in the Severn practicable?*

Both Regen and NGOs (Kate Jennings of RSPB, Q.77) are in favour of an incremental roll-out of marine renewable energy in the Bristol Channel.

Incremental testing and roll-out of tidal range technology sounds good in principle. However, there is nothing new in the design and deployment of caissons or embankments which requires pilot projects to take it forward. This is tried and tested engineering.

The critical issue is the successful cost effective commercial development of fish friendly very low head (VLH) turbine technology.

— Firstly, this objective has already been achieved for a 4.5m–5.0m diameter turbine by MJ2 Technologies in France (see Topic 4 below). There can be no reason to suppose that Rolls Royce or any other major turbine manufacturer could not achieve the same results and produce a British built turbine (whether owned by a foreign company or not) with fish mortality rates reduced to a comparable non-significant level.[77]

— Secondly, the development programme for a large (9.0m +) VLH bi-directional turbine, is likely to cost in the region of £3–4m per turbine unit, and will require considerable upfront investment. It is very difficult to see how this investment could be forthcoming for minor pilot schemes unless government funded. However, all schemes, minor or major would benefit from this long needed investment.

The designs for both the Swansea lagoon[78] (0.25GW) and Stepping Stones lagoon[79] (0.60GW) are not breaking new ground with their turbines. Instead, although reference is made to the possibility of using the Stepping Stones project as a test bed for new VLH turbine designs,[80] the generation capability for these two projects is firmly based on old style bulb turbines similar to those used at La Rance for 40 years, and rejected by the Severn Tidal Power Feasibility Study[81] because of completely unacceptable damage to fish populations.

As such they cannot provide comparators for fish studies, except in respect of behavioural screening—itself a useful contribution. They would provide little contribution to the central issue of fish damage, disorientation and mortality which has to be addressed by the new generation of large diameter VLH turbines essential for the large scale electricity outputs and therefore needed to make a meaningful contribution to national energy requirements.

The development of these two lagoons, although highly desirable, *is therefore not seen as supportive of an incremental roll-out of innovative VLH turbine technology and, in this particular regard, cannot be said to be a step forward.*

It is concluded that the scale of product development required to bring a VLH turbine to full commercial realisation could only realistically be progressed under the umbrella of a substantial volume of projected sales and prospect of economies of scale in manufacture. Therefore, the HP VLH barrage would seem to be the ideal vehicle to support development of this innovative technology. As noted during the 3rd evidence session, this would be a great commercial prize for the UK.

TOPIC 4: *Mortality rates and behaviour of fish passing through turbines. Is a fish friendly turbine achievable?*

4. *Q.58.* Ian Lavery asked about "mortality rates and behaviour of fish because of the turbines…."

The respondent, Martin Salter, had a number of concerns about turbine blade tip speed, strike (fish mincing), rapid pressure flux, cavitation, gradation in salinity, turbidity and disorientation.

Response

4.1 It is not correct to describe as *"guff"* or "*spin"* the suggestion that fish friendly turbines are attainable. Zero or close to zero mortality has already been very well demonstrated by MJ2 Technologies.[82]

It is clear that all future tidal range and tidal stream technologies will have to be predicated on "zero" or genuinely "negligible" impact on fish, relative to other mortality factors. This applies just as much to tidal lagoons which, from the perspective of fish moving in and out with the tide, are not a fish friendly alternative

[77] below the 1% suggested necessary by the EA during the 3rd evidence session, before repeated fish transit could become viable but obviously subject to confirmation from appropriate experts

[78] http://www.tidallagoonswanseabay.com/

[79] http://regensw.s3.amazonaws.com/120831_stepping_stones_tidal_lagoon_presentation_for_bristol_tidal_forum_ead4881f6fce116d.pdf

[80] http://regensw.s3.amazonaws.com/120831_stepping_stones_tidal_lagoon_presentation_for_bristol_tidal_forum_ead4881f6fce116d.pdf

[81] DECC 2010: *Severn Tidal Power Feasibility Study Conclusions and Summary Report*. pp. 5 and 7

[82] Lagarrigue T and Frey A, 2010, ECOGEA *Test for evaluating the injuries suffered by downstream-migrating eels in their transiting through the new spherical discharge ring VLH turbogenerator unit installed on the Moselle Frouard.* http://ontarioriversalliance.ca/wpcontent/uploads/2011/08/ECOGEA_Tests_VLH_Frouard_Rapport_ANGUILLES_2010_vers_def_Eng.pdf

to barrages. It is not enough to say that lagoons would be screened—there will always be some transit by fish of screening devices—the requirement for all tidal range schemes is for a turbine which allows repeated transit without impact on the population.

4.2 *Blade tip speed.* This is a complex area. The key driver is that turbine components and flow rates need to be within or close to the normal range of parameters experienced by fish in nature. This means slow flow rates and slow rotation. The rest follows naturally.

The Idaho Studies[83] show that there is a gradually increasing impact on fish at tip speeds above 6–7m/s. It is not a case of sudden total mortality above this speed. This is illustrated by the graph below (Atkins-Rolls 2010[84]), prepared for the SETS study, which at that time considered that 12m/s might be acceptable; the HP VLH turbines are likely to be based on these or similar turbines but with a significantly reduced tip speed to reflect current thinking. This would bring strike rates to zero or close to zero depending on species and fish size.

It is significant that the MJ2 with a tip speed of 8m/s (Table 3 below) has a successful record of safe fish transit with zero strike at this tip speed.

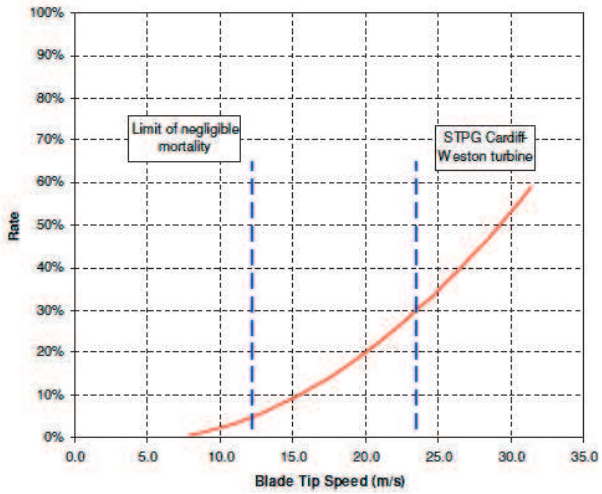

Fig. 1: Illustration of the relationship between turbine blade tip speed and fish strike: tip speeds above approx. 8m/s show a progressive rise in strike rate. At 12m/s the strike rate is considered "negligible". The HP turbine tip speed is currently estimated at 9m/s. Further development is likely to reduce this closer to 5m/s (graph from Atkins and Rolls Royce, 2010[85]).

4.3 *High pressure flux.* Shear forces generated by pressure gradients associated with turbine blades can be damaging to fish, some more than others.[86] However, during the computer design process of turbines these pressure gradients can be designed down to levels comparable to those found in nature (MJ2[87]) and certainly much better than the standards set out by the USDoE (Table 3 below).

Sudden increases in pressure are not generally a problem for fish swimbladders. Conversely, in some fish species (bass) the swimbladder is equilibrated slowly through gaseous diffusion and sudden large pressure drops can rupture it. Other species (salmon, trout, herring) which have a swimbladder duct to the oesophagus can vent air rapidly during sudden pressure drops and are therefore less vulnerable.

However, the pressure drop with a very low head turbine is considerably less than that of a high head conventional barrage turbine so there is far less likelihood of problems. Table 3 below shows that the pressure drop with the MJ2 turbine is well within USDoE guidelines.[88]

4.4 *Cavitation:* The formation and release of localised high energy cavitation bubbles can damage fish. However, cavitation is not a characteristic of low flow rate VLH turbines and, as explained by Prof. Broyd (Q.122) cavitation would anyway be designed out in the interests of the integrity of the machinery.

[83] Odeh, 1999: "*Criteria for Design and Evaluation of the New ARL/NREC Fish Friendly Turbine Runner*". US Department of Energy: Idaho Operations Office http://www1.eere.energy.gov/water/pdfs/doewater-13741.pdf

[84] Atkins PLC and Rolls Royce Limited 2010: *Concept Design of a Very Low Head Dual Generation Tidal Scheme for the Severn Estuary. Volume 1: Summary Report* p.23.

[85] Atkins PLC and Rolls Royce Limited 2010: *Concept Design of a Very Low Head Dual Generation Tidal Scheme for the Severn Estuary. Volume 1: Summary Report* p.23.

[86] Nietzel, D A, *et al* 2000 *Laboratory Studies on the Effects of Shear on Fish: Final Report* Prepared for the U.S. Department of Energy Idaho Operations Office *http://hydropower.inel.gov/turbines/pdfs/doeid-10822.pdf*

[87] MJ2 technologies http://www.vlh-turbine.com/EN/html/Fish_friendliness.htm

[88] Odeh, 1999: "*Criteria for Design and Evaluation of the New ARL/NREC Fish Friendly Turbine Runner*". US Department of Energy: Idaho Operations Office

4.5 *"Lack of gradation in salinity"*. Even in a high head conventional barrage with its long holding period, the peak inflows of fresh water into the basin are negligible[89] compared with the volume of seawater moved on every tide.[90] With a VLH barrage, and over 1,000 turbines, the normal mixing of water volumes in the Severn estuary would be maintained. There would be no salinity barrier across the barrage.

4.6 *Turbidity and fish passes.* The estuarine environment is likely to be somewhat less turbid following construction of the barrage. Regardless of this, fish are highly sensitive to water movement[91] and have no difficulty navigating up and downstream in the already turbid environment of the Severn. If, ultimately fish passes are required for fish transit past already fish friendly turbines, the behavioural guidance systems now recognised as effective in such conditions could include light, sound and bubble curtains. Species-specific passes such as up and over elver passes, could also be included.

4.7 *Are fish friendly turbines attainable?* Table 3 below shows a comparison of the US Department of Energy (USDoE) criteria, (referenced by Martin Salter, Q.58), with the French MJ2[92] and the Rolls Royce "blue concept" turbine.[93]

Table 3

COMPARISON WITH USDOE CRITERIA OF MJ2 PRODUCTION MODEL TURBINE AND ROLLS ROYCE CONCEPT TURBINE

Comparison of "fish friendly" elements of MJ2 turbine and Rolls Royce "blue concept" turbine based on US DoE criteria			
Item	*DoE Criterion*	*MJ2*	*RR "blue concept"*
Runner (m)	4.9	3.15—5	9
Head (min/max) (m)	23–30	1.4–2.4(for 5m)	1.7–3
Pitch	Helical in DoE concept turbine	Variable	Variable
Crossing/axial velocity (flow rate) (m/s)	4	1.85	1.4–2.8
Max speed at blade tip (m/s)	6 =zero mortality 12 =negligible mortality	4.5–8	9
Minimum permissible encountered pressure (kPa)	69	94	Commercially confidential
Maximum pressure gradient (kPa/s) = rate of change of pressure	550	80	Commercially confidential
Maximum shear speed gradient (m/s/m)	180	10	Commercially confidential
Minimum tip clearance (mm)	2	4.5 (possibly 1.5)	Commercially confidential
Surface roughness	Minimised	Minimised	Minimised

Conclusion: Is a fish friendly turbine achievable?

Table 3 clearly shows that the MJ2 and Rolls Royce concept turbine (where data has been released) fall within virtually all the USDoE parameters for safe fish passage. Where data is not available on pressure and shear speed gradient, this is because the fluid dynamics modelling is commercially confidential and has not yet been released. However, the pre-conditions for satisfactory performance with regard to pressure and shear have been met insofar as the flow rate and blade speeds are both comparable with those of the MJ2.

Questions have been raised during the 3rd evidence session about the contra-rotating nature of the turbine runners (blade assembly) and the possibility of fish entrapment. In the Rolls Royce blue concept turbine the contra-rotating runners are separated by a gap of approximately 1.5m, sufficient to allow the largest salmon through with full body length clearance.[94]

[89] Severn Estuary.net 2011 *State of the Severn Estuary Report* http://viewer.zmags.com/publication/ad5b93bd#/ad5b93bd/1

[90] Xia, *et al*, 2011, *Estimation of future flood risk in the Severn Estuary due to a barrage.* Journal of Flood Risk Management 4 (2011) 247–259 http://onlinelibrary.wiley.com/doi/10.1111/j.1753–318X.2011.01106.x/abstract

[91] Turnpenny A. 2012 Personal communication.

[92] MJ2 technologies CFD http://www.vlh-turbine.com/EN/html/Fish_friendliness.htm

[93] Atkins PLC and Rolls Royce Limited 2010: *Concept Design of a Very Low Head Dual Generation Tidal Scheme for the Severn Estuary. Volume 1: Summary Report*.

[94] Atkins PLC and Rolls Royce Limited 2010: *Concept Design of a Very Low Head Dual Generation Tidal Scheme for the Severn Estuary.* Volume 1: Summary Report , pp.77–78

The MJ2 turbine is currently operational in environmentally sensitive riverine locations. Single pass field tests[95] have demonstrated the validity of the turbine parameters with 100% survival of adult European eels and other native species. Further, more intensive tests are ongoing in 2013[96] with trout and salmon.

In the context of tip speed, it is important to note that an operational tip speed of 8m/s is found to be satisfactory in the MJ2. All the fish friendly and generation performance characteristics were developed through computer analysis with only minor iterations needed to refine the turbine blade to reduce test mortality to zero. It seems reasonable to believe that a company like Rolls Royce or a turbine manufacturer of similar reputation could achieve the necessary performance criteria and should be given the opportunity to do so.

Finally, it is understood that Hafren Power have appointed an aquatic biology team of international standing led by Dr. Andrew Turnpenny to oversee the design of turbines and fish passes. He would also design and oversee necessary monitoring, mitigation and compensation programmes.

In addition, Dr. Turnpenny would be advising on prospective species/habitat enhancement programmes which could be carried out over and above the mitigation/compensation strategies. Dr. Turnpenny has long experience of the Severn estuary and has contributed to past barrage studies.

TOPIC 5: *Could the loss of the "unique hypertidal feature of the Severn estuary" be compensated for?*

5. *Q.212 Barry Gardiner* was concerned that the hypertidal nature of the estuary was "a very unique feature, that the Directive is saying needs to be re-created and compensated for in the locality, and it cannot be".

The English Nature 2006 Position Statement[97] with regard to a (high head) Severn estuary barrage states:

> *"within the basin formed by the barrage the hyper-tidal nature of the estuary would alter significantly and no measures to compensate for the loss of this particular feature could be engineered".*

The same points have been made by other critics of the barrage, (FoE 2007 Position Statement[98]). It should be noted that these position statements refer to the original STPG ebb-only barrage and not to the new HP proposal for a bi-directional VLH barrage.

Response

- Hypertidal range is defined as 6.0m or greater (DECC[99]).
- HP barrage (passive sluiced) will reduce spring tide range symmetrically about the mid-tide level from 14m to approx.10m[100] (2m top and bottom), so will remain well within the definition.
- Hypertidal is *not a designated feature* under SAC, SPA or Ramsar,[101] so *would not require mitigation* or compensation as such.
- However, any habitats or species losses, or other impacts resulting from reduced tidal energy and tidal range must be mitigated or compensated for by HP.
- Turbine pumping at slack water could partially restore basin levels[102] and intertidal areas, and reintroduce energy into the system. In this way some of the physical and biological consequences of an otherwise reduced hypertidal regime might be partially restored, subject to safe repeated transit for fish being achievable (Topic 4, above).

Conclusion

The "hypertidal" feature of the Severn estuary is not a designated feature and therefore does not of itself require mitigation or compensation. However, some of the physical and biological characteristics which are referenced in the designations are determined by the extreme tidal range and would require appropriate mitigation or compensation.

TOPIC 6: *What would be the benefit of the barrage to flood protection and cost savings?*

6. *Q.3 (Chair):* When discussing strike price, it was made clear that flood protection savings to the nation could not be netted against the strike price. Gregory Shenkman on behalf of HP (Q.138) urged that the "*benefits should be taken into account.....*"

It is therefore appropriate to look at the flood protection benefits of the barrage.

[95] Lagarrigue T and Frey A, 2010, ECOGEA *Test for evaluating the injuries suffered by downstream-migrating eels in their transiting through the new spherical discharge ring VLH turbogenerator unit installed on the Moselle Frouard.*
[96] 2013 Personal communication with MJ2 Technologies
[97] EN Position Statement http://jncc.defra.gov.uk/default.aspx?page=2066
[98] FOE 2007The Severn Barrage—Position Statement, p.17 http://www.foe.co.uk/resource/briefings/the_severn_barrage.pdf
[99] DECC 2010 Severn Tidal Power—SEA Topic Paper Flood Risk And Land Drainage
[100] Atkins 2010, *DECC SETS Bi-directional very low head turbine study (Atkins Study Report, March 2010)*
[101] JNCC Information Sheet, UK11081 http://jncc.defra.gov.uk/pdf/RIS/UK11081.pdf
[102] De Laleu V, 2009: *La Rance Tidal Power Plant 40-year operation feedback—Lessons learnt* BHA Annual Conference 2009

Response

6.1 The areas under consideration include two shoreline plan regions, now updated to v.2.

— *Severn estuary SMP 2*[103]—Lavernock Point in South Wales, along the Welsh shore up to the tidal limit of the Severn and back down the English shore to a point just north of Weston-super-Mare.

— *North Devon and Somerset Coastal Advisory Group* (NDASCAG[104]) SMP 2, which covers the shoreline to the west of Weston-super-Mare.

6.2 *No Active Intervention (NAI)—Damages:* the baseline scenario for flood defence assessment is set by a consideration of flood damages arising under a management policy of NAI. In this scenario, flood defences are not upgraded or replaced to meet climate change impacts—sea level rise, increased storm surges and increased wave heights. The SMP 2 study period of 100 years assumed a sea level rise of 101cm by 2105 (Defra 2006[105]). There are other sea level rise scenarios which describe a far more serious situation,[106,107,108,109] particularly those resulting from acceleration of melting of Greenland and Antarctic ice sheets.

The study was restricted to the Severn estuary SMP 2 area and there were many exclusions (eg property contents) and conditions. Valuations were at 2005 and 2008 and many of these are not believed to now be a fair representation.

The SMP 2 showed progressively increasing flood damages and write-off losses over the 100 year period amounting to £14.97 billion[110] (discounted). If these figures are extended to include secondary losses at a conservative rate of, say, 30% of insured losses,[111] the total costs to the community are estimated to rise to £19.46 billion.

If a Bridgewater Bay bund were to be included to protect the towns and villages of the Somerset Levels, at, say, an additional 25% of insured value, the total NAI damages saved by a barrage complex could be £24.33 billion. These figures correlate with NAI or similar scenarios arrived at when considering other studies (Defra 2001,[112] EA Wales 2010[113]). They also correspond with estimates of total insured value at risk from a major storm surge or tsunami.[114]

Other factors could increase NAI damages. The projected figures would also increase if the study period were to be extended beyond 2105–2144, which is the minimum lifespan of the barrage. The result are summarised in Table 4, below.

[103] SECG, 2010, *Severn Estuary Shoreline Management Plan Review (SMP2) Final Strategic Environmental Assessment Report: Part A Signpost Report http://www.severnestuary.net/secg/smpr.html*

[104] North Devon and Somerset Coastal Advisory Group (NDASCAG) 2010 *Shoreline Management Plan Final (SMP2)* http://www.ndascag.org/finalsmp/docs/SMP/Main_SMP_FINAL_pts1to5.pdf

[105] Defra, 2006, Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities—Climate Change Impacts October 2006 http://www.sdcg.org.uk/Climate-change-update.pdf

[106] Hansen, J E and Sato, M, 2011, *Paleoclimate Implications for Human-Made Climate Change* http://www.columbia.edu/~jeh1/mailings/2011/20110118_MilankovicPaper.pdf

[107] http://energybulletin.net/stories/2012–01–03/hansen-still-argues-5m-21st-c-sea-level-rise-possible

[108] Hansen, J and Sato, M 2012Update of Greenland Ice Sheet Mass Loss: Exponential ? 26 December 2012 http://www.columbia.edu/~jeh1/mailings/2012/20121226_GreenlandIceSheetUpdate.pdf

[109] UKCP09 http://www.ukcip.org.uk/resources/ukcp09/

[110] SECG 2010, *Severn Estuary Shoreline Management Plan Review, Severn Estuary SMP Review Appendix H: Economic Appraisal* p.14 *http://www.severnestuary.net/secg/docs/public%20consultation/dec10/Appendix%20H%20Economics_FINAL_Dec2010.pdf*

[111] RMS 2007, *1607 Bristol Channel Floods: 400-Year Retrospective—RMS Special Report, pp. 14–15*. Analysis indicates that average contents losses amount to a further approx. 75% of insured property losses under a storm surge scenario. https://support.rms.com/publications/1607_Bristol_Flood.pdf

[112] Defra, 2001, *National Appraisal of Assets at Risk from Flooding and Coastal Erosion including the potential impact of climate change—Final Report*

[113] Environment Agency Wales, 2010, *future flooding in Wales: flood defences—Possible long-term investment scenarios http://www.environment-agency.gov.uk/static/documents/Research/Flooding_in_Wales_Flood_defences_ENGLISH_V5.pdf*

[114] RMS 2007, *1607 Bristol Channel Floods: 400-Year Retrospective—RMS Special Report, pp. 14–15*. Analysis indicates that average contents losses amount to a further approx. 75% of insured property losses under a storm surge scenario. https://support.rms.com/publications/1607_Bristol_Flood.pdf

Table 4

SEVERN ESTUARY SMP 2 NO ACTIVE INTERVENTION LOSSES (£BN DISCOUNTED)

Severn estuary SMP 2 NAI losses (£bn discounted)					
To 2105			*To 2144*		
Severn estuary SMP 2 only	+ secondary losses @ 30%	+ Bridgewater Bay @ 25%	Severn estuary SMP 2 only	+ secondary losses @ 30%	+ Bridgewater Bay @ 25%
14.97	19.46	24.33	?	?	?

6.3 *Flood defence costs averted by construction of a barrage.*

Both SMP2[115] and DECC[116] arrive at 100 year discounted flood defence costs for the Severn estuary SMP 2 study area of £219 million when costs of managed realignment are taken into account. Inclusion of Bridgewater Bay (if protected by lagoon L3), would add a further £88 million to reach a total of £307 million. This raises a number of issues:

6.3.1 *Growth Rates:* Different studies suggest significantly higher growth rates in flood defence costs driven by climate change and sea level rise. For example:

— *The EA Wales 2010 study*[117] for the whole of Wales showed a growth rate in marine flood defence costs of 5% over a 25 year study period for its Scenario 3 (equivalent to SMP policies). This was despite the fact that the sea level rise contingency estimates were not based on Defra 2006 but on mid-range UKCP09 sea level rise projections which are approximately half those used in the SMP 2 study.

— *Pitt Review 2008*[118] estimates of coastal change drivers (x20) over a 75 year period, would lead to a corresponding reduction in the "Standards of Service" of flood defences[119] (EA Wales 2010, p.14). This corresponds to a growth rate in defence costs of 4.25%

— *The SMP 2 technical Appendix C*[120] shows flood return periods increasing in frequency from 1:200, to as much as 1:10 over 75 years which corresponds to a 1/20th reduction in Standards of Service of flood defences. This is based on 2001 data. Since then climate change and sea level rise projections have increased which would drive further deterioration of Standards of Service.

Notwithstanding the above, the SMP 2 analysis assumes the following costs for the three study periods:

— 2005–30 zero increase in costs.

— 2030–55 1.5x increase in costs.

— 2055–05 2x increase in costs.

This equates to a 100 year growth rate of only 0.97%.

6.3.2 All SMP 2 flood defence costs are shown discounted to Present Value (PV) even though discount rates would normally be expected to follow Treasury Green Book guidance (eg EA Wales 2010 p.19). Examination of DECC 2010 suggests that the discount rate applied to *flood defence* as distinct from flood damages averted, was 8% for the first 35 years and 3.5% thereafter up to 2105.

6.3.3 When these data are combined, it is possible to back calculate to establish the discount table and then introduce growth rates more in line with other studies, and which assume a realistic assessment of coastal change drivers which also correspond to the SMP's own technical Appendix C. The results of this calculation are shown in Table 5 below.

[115] SECG 2010, *Severn Estuary Shoreline Management Plan Review,* Severn Estuary SMP Review Appendix H: Economic Appraisal p.14

[116] DECC 2010 Severn Tidal Power—SEA Topic Paper Flood Risk And Land Drainage

[117] Environment Agency Wales, 2010, *future flooding in Wales: flood defences—Possible long-term investment scenarios*

[118] Sir Michael Pitt (2008). *An Update of the Future Flooding 2004 Qualitative Risk Analysis* http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/_/media/assets/www.cabinetoffice.gov.uk/flooding_review/evidence/foresight_report%20pdf.pdf

[119] Environment Agency Wales, 2010, *future flooding in Wales: flood defences—Possible long-term investment scenarios*

[120] SMP 2: *Socio-Economic Appraisal and Sensitivity Testing, Table C3.1 and Fig.C3.1* http://www.defra.gov.uk/publications/files/smpg-vol2-appc.pdf

Table 5

SEVERN ESTUARY SMP 2 STUDY AREA AND EXTENDED STUDY AREA: FLOOD DEFENCE COSTS UNDER DIFFERENT GROWTH RATE SCENARIOS

		Severn Estuary SMP 2 Flood Defence Costs (£bn discounted)			
		SMP 2 Study Area		*+ Bridgewater Bay*	
Regime	*Growth rate*	*To 2105*	*To 2144*	*To 2105*	*To 2144*
SMP 2 2010 DECC 2010	0.97%	0.219	?	0.307	?
Pitt Review 2008	4.25%	1.834	4.083	2.571	5.724
EA Wales 2010, Scenario 3 = SMP2 equivalent	5.00%	2.987	8.402	4.188	11.777

Conclusion:

Savings against flood damages:

The construction of a shore-to-shore barrage with lock gates and turbine gates to prevent excess water levels in the impoundment basin would protect the upstream coastlines against "regular" flooding risk, storm surge and sea level rise.

The new HP proposal for ebb-flow generation would maintain mean water levels and remove the oft quoted tide locking risk associated with the former ebb-only barrage. DECC and EA data are not clear as to whether all the invert levels of drains into the Severn are recorded or their levels known and the EA expressed concern that the full low tide may be required to ensure adequate drainage was maintained. This could be achieved with a low water pumping regime by barrage turbines.

Fluvial flooding risk could therefore be reduced by active control (lowering) of basin levels and facilitating river flows during peak rainfall periods. In this context, 2 hours of peak rainfall over a high tide period would raise basin levels by only 4cm.

The potential savings in flood damages averted under a scenario of No Active Intervention could be as high as £19bn for the SMP 2 area and £24bn if Bridgewater Bay is also protected.

Savings in flood defence costs:

Flood defence costs are currently indicated by the SMP 2[121] and DECC 2010[122] at only £0.219bn to 2105 for the SMP 2 study area alone and £0.307bn if the Bridgewater Bay impoundment were to be included.

However, when realistic growth rates reflecting authoritative guidance on coastal change drivers are applied, the potential savings *could be very considerably more, amounting to between £1.8 billion and £3.0 billion to 2105 for the SMP 2 study area and between £2.6 billion and £4.2 billion if Bridgewater Bay is included for the same period.*

When the flood defence tables are extrapolated to 2144, which is the minimum life expectancy of the barrage, the cost saving appear to be very considerably more as shown in Table 5.

SUMMARY OF THE NEW HAFREN POWER PROPOSAL

(i) The idea of a barrage across the Severn estuary is not new. However, the HP proposal comes at a time when understanding of tidal technologies and computer aided turbine design is now sufficiently advanced to merit very serious consideration of the enormous potential of this most recent proposal for a tidal bar from Lavernock to Brean.

(ii) This would not just be a tidal power station but would also be a major flood, storm surge and sea level rise scheme protecting one of Britain's most vulnerable stretches of coastline. Although it is true that there are other options for harnessing the power of the Severn, none of these has anything like the potential to produce so much electricity whilst giving flood security to so many people.

(iii) The barrage would deliver clean, secure, reliable, and ultimately very low cost zero carbon electricity to the nation for over 120 years. It would use no imported or other fuels and leave no legacy of hazardous waste. It would make a major contribution to the UK's legally binding carbon reduction targets, help the UK to establish a leading position in the global marine energy market and create long-term employment. All its fabricated components would be recyclable. This is a truly sustainable project meeting all the sustainability objectives of the UK and Welsh governments.

[121] SECG 2010, *Severn Estuary Shoreline Management Plan Review, Severn Estuary SMP Review Appendix H: Economic Appraisal* p.14

[122] DECC 2010 Severn Tidal Power—Sea Topic Paper Flood Risk And Land Drainage, para 2.2.17

(iv) The HP barrage would finally bring to fruition the ground-breaking work carried out on the very low head (VLH) *tidal bar* concept developed by W.S. Atkins and Rolls Royce Limited under the Severn Embryonic Technologies Scheme, and the HP proposal is hereafter referred to as a "tidal bar". This tidal range power scheme is very different to the high head B3 barrage proposal examined by the government during the Severn Tidal Power Feasibility Study[123] and should in no way be regarded as a cosmetic upgrade of that proposal.

(v) In terms of alternatives, there is no other scheme or combination of schemes[124] at or near this location which could generate *anywhere near* the 16.5TWh/y of electricity output of the HP VLH tidal bar. Although "alternative" schemes are currently being suggested on the basis that they would have lower environmental impacts, the truth is that all energy extraction schemes entrain their own consequences and none of these alternatives would be without impact. For instance, although an incomplete barrage without locks (a tidal fence), would have less impact on tidal range, intertidal areas and fish, this is only because it would extract far less energy. It would generate only 1/20th of the electricity of the HP locked barrage and would accelerate the already strong currents through the shipping gap by up to 2.3 times,[125] with potentially serious impacts on shipping movement and ports upstream.

(vi) On the other hand, in terms of complementarity, the HP tidal bar would fully integrate with a wide range of marine energy schemes and technologies, including offshore wind, offshore and coastal wave farms, and many tidal stream installations, as well as offshore and coastally attached lagoons—all in the outer estuary, Bristol Channel or its western approaches. This has been recognised by Regen SW.

(vii) In this way, a coherent and holistic energy strategy could be rolled out over time, just as Regen SW envisage in their discussion document. The HP tidal bar, in an optimum location for harnessing the estuary's unique tidal range power potential, would kick-start this integrated approach which could eventually yield up to 10% of the nation's electricity needs through a coherent multi-technology development of just this one marine region. It would also lead the way for others.

(viii) This is not to say that there are no environmental and socio-economic difficulties either with the HP tidal bar or any of the other complementary schemes. These have to be fully identified and overcome.

(ix) The HP tidal bar would, for instance, reduce tidal range both upstream and downstream which, unless mitigated, would affect access to ports upstream. However, this reduction in tidal range would directly assist in flood protection, particularly as sea level rise begins to accelerate (and even more so if the concerns of James Hansen[126] turn out to be justified).

Removal of energy from the tidal system, and associated reduction in tidal range, would also affect intertidal areas, current flows and sedimentation. Clearly a great deal of study and modelling remains to be done to quantify effects and develop mitigation and compensation strategies. This applies to all marine energy extraction, not just the HP tidal bar.

(x) A number of authors[127,128,129] have suggested one potential mitigation strategy for tidal range losses which is unique to barrages and lagoons, in the form of turbine pumping at high and low slack water. This could accelerate and prolong natural sluicing through turbines at the end of each generation period. It would have the effect of reintroducing energy into the system and restoring impoundment basin levels, intertidal areas, tidal currents and sedimentation patterns to some degree—but, significantly, in a controlled and predetermined manner.

Professor D.J. Mackay[130,131] and others have also demonstrated the potential for low head pumped storage in the form of two or three basin lagoons (generally conceived as offshore) which could absorb surplus electricity production from all renewable energy resources, including wind farms and supply pumping loads on demand.

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[123] DECC 2010: *Severn Tidal Power Feasibility Study Conclusions and Summary Report*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/50064/1._Feasibility_Study_Conclusions_and_Summary_Report_-_15_Oct.pdf

[124] Aside from either an Aberthaw-Minehead barrage, which although generating more electricity, would cost more and create larger tidal range losses, or the old style high head barrage, which would have a wide range of adverse environmental impacts.

[125] Giles *et al*, 2010: *An Innovative Tidal Fence Development for the Severn Estuary, UK*. p.4 http://www.itpower.co.uk/files/An%20innovative%20tidal%20fence%20development%20for%20the%20Severn%20Estuary%2C%20UK_Jack%20Giles.pdf

[126] Hansen, J E and Sato, M, 2011, *Paleoclimate Implications for Human-Made Climate Change* http://www.columbia.edu/~jeh1/mailings/2011/20110118_MilankovicPaper.pdf

[127] Burrows *et al*, 2009*: Tidal Energy Potential in UK Waters.* Draft paper for ICE special issue: Offshore Renewable Energy. http://www.liv.ac.uk/media/livacuk/engineering/burrows/BURROWSHC2_final_17.pdf.

[128] Atkins PLC and Rolls Royce Limited Feb 2010*: Concept Design of a Very Low Head Dual Generation Tidal Scheme for the Severn Estuary. Volume 1: Summary Report* https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69830/21._Severn_Embryonic_Technology_Scheme__-_Final_Report_and_Development_Route_Map_-_Rolls_Royce-Atkins.pdf

[129] Anderson 2007, Barrages and Impoundments: A Preliminary Study of the Potential for Sustainable Net Energy Capture Obtainable by Storage for Tidally Amplified Release http://d1180280.u211.pipeten.co.uk/wp-content/uploads/7ecostar1.pdf

[130] MacKay 2009*: Sustainable Energy without the Hot Air* http://www.withouthotair.com/

[131] MacKay, 2007 *Enhancing Electrical Supply by Pumped Storage in Tidal Lagoons* http://www.inference.phy.cam.ac.uk/sustainable/book/tex/Lagoons.pdf

(xi) In practice, adjustment of basin levels through pumping has been demonstrated at La Rance,[132] although restrictions in turbine efficiency and numbers, which affect water throughput capacity and slow down pumping, limit its economic value.

(xii) It may be thought that this process would waste the electricity produced during generation (and "*turn off 5% of the nation's electricity every time a ship arrives"* Q 241). However, counter-intuitively, slack water pumping should in fact provide a net gain in electricity output. This is because the extra volume of water "actively sluiced" at, say, high tide, would only be released once the operating head had been reached on the ebb and vice versa at low tide.

It has been estimated[133] that a further 24% net of electricity could be generated in this way, through this low head pumped storage and tidally amplified release.

In other words, more electricity would be generated than consumed. It is important to note at this stage that comprehensive 2D modelling of the hydrodynamics will be required to verify tidal range amelioration and additional net generation outputs.

(xiii) The principle is therefore clear, that a significant measure of active control of the hydrodynamic regime could be attainable in the case of a VLH tidal bar incorporating a large number of bi-directional turbines capable of operating in pumping mode, creating a highly permeable and fully controllable tidal bar structure.

(xiv) This leaves the major question of safe fish passage, the more so if turbines are active for longer. It is now understood that even migratory fish do not make a single run of the estuary but tend to swill up and down with the tide[134] in a similar way to resident species. There is a lot of concern and much has been said to the effect that the HP turbines will be "*fish mincing machines"*.

When considering the B3 high head option, the Severn Tidal Power Feasibility Study Conclusions[135] were rightly sceptical about the viability of migratory fish populations, with high flow rate, high rpm bulb turbines. The mortality rate for those turbines has been estimated at 40% for adult salmon, 10% for salmon smolt, 28% for adult eel, and 53% for shad.[136]

(xv) The very low head tidal bar concept changes everything. For instance, the MJ2 Technologies VLH turbine has already delivered outstanding results in French rivers showing zero mortality in recent single pass trials using adult eels[137] in which the mortality rate was *"extremely low, and even zero, and that the rate of injuries not lethal in the short term (from 24h to 48h)* (was) *close to 2%*". Further test work is on-going.

(xvi) The drivers behind this new approach to fish safety in tidal range generation lie in a shift in the parameters used in computer aided design, in the very low operating head of turbines (typically 1.5m–3m), and the considerable increase in the numbers of turbines proposed (typically x3 to x5). A drastic reduction in rate of water flow through turbines and in their rate of rotation means that virtually all the critical parameters for fish survival are, at a stroke, brought much closer to levels found in nature. These include significant reductions in strike rate, impact, pressure drop, shear stress and cavitation. Accurate fabrication and high standards of quality control bring down other factors such as blade tip clearance and surface roughness to levels where fish cannot easily be trapped between casing and blade tip.

(xvii) In parallel with an on-going revolution in turbine technology, are recent advances in fish behavioural guidance technology currently being developed to screen marine power station intakes. It would now appear reasonable to expect very high survival rates for repeated fish transit of a tidal bar operating with VLH turbines specifically designed to be fish friendly. This, combined with targeted expenditure on habitat and species improvement programmes funded out of electricity revenues, could potentially bring an overall positive benefit to currently threatened fish populations.

(xviii) It does not seem at all likely that incremental rollout of small scale tidal range projects as suggested by Regen and the RSPB, could ever provide sufficient stimulus to the market to warrant the development cost of a 9–12m diameter VLH fish friendly turbine. Without the reasonable expectation of sufficient sales to recoup investment it is difficult to see how a turbine manufacturer would unilaterally commit to these considerable costs.

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[132] de Laleu V Summary of La Rance BHA Annual Conference 2009—*http://www.british-hydro.org/downloads/La%20Rance-BHA-Oct%202009.pdf*

[133] Atkins, March 2010, *DECC SETS Bi-directional very low head turbine study (Atkins Study Report, March 2010)*—0D modelling which requires updating to confirm the result https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69830/21._Severn_Embryonic_Technology_Scheme__-_Final_Report_and_Development_Route_Map_-_Rolls_Royce-Atkins.pdf

[134] Turnpenny, A, 2012 *Personal communication*

[135] DECC 2010: *Severn Tidal Power Feasibility Study Conclusions and Summary Report*. pp.7, 38–39

[136] Turnpenny, 2001: *Report to Parliamentary Science and Technology Committee* http://www.publications.parliament.uk/pa/cm200001/cmselect/cmsctech/291/291ap03.htm

[137] Lagarrigue T and Frey A*, 2010,* ECOGEA Test for evaluating the injuries suffered by downstream-migrating eels in their transiting through the new spherical discharge ring VLH turbogenerator unit installed on the Moselle Frouard. Pp. 2, 19, 22–24 http://ontarioriversalliance.ca/wpcontent/uploads/2011/08/ECOGEA_Tests_VLH_Frouard_Rapport_ANGUILLES_2010_vers_def_Eng.pdf

Without suitable turbines and a large enough project to support their development, tidal range technology would therefore appear likely to be severely delayed for many years, and the UK overtaken by more forward thinking countries. The case for the HP Severn barrage is imperative.

(xix) In conclusion, many commentators say that the risks of constructing a large scale barrage or tidal bar are still too great and should be deferred or abandoned without consideration of the wide ranging benefits that always accrue from any new and ambitious large scale project. There is no rational substitute for this location which does not carry the same risks.

NGOs and other organisations are right to be concerned about runaway global warming, climate change, sea level rise, acidification of the oceans and disruption of eco systems. They urge swift action on de-carbonisation of the economy, yet ask for still more time to consider other options. The "alternatives" to a barrage in this location, which they have suggested so far, would produce negligible outputs by comparison and would waste the most significant tidal resource possessed by the UK. It would be interesting to hear their response to Hafren Power's offer to work in collaboration with NGOs and other organisations to progress investigation of the tidal bar itself and its potential to support other, complementary, technologies to meet the UK's pressing energy needs.

In response to Qs 65–71, one opponent to the barrage suggested that an about-turn on nuclear power was now acceptable. He did not however provide any accompanying suggestion as to where additional new nuclear sites would be located (assuming developers would come forward, which is becoming a matter of some doubt), what the local population might think of such proposals, or where and how the nuclear waste would be stored,[138] or how the massive mortality of young and larval fish and other marine life which enter cooling systems would be dealt with.

Proponents of the barrage say that the time is right, and we would agree. The evidence, particularly on progress of turbine technology, operating methodology and fish screening strongly suggests that a large scale fish friendly VLH turbine, and therefore tidal bar, is now achievable. Further investment in turbine design is obviously required to refine what we already appear to have, to the point of a fully tested production model of suitable diameter. With this achieved, it would not seem unreasonable to believe that a tidal range scheme like the one proposed by Hafren Power, should be able to comply with the necessary environmental criteria and legal conditions suggested by the NGOs (responses to Q. 81).

We urge the Energy and Climate Change Select Committee and the government to support this project as part of an ongoing holistic approach to development of the Bristol Channel marine resource, and to give a clear and public signal of its commitment. This would encourage further investigation of the tidal bar strategy proposed by Hafren Power in the proper manner, through an EIA.

March 2013

Written evidence submitted by Karsten Evans (SEV91)

One thing I've been using Google earth for, is looking at how Severn channel could be made into a power source. No need for a dam.

There are two holms (islands) between Barry (Wales) and Weston (England) and at high tide you could walk between them. They are located between Laverrock in Wales and the Mouth of the Severn in England.

Most of the Severn behind Flat Holm is mud flats. Instead of running the tidal power option with a barrage a much better option is a mid channel lagoon. Not built with standard costly pre fab. or insitu. concrete like most dams, but with natural silting, soil nails and land fill forming a mid channel lagoon contained by landfill dyke using/starting at the two Holms and stretching towards the Bridge.

Just use soil nails at low tide to create piles in the mud between the two islands Flat Holm and the other holm. Some concrete or natural stone slabs would need to be used to top the soil nails so the tide doesn't snap and rip them out of sand during tides.

Dredge the channels between the holms and the coast and then drop the sludge up river of the piles. This should increase the flow in the channels, keeping the silt in suspension. Drop a load of rubble too and create a natural obstacle for the tidal flow.

Use one channel for ship traffic and the other for underwater flow turbines. This would cost peanuts in relation to a barrage solution and preserve the Severn as a river. The Severn Bore would still happen too.

Rail engineering companies have used soil nailing for over a decade to fix subsidence. It would be quick & easy and I think it would be better using the Severn to produce power than building another Chernobyl.

How do you suggest ideas like this though?

[138] Sellafield now costing £1.5bn/yr and the total to date £67.5bn http://www.bbc.co.uk/news/uk-england-cumbria-21298117

Look at the Islands using Google

There are lots of ideas for flow turbines. Just read how the whale shark has inspired a new and better design for a turbine casing that increases eff. by upto 40%. It swims around with it mouth open all day and the drag doesn't bother it, it actually helps it fly thru the water pulling water into its mouth.

Scotland is ahead of the world using Norwegian Tidal Generators in the sea off the East Coast. Surely this is easier than a costly barrage.

Why a Barriage is Bad for Tidal Power

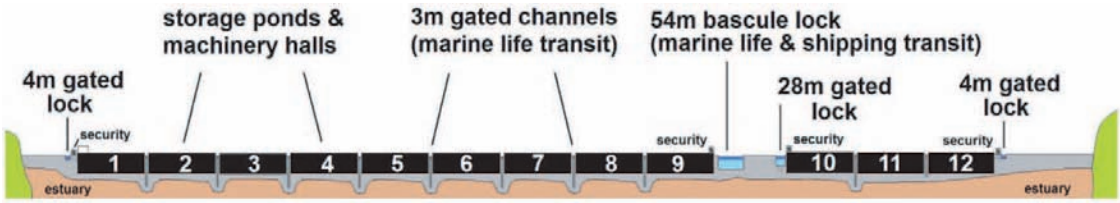
A Lagoon would be able to even out the power generation by enabling pumping water in at high tide with grid power and then letting it out at low tide thereby doubling the fall of the water (energy). Soil nail between the Holms, wait a while so it silts up, build a land fill bridge with lifting bridge section for ships from Weston side. At low tide lower bridge and dump fill behind silted up nails, Soil nail fill. Keep this up and build up walls of lagoon like this first from Flat Holm to bridge and then back again. A dam with Tidal Generators can then be created without the tide interfering before the lagoon is finished.

Wales has already done this type of construction in The Cardiff Bay Barrage. It's a mostly land fill dam.

Another place perfect for a flow turbine is the divide between Angelsy and mainland wales. It would be a great place to prove the tech works.

March 2013

Written evidence submitted by Dr Edward Grist (SEV92)



1. Essential Requirements and Acceptance Criteria

1.1 *Wildfowl*

Wildfowl and Severn estuary bank life must not be affected by the barrage. The existing upstream water level patterns adjacent to wetlands and river banks should be retained.

To accomplish this the barrage should include transit channels distributed across the barrage that remain open for a sufficient period at both high tide and low tide for water levels either side of the barrage to level out at values typical of those prior to 2013.

1.2 *Marine life*

Marine life should retain the same freedom to roam or to migrate as enjoyed prior to 2013.

To accomplish this the barrage transit channels should have at least a cross sectional area (width by depth) that approximates in aggregate to at least that at the combined mouths of the principal rivers entering the Severn estuary above the barrage, namely the Taff, Wye, Usk, Severn and Avon.

1.3 *Sediments*

Sedimentary accumulations, flotsam (including trees) and jetsam must be either removed from the water or, where appropriate, diverted through the barrage transit channels. The access routes and equipment required for this activity must be included in the barrage design.

1.4 *Shipping*

Shipping, pleasure craft and other vessels currently crossing the estuary line—Lavernock Point to Brean Down—should continue to pass through the barrage at the same traffic volumes recorded prior to 2013 with minimal obstruction or delay. Provision should be made to accommodate increases in the size and volume of commercial shipping to meet reasonable forecasts of future growth in maritime trading activity.

A separate transit channel is required for very large ships. This should permit transit through the barrage for a limited time period at high tide without the need to stop.

A ship lock for vessels (typically those less than 5,000 dwt tonne) should be included to make possible the option of providing transit through the barrage 24 hours a day.

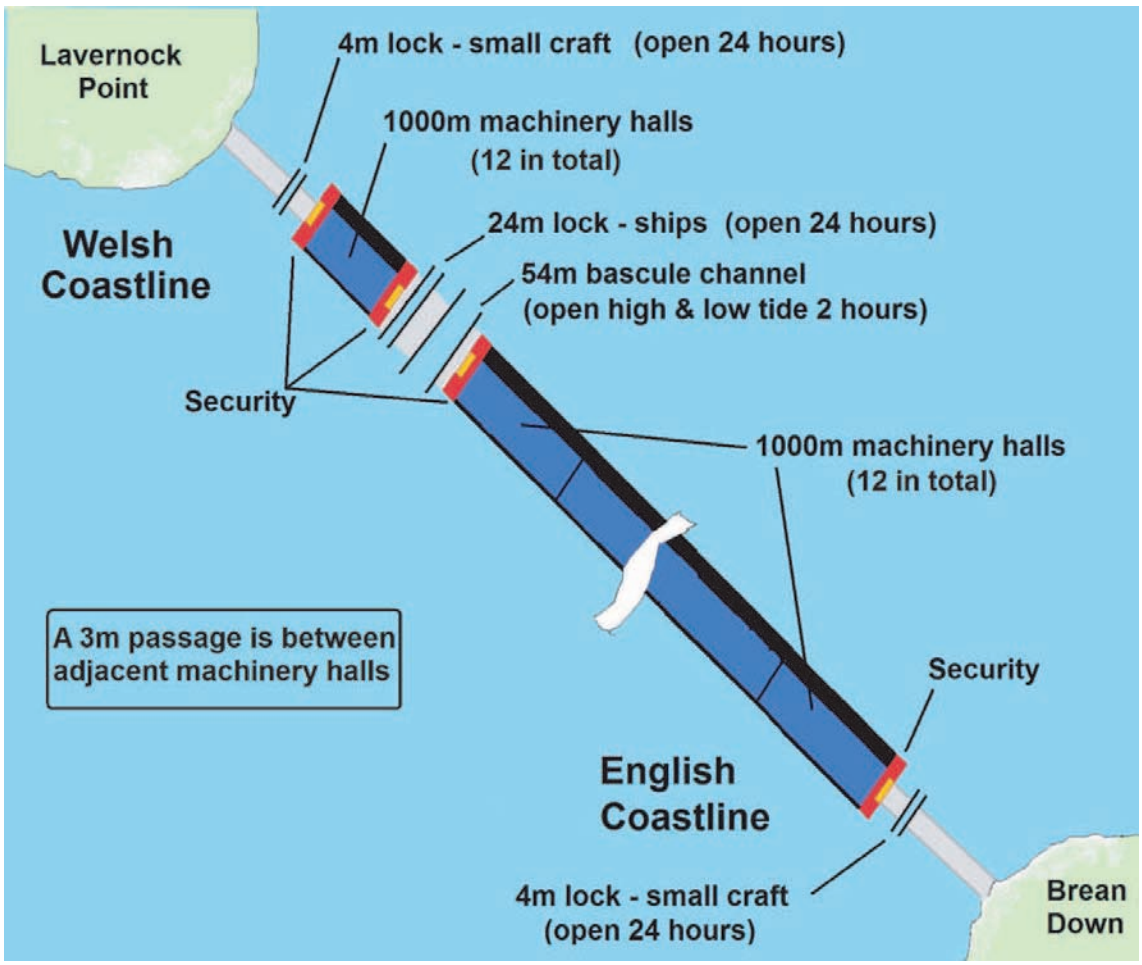
Two locks for small craft, one adjacent to each estuary shore should be included. These locks should be designed to make possible the option of transit through the barrage 24 hours a day.

1.5 *Electricity generation*

Water turbines, generators, pumps and electrical transmission equipment are required that maximise the electrical power that can be generated for transmission to the National Grid. A priority requirement is for the barrage structure to be of a design that restricts the loss of electrical power output resulting from credible events, both accidental and intentional, to less than 20% of the total barrage design electricity generating capacity. The barrage design must enable this 20% loss to be restored within 180 days.

Fig. 1

TRANSIT PASSAGES WIDTHS IN THE BARRAGE



(Measurements are metre lengths along the barrage)

2. Tidal Flow Control—Severn Barrage Design Essentials

2.1 *Protecting Wildfowl*

At high-tide and at low-tide the water flows close to the barrage have very little momentum. If sufficient water channels are provided through the barrage and these are distributed sensibly at points across the estuary then, provided such channels are open long enough, the water levels either side of the barrage will equate to estuary levels prior to construction of the barrage.

The reference design includes ten 3 metre wide channels that extend down to the bed of the estuary and a single channel that is 54 metre wide and 18 metre deep (relative to high water). All these channels are always to be open for two hours at every high tide and low tide. The resulting total of eight hours in each 24 hour 50 minute diurnal cycle is considered adequate to ensure that the existing wildfowl and Severn estuary bank life is unaffected.

2.2 *Protecting Marine Life*

The Bristol channel, extending as it does from the Atlantic ocean to the city of Gloucester, is the natural home to a wide spectrum of marine life. The line between Lavernock Point and Brean Down is crossed by many indigenous species that share the waters with a large variety of migrating and breeding species. They range from those able to swim vigorously to those crawling along the bottom. In 2013 this marine life has the freedom to pass through the line of the barrage at any time of the day or night. Replacing this freedom with the channels that have limited opening times necessarily imposes a restriction.

Channels that extend down to the estuary bed are considered to be the best way of encouraging the existing marine life to continue and adapt to meet the challenges imposed by the barrage with the least influence on their lifestyle and breeding patterns. The total channel opening time of eight hours evenly distributed in blocks of two hours in each diurnal cycle of 24 hour 50 minute is considered sufficient.

2.3 *Managing Sedimentary Deposits*

The barrage will change patterns of sedimentary accumulation. Ten 3 metre wide channels are more than adequate to provide routes through the barrage through which unacceptable sedimentary accumulations can be periodically scoured. These same passages also provide a place where flotsam and jetsam can be isolated and removed.

2.4 *Accommodating Large Ships*

Ships in the Severn estuary are an essential part of a profitable trading structure within UK commercial markets. The Severn barrage must accommodate these ships. They come in many sizes ranging from small to the very large. The reference design caters for increasing ship sizes to meet future needs.

Ships travel speedily and most efficiently when taking advantage of the estuary flows at high tide. A barrage that requires very large vessels to stop as they pass through ship locks at high tide is unacceptable. An alternative is provided in the reference design.

The submerged double bascule closure permits very large ships through the barrage. A shipping channel 54 metre wide and 18 metre deep sill (relative to high water) meets needs now and in the future. It enables non-stop transit through the barrage—albeit at a very slow speed to avoid the risk of unintentional collision with the barrage structure.

The design imposes no limitations on the height of ship superstructure. Underwater access tunnels provide for ready inspection and maintenance of the sealing between the bascules and their sills. These tunnels avoid the need for bridging across the channel above the water line.

The double bascule design can be opened and closed quickly even when storm conditions create large estuary surface waves. It is the most appropriate engineering design and can easily cope with local currents arising in the channel for one hour before and after high tide.

A 28 metre wide double-gated lock is also provided for ships travelling through the barrage outside the two hour period at high tide.

Fig.1 identifies in a single diagram all the transit passages through the barrage.

3. The Reference Design

The reference design and its associated logic are described so as to form a benchmark against which the merits of any alternative can be judged.

3.1 *The validity of two hour periods of "unhindered passage"*

The presence of a Severn barrage distorts the estuary flow patterns. The magnitude of this distortion is governed by the design choices that interact with tidal flows—essentially the water channels through the barrage provided for power generation, those for the transit of marine craft and those for transit of marine wildlife, sediments and debris.

Ship locks normally have two-gates which, by sequential operation, facilitate the transfer of vessels between two water levels. Vessels have to stop. This is a time consuming process. In a tidal barrage it is possible for a short period at both high tide and low tide to sail through the barrage with both gates open. Only shallow draught vessels can do this at low tide.

Consider conditions as high tide is reached. The water close to the barrage loses its momentum. At high tide the aggregate of energy in upstream and downstream counter-flows is zero. The power generation capability for that moment is zero. All gates to ship locks and all sluices in the barrage could be open without loss of potential power generation. Ships could pass through the barrage unhindered. Marine life could also pass freely through the locks and sluices.

For five minutes before high tide the water level is slightly below the maximum for the particular tide. After high tide it is again slightly lower as the estuary water slowly begins to recede. A tiny amount of electricity could, in theory, be generated.

Consider now one hour before and after high tide. The flows through the barrage are stronger and a meaningful amount of electricity generation starts to become a possibility. At one hour either side of high tide the largest of the ships can still navigate the estuary to pass unhindered through an appropriately designed transit channel in the barrage. Ocean going vessels arriving from distant ports and those leaving from ports upstream of the barrage require flexibility. A two hour slot is the minimum acceptable.

Throughout the two hour period when very large ships can pass through the barrage there is no obstacle to marine life choosing to pass through this channel at the same time. However, to fully meet the needs of marine life more channels are required—ideally smaller in width but to full estuary depth and distributed across the estuary. Adding such channels allows measures to be taken to prevent marine life from passing through the water turbines and permits the inclusion of high-power jet cleaning to prevent damaging sediments and debris from entering the running clearances, including the shaft seals, of the water turbines.

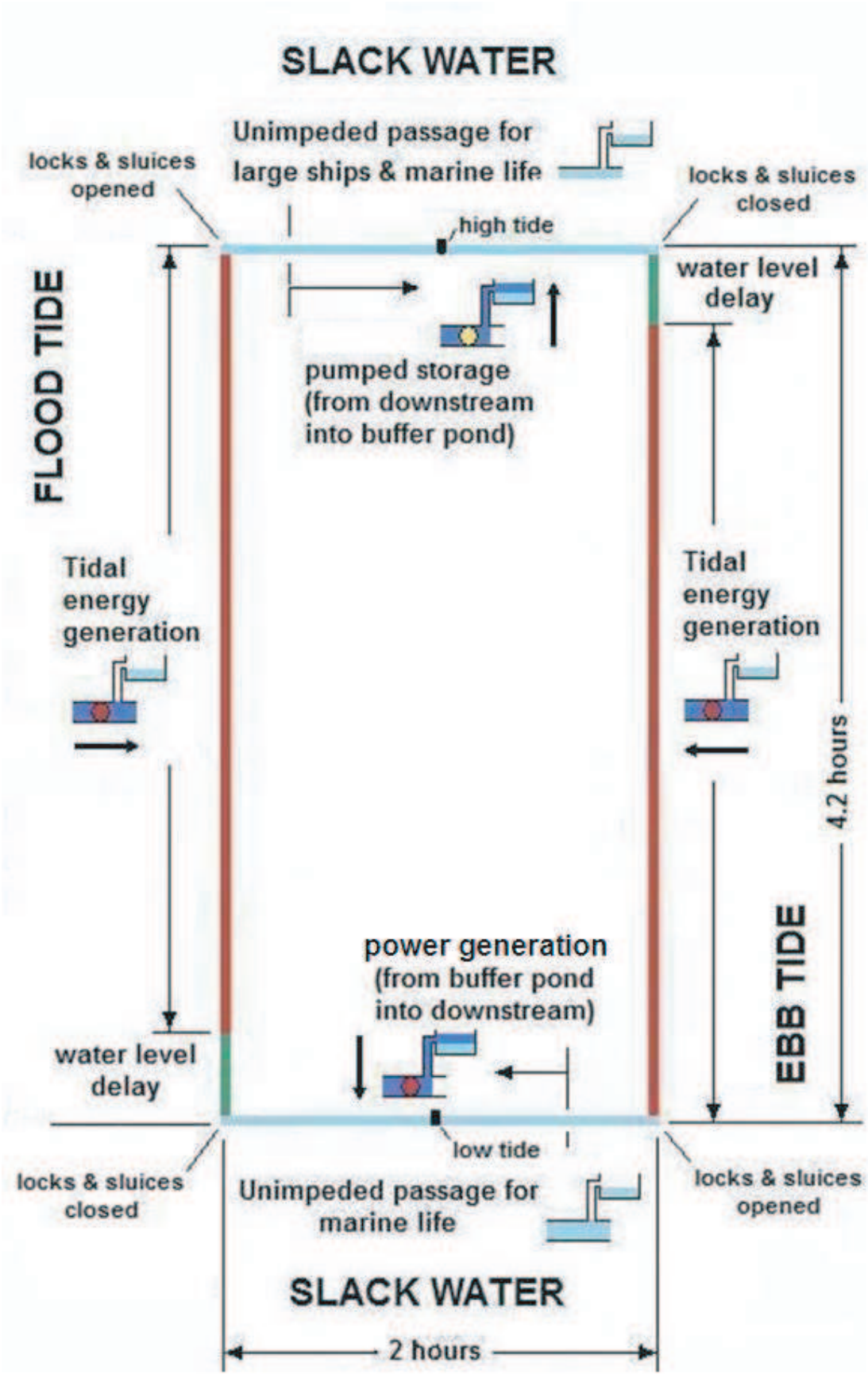
The limitations on power generation as high tide is reached also apply at low tide. All the channels passing through the barrage could open once more for a two hour period giving marine life a further opportunity to travel through the barrage. Equally important, this two hour period is sufficient for the estuary levels either side of the barrage to level out and replicate the upstream conditions in the estuary that existed prior to the construction of the barrage.

The conclusion reached is that opening all the channels one hour before and closing all of them one hour after both high tide and low tide has considerable advantages and is a valid basis for a compromise to meet all the requirements described earlier.

Fig.2. shows how the unimpeded passage for marine life is accommodated in the tidal cycle.

Fig.2

THE TIDAL CYCLE—A COMPROMISE THAT MEETS ALL REQUIREMENTS



3.2 *The double bascule channel*

The reference design makes use of two independently operated bascules. The hinge of each bascule is situated below the level of the shipping channel sill which, of course, is well below low water. Maintenance of the hinge seal is carried out dry from a chamber in which pressurised air drives out the water prior to and during use. The maintenance chamber for each bascule gate, accessed from adjoining service tunnel, extends across the full width of the shipping channel. Use of these chambers requires safety procedures being followed similar to those used by divers in tourist underwater activity vessels.

Each bascule is balanced by counterweight arms that extend above the water on each side of the channel. The bascule in operation is fast and certain. Operating the bascules in sequence particular to tidal direction minimises still further the energy to raise or lower them.

The alternative choice of a vertical hinged "lock gate" design for the 54 metre wide channel could have problems operating against tidal currents and surface waves during storms. Vertical seals in sea water for large heavy "gates" are very difficult to maintain.

A well recognised use of the bascule principle is Tower Bridge, London. Each of its 30m long counterbalanced bascules has a roadway plus pavements width of 20m and weighs over 1,000 tonnes. It opens and closes again in only five minutes to allow ships to pass through. When open each bascule stands at 86 degrees to the horizontal.

The Severn barrage bascules require a more modest load carrying capability and are, consequently, of a lighter construction than those of the vehicle carrying Tower Bridge but do have to contend with an aggressive sea water environment. The four hour period of closure at low tide provides ample time to secure the channel as a "stop lock" whilst remedial work is carried out.

Fig.3 and Fig.4. detail the double bascule and its operating cycle.

Fig. 3

THE DOUBLE BASCULE CHANNEL—CROSS SECTIONAL VIEW

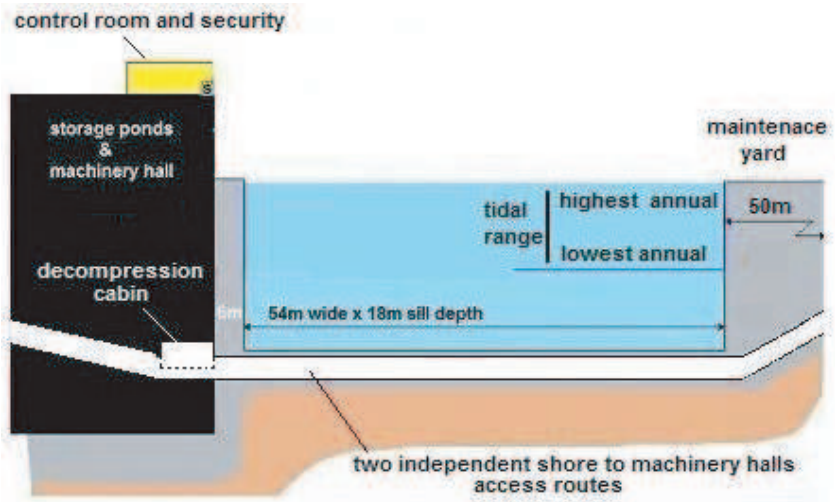
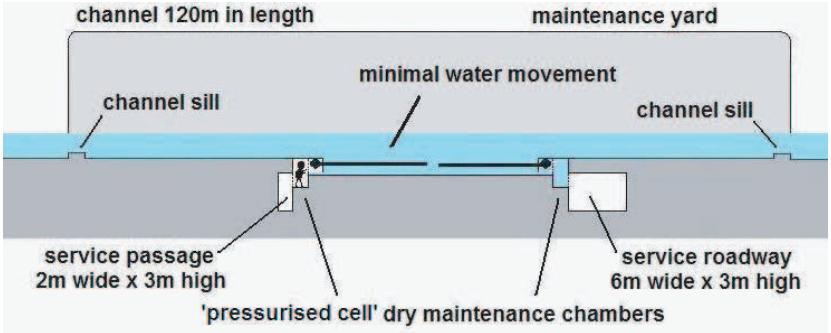


Fig. 4

THE DOUBLE BASCULE CHANNEL—OPERATING CYCLE



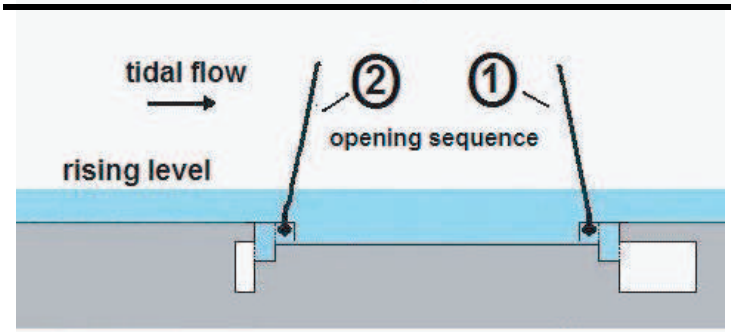


Fig 4b Low tide plus 1 hour

Bascules raised ready for power generation

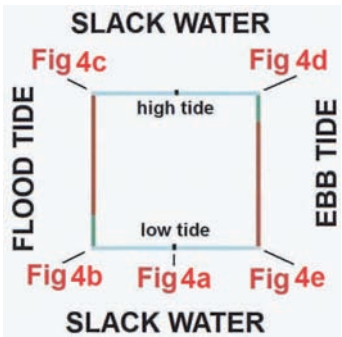


Fig 4c High tide minus 1 hour

Bascules lowered

Allows marine life and ships through unimpeded

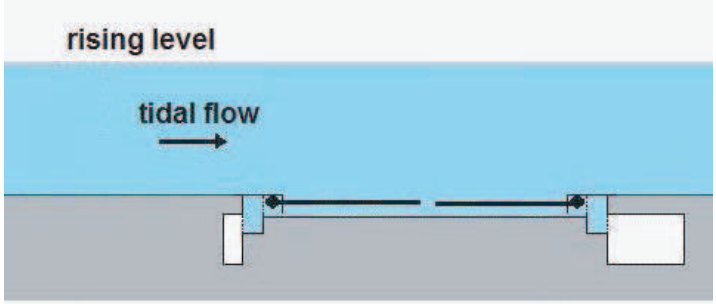
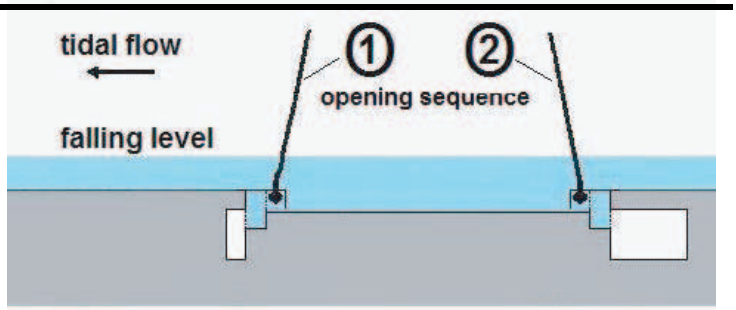


Fig 4d High Tide plus 1 hour

Bascules raised ready for power generation



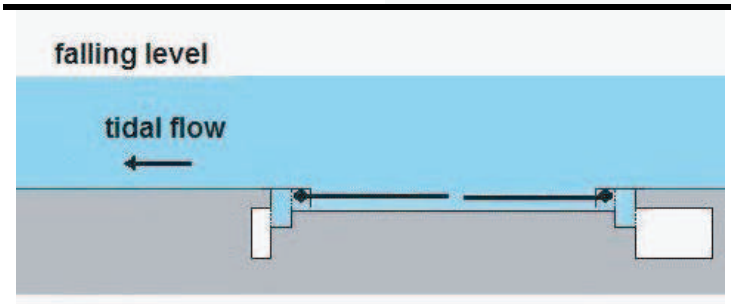


Fig 4e Low tide minus1hour

Bascules lowered

Allows marine life through unimpeded

3.3 *Security*

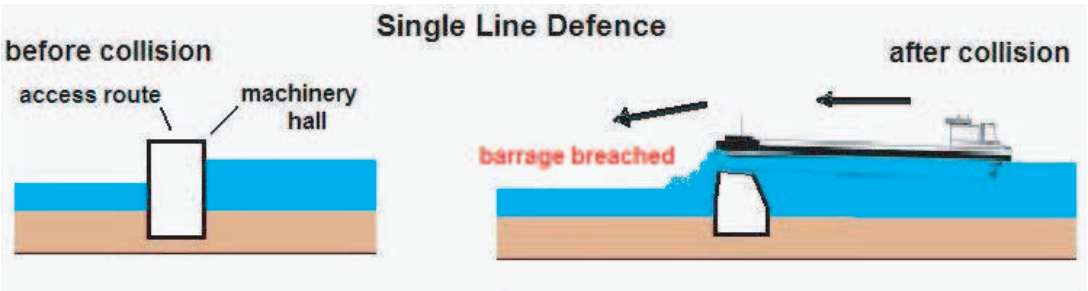
The barrage design must be such as to enable a 20% loss arising from any credible event to be restored within 180 days. Two credible events are identified.

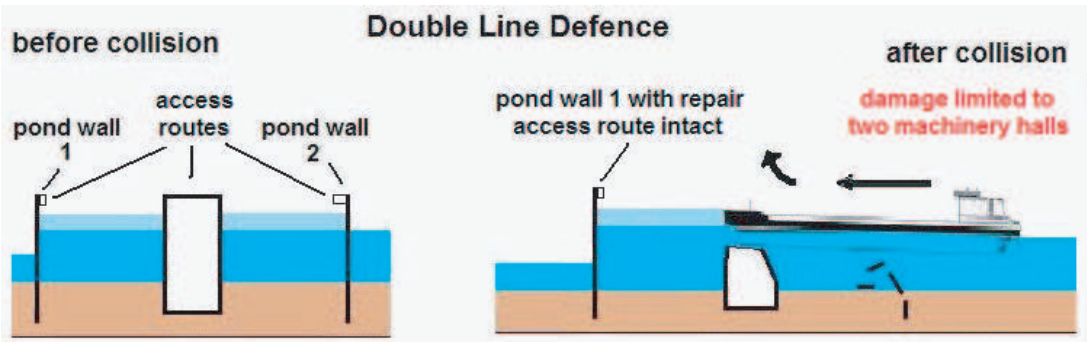
1. A large ship driving into the barrage at speed either deliberately or accidentally.
2. An explosion at any location on the barrage caused either maliciously or accidentally.

The Severn barrage has to be capable of resisting a collision from any ship in the Bristol Channel both from downstream or from upstream of the structure. A worst case collision scenario is a ship deliberately driven at speed into the barrage—such as a vessel hijacked as part of a terrorist attack. Designated "exclusion areas" and other forms of maritime policing are unlikely to prevent this happening. Bristol docks can accommodate vessels "up to 120,000 tonne dwt". Cardiff docks can accommodate vessels "up to 20,000 tonne dwt". Larger ships ply their trade at ports in South Wales downstream of the barrage. Clearly, the barrage must be of a very robust design and incorporate engineering features that enable it to repel collisions from any such vessels whilst at the same time minimising the loss of hydroelectric power generation. At the barrage detailed design stage a plan for dealing with credible events is required that describes how aspects of the implied capability can be demonstrated.

Fig. 5

SINGLE & DOUBLE DEFENCE LINES—A COLLISION DAMAGE COMPARISON





A strategy for limiting loss to 20% of the electricity generating capacity in a way that can be restored within 180 days can be achieved by adopting the following:

(i) Prevent a breach in the barrage that releases very destructive energy inherent in tidal flows**.** A single 30m wide structural line that forms a "single defence line" has proved suitable for a barrage in a narrow river estuary. This is not appropriate for Severn barrage. The resulting loss of total power generating capability and the inevitably difficult access to effect a repair, particularly out in the estuary, make very costly and time consuming repairs inevitable. A "double defence line" is essential. These defence lines should be separated by a means of absorbing a significant amount of the energy inflicted by the colliding ship.

The reference design shows two structural defence lines 100m apart separated by two water filled buffer ponds that straddle the turbine halls provided the ponds are filled to a height of at least 5 metre above an appropriate value for maximum high tide. The natural evaporation loss

from the ponds can be met by diverting the waters of the River Axe just upstream of the point where these waters enter the estuary in 2013. Security of this make-up water is ensured at times when drought restrictions prevent its use by topping up with water pumped into the ponds from the estuary.

Following a collision with a first defence line the retardation produced by buoyancy forces from the buffer ponds together with the resistance offered by the destruction of the turbine hall(s) the second defence line should escape unscathed. Access enabling repair from a collision to be speedily concluded is provided by integrating a passage way into the downstream defence line and a roadway into the upstream line.

(ii) Locate power generation units in a number of separate machinery halls so that any credible event disables a maximum of two of them. In a Severn barrage comprising twelve 1,000 metre long halls where each is hydraulically, electrically and security isolated from its neighbours damage to any two halls meets the 20% requirement. A single source accident or malicious act in adjacent halls could produce this worst case scenario. Multiple events involving non-adjacent halls where each has an independent security regime and is at least over 1000 metre away are considered incredible.

Fig. 6

BUFFER WATER PONDS—A VITAL SECURITY FEATURE

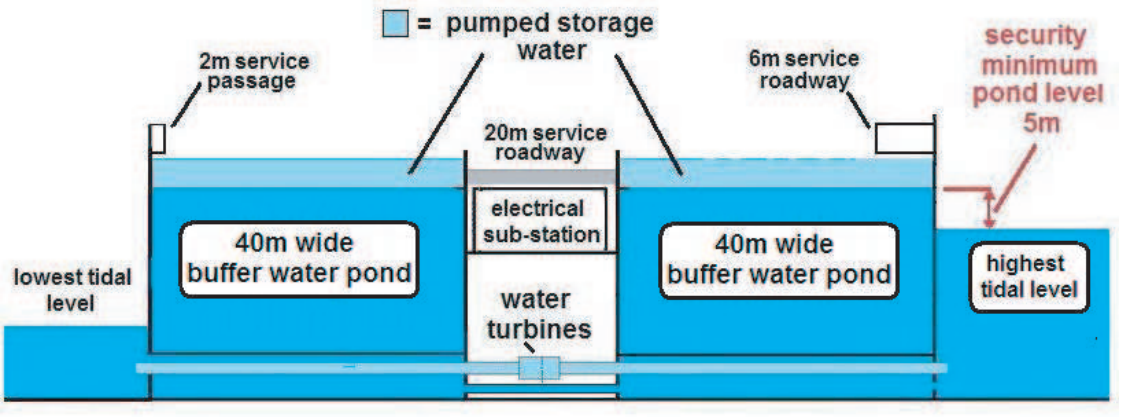
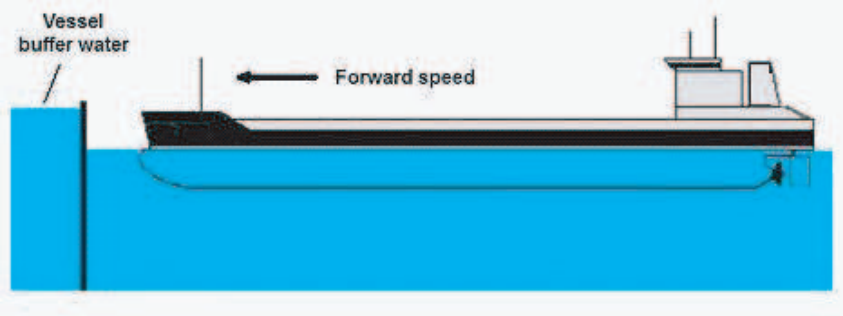


Fig. 7

THE EFFECT OF BUOYANCY FORCES ARISING FROM A BUFFER POND



Typical 10,000 tonne dwt oil tanker

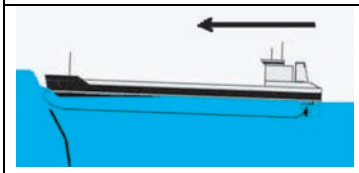
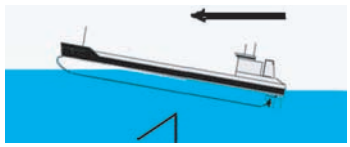
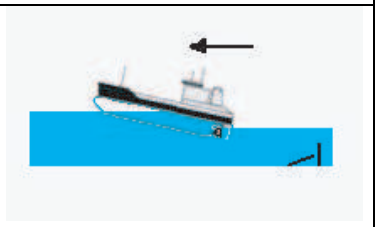
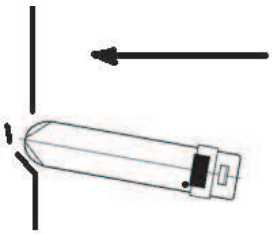
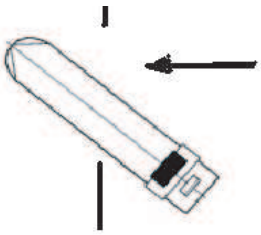
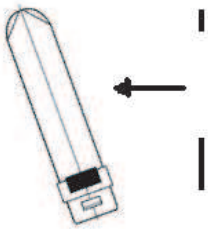
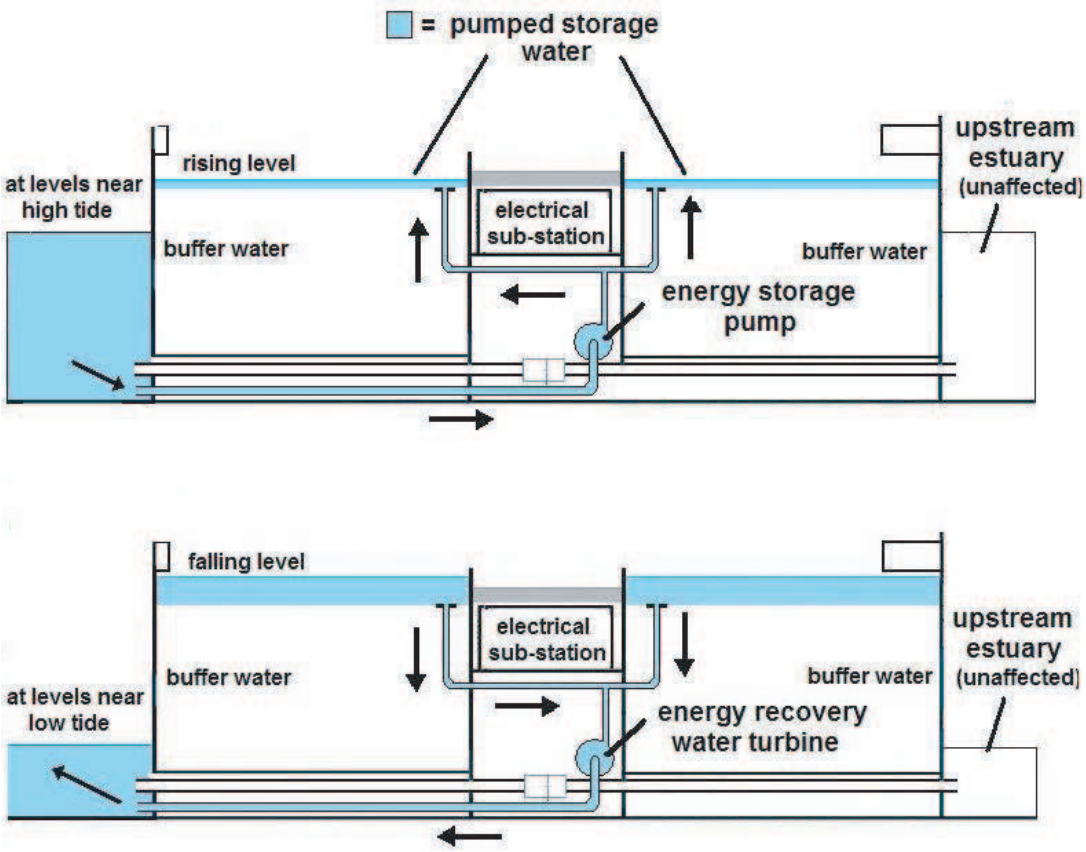
Collision with wall	Shortly after collision	
		
Vertical lift : 2 degrees	Vertical lift : 10 degrees	Vertical lift : 12 degrees
		
Horizontal rotation : 10 degrees	Horizontal rotation : 40 degrees	Horizontal rotation : 70 degrees

Fig. 8

PUMPED STORAGE UTILISING THE BUFFER WATER PONDS



3.4 *Pumped storage—A "not-to-be-missed" economic benefit*

Buffer ponds are necessary to mitigate the consequences of a ship colliding with the barrage. The ponds provide a golden opportunity to add, at minimal capital cost, a substantial pumped-storage facility. The security requirement is for the pond height never to be less than a fixed amount above the high tide annual maximum provides a particularly advantageous base from which to achieve this. This minimum pond height is shown as 5m in Fig.6.

Storing water on top of the buffer minimum requirement produces the possibility of generating significant amounts of electrical power at times in the diurnal cycle when tidal power generation from the main water turbines is not possible. The very substantial tidal range particular to the Severn estuary make this possible. It is achieved, as shown in Fig.7, by pumping up to the buffer pond at high tide and recovering the stored energy at low tide. The total pond area above twelve machinery halls is approximately one million square metres. With an average annual tidal range approaching 10m pumped storage more than pays for providing the buffer ponds, an essential security feature.

Construction Timetable

The reference design includes twelve 1,000 m long machinery halls. The power generated by each will differ according to the opportunities afforded by the various local estuary depths and currents. However, the "double line" defence security requirement together with the provision of electrically independent sub-stations means that a significant amount of electrical power can be supplied to the National Grid at the end of Year 6. As more Machinery Halls are completed the amount generated will increase progressively. Aided by the triple access-way design the project could be completed in 15 years.

Project Years 1 & 2

Site clearance; finalise detail design; order hardware.

Project Years 3 & 4

Construct the shore piers.
Construct the 28m ship lock and gates.
Construct the 54m channel and install the two bascules.

Project Years 3 to 5

Complete construction of the upstream barrier wall (the buffer pond wall) for the full width of the estuary together with the ten 3m wide marine life transit channels.

Project Year 5

Construct upstream service road across the estuary (Fig.3 & Fig.4a).
Except for construction of remaining machinery halls complete all other major civil engineering works.

Project Year 6

Commission Machinery Halls between the coast and the 28m ship lock.
Commission the Machinery Hall adjacent to the 54m bascule channel.
Commence the limited generation of electricity for the National Grid.

Note : Activities completed by Year 6 end enable :-

(i) marine life to commence transit using all planned routes through the barrage
(ii) shipping to use 54m bascule channel or 28m ship lock (as appropriate)
(iii) a limited amount of electricity to be transmitted to the National Grid

Project Years 7 to 15

Construct and progressively commission remaining Machinery Halls.

Project Year 15

Commence full capability generation of electricity for the National Grid.
Completion of the project.

APPENDIX A

A PUBLIC ACCESS BRIDGE OVER THE BARRAGE—AN UNACCEPTABLE SIMPLE AND EASY OPPORTUNITY FOR A TERRORIST

It is generally agreed that a breach in the barrage that releases the stored energy during a significant tidal difference always leads to catastrophic damage. Estuary currents through the breach quickly erode the sea bed—even where this is concrete—making repair work very, very difficult and time consuming. Following such a breach the claimed 5% of National Grid power generation would be unavailable for a considerable period.

A public road bridge very obviously provides a means for terrorists to simply and efficiently deliver long term destruction to the power generating capability of the Severn Barrage. At a time of their choosing explosives (bombs or depth charges) can be dropped/ejected from lorries on the bridge—day or night; clear or foggy weather; placid sea or storm force Atlantic generated waves. Lorries with high-lift cranes or conveyor arrangements capable of delivering explosives to previously selected locations are in everyday use by builders merchants. The 10 plus miles length of barrage below the bridge carriageway is indefensible from this threat. To make matters worse, the high level of the bridge carriageway makes unplanned detonations below the bridge of little risk to those carrying out this activity so ensuring a full load can always be delivered.

It is clear that a public road bridge above a Severn Barrage is totally unacceptable.

The generation of power by a barrage does not require a bridge.

There is an alternative *IF* a bridge across the River Severn really is needed. Put it upstream from the Lavernock Point/Brean Down barrage as shown in Fig.A1.

Assuming a Severn bridge from Cardiff to North Somerset is really needed then it makes more sense to have one that directly serves the docklands and industrial districts that are to the east of Cardiff. I suggest consideration be given to a Tremorfa—Sand Point bridge. This is some four miles upstream of the proposed Severn Barrage site. At a stroke the real terrorist threat to the Severn Barrage is removed.

A bridge between Tremorfa and Sand Point would require less than one kilometre of new road infrastructure and about half a kilometre of new rail infrastructure on the Welsh shore. Fig.A1 shows in more detail the potential site access from the M4/A48(M) and from the Cardiff to London & Midlands rail line. This is a very significant saving compared to the recent Lavernock/Brean proposal. The Somerset shore connection to the M5, at 2.5 kilometre, would also be slightly less than a Brean Down alternative.

An upstream bridge might seem to pose an additional hazard to wildlife in the Site of Special Scientific Interest (SSSI) along to shoreline near Tremorfa. Such an assessment is false. An anchorage point well inland to first bridge pier easily spans the protected area.

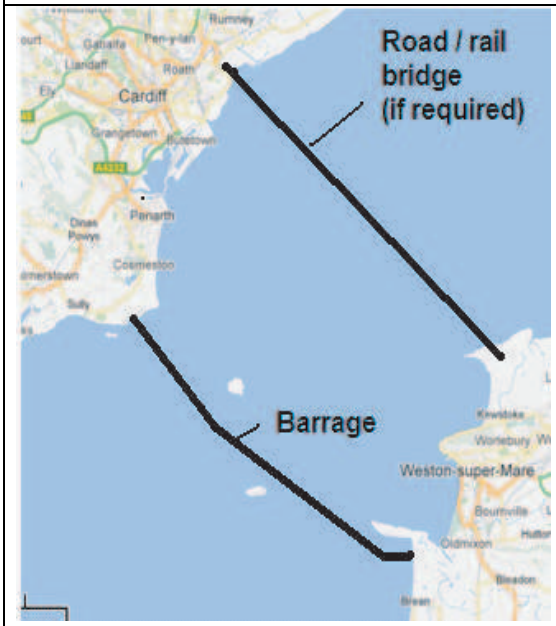
The presence of bridge piers at points across the estuary might also seem to present a hazard to shipping. The difficulties in estuary navigation for shipping are increased but only marginally. There are already times when visual observation by ships in the estuary is very difficult or impossible. Estuary fogs are the worst example. Finding the narrow "window" of passages for shipping to pass through already imposes a need for extreme vigilance in poor weather and sea conditions. Avoiding widely spaced "mid-stream" piers of an upstream bridge that are outside designated shipping channels adds only marginally to this difficulty.

Fig. A1

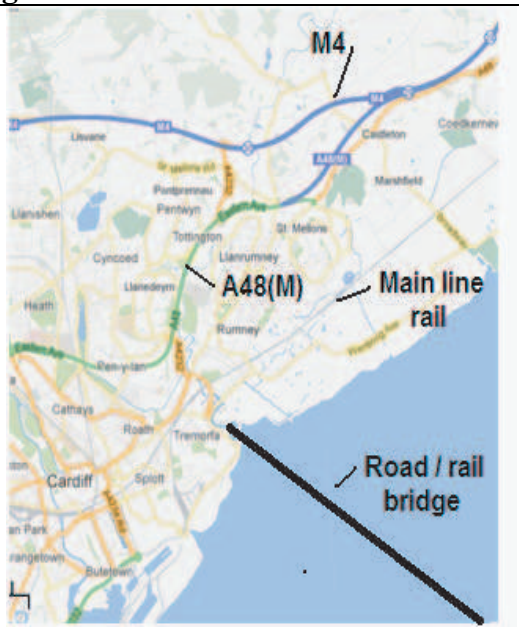
A POTENTIALLY MORE APPROPRIATE SITE FOR A PUBLIC TRANSPORT BRIDGE

IF a road or rail bridge is needed

Four miles upstream is a better location for a public road and/or rail bridge



1. An overview



2. Existing road & rail infrastructure (M4 and Cardiff - London & Midlands rail lines)

3. Proximity to Cardiff docks and industrial area

4. Local access

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