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Energy and Climate Change Committee

Building New Nuclear: the challenges ahead

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Additional written evidence

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The Energy and Climate Change Committee

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List of additional written evidence

(published in Volume II on the Committee's website www.parliament.uk/ecc)

Written evidence

Written evidence submitted by Brian Catt (NUC 32)

Thanks for a generally very direct and sometimes probing session on New Nuclear today. It seems energy policy is getting a more rational focus now the inevitable physical undeliverabilities and avoidable expense of subsidising the wrong modalities by law are manifesting themselves.

There were specific points made today that lacked either some essential logic or a proper wrap up, which I address summarily by numbers below. Before that:

I write to highlight that important assertions crucial to this debate and energy policy as currently practised, that are presented as fact or a legal imperative we must follow by witnesses, in this and other select committees on energy policy, are either simply unsupportable in fact, based on old data, or misrepresent the scientific principles or the data in a partial way for gain, rather than present the objective truth for the greater public prosperity.

Energy use ifs 1:1 proportional to GDP and hence everything the country does. Our future prosperity depends on generating more, cheap, electricity, not less expensive.

Only a nuclear approach can deliver this at whatever level we require long term to be a truly substantive alternative to fossil energy, without generator subsidies. Current policy is increasingly, avoidably, and very expensively, placing the UK's economic future in jeopardy, in absolute and competitive terms.

This discussion deserves the ruthless application of objective science and economics replaces EC ideology, enacted as undeliverable policy for lobbyist profit. Call that what you like, it can only ever cost the UK to eventually fail on the physics. Our nation's future prosperity must exclude the politics, aside from the rate at which we spend on the best solution, and we should certainly stop marching our energy future and disposable incomes off a cliff on the orders of unelected foreign legislators and their lobbyists, based on a set of self-evidently false assertions, anyone can disprove with AS physics, DUKES data and a scientific calculator. Such a vital committee should all be able to do this for themselves.

None of these directives can deliver the core objectives of energy policy in the UK. On the evidence they are predictably and expensively failing in Germany as physics meets ideology—there is only ever one winner in this contest. Bio fuels do the opposite—double the cost and more CO_2 than coal even, etc.

We have the technology to get it right, in fact do it best, without any subsidies. So let's do nuclear (and gas) well, and not self harm our energy supply on an undeliverable energy fantasy like Germany and Denmark, especially when Island UK has no "Get Out of Jail Expensively" Euro Grid card, and shouldn't need one.

Most EC countries have no "energy security" and are utterly interdependent. Apart from France on 80% nuclear and 20% hydro, of course.

While energy policy is under review I strongly suggest the committee call the DECC's Chief Scientific Advisor Prof David MacKay to give evidence on the particular areas of intensity, adequacy, controllability and sustainability which he has written on extensively (iv), and ask him about the capabilities of the "alternative" modalities the law current law massively subsidises to deliver these objectives, in particular whether preferred "alternatives" are the best way to deliver our future electrical energy needs of adequate, affordable, controllable, sustainable, secure or even zero carbon generation at the levels that we will require in future, and what part nuclear should play in this long term.

Based on a study of MacKay's work, and that of many other independent experts, including Prof Colin McInnes (v) and his useful references Ausubel (i) , Marchetti(ii) and Smil (iii), it is clear and simple to demonstrate that none of our policy objectives can be met by prescribed alternatives in full, and should not be met in part by them when they are avoidably expensive, inadequate for the job and obsolete without fossil backup—which also denies the claims of energy security made for them.

I can demonstrate, as can Prof MacKay, that subsidy preferred alternatives aren't adequate, affordable, controllable, sustainable, secure or even zero carbon. Not alternative to fossil at the level required, in fact, and cannot be for the reasons of intensity and variability alone. The energy source is renewable, yes, but not the generation which is massively expensive through weakness of its source and fossil dependent through both variability and inadequacy in any realistic deployment.

In reality, and uniquely, only nuclear technology can deliver all these objectives after fossil. We can even make nuclear power by far the most sustainable and renewable modality by using transmutation to create new fuel and minimise high level waste, we are now nuclear alchemists. I suggest the most important technology of the late 21st and 22nd Century will be nuclear processing, using both fission and fusion fast neutron sources as we approach sustainable fusion power—ignition.

We can go there, or back to the Third World.

And it can all be much easier than it appeared in committee to make the next set of nuclear choices well, if our elected representatives take good INDEPENDENT advice, ask the right questions with advice from independent experts, and lead this process with generators, rather than being led by generators and lobbyist law enacted as EC directives and political dogma.

General Observation on The Realities of Electrical Generation in a Developed Economy with Nuclear Emphasis:

Over a century we developed the most efficient electricity generation and distribution system by maximising the use of controllable intense energy sources, consolidated at the core of a grid distribution system to match variable demand across the grid in real time. This has proven to be the most cost effective way to operate an electricity system on a national scale. Nuclear can simply carry that forward, using the existing infrastructure and its more intense energy source when fossil has gone. Gas can fill gaps while reducing carbon emissions, CCGT is very compact, intense, clean, 60% thermally efficient and can be built inside major coal fired facilities, as with Didcot A and B. CCGT gas at Didcot B occupies 10% of the old coal fired site alongside A and no cooling towers are required. It will fit on cleared former coal fired sites on the grid. Nothing else is intense enough to do the same job—except coal, or Bio Fuel at twice the price and NO carbon reduction under current subsidy law. Another nonsense, care of energy policy.

Aside from Biofuels it is a physical and economic nonsense to prefer subsidising the aggregation of thousands of historically failed, inherently weak, uncontrollable, diffuse and directly fossil dependent energy sources, distributed around the extremities of a yet to be massively and avoidably expanded grid, when nuclear and gas can deliver decarbonisation fastest from the most adequate, affordable, sustainable nuclear and gas technologies, on a simply beefed up version of today's grid.

As for Bio Fuelling—it is irrational to support a policy that encourages the burning of "Bio fuel" in old coal fired stations at twice the price to the grid and produces more CO_2 than coal on environmental or economic grounds, when we could have unsubsidised CCGT gas at half the CO_2 and the same price as coal? How eco is that?

In the case of DRAX at a cost to bill payers of £1B pa for its life burning American wood pellets. Why not just carry on burning coal while replacing the capacity with clean unsubsidised gas at half the CO_2 as planned at Didcot B. Answer? = easy money by lobbyist law, nothing to do with environment or climate change, at all. This is the stark reality of energy policy for maximum profit by law.

Utterly irresponsible, in a recession when Health, social services and policing are being cut that could easily be paid for with just some of the Billions already lost annually to the economy by EC energy directives.

CONCLUSION: Generator lobbyists cannot be trusted, nor their EC bureaucrat regulator colleagues. Before any decision is made we need to, and have time to, study the nuclear alternatives from France, the US and China. Our entire policy and its subsidy regime remains based in a quantitatively delusional ideology that ignores the core energy physics and economics, and simply can't deliver the double then treble electrical energy needed to power a developed economic future for the UK when fossil has gone. Ask some real scientists and energy professionals who don't work for the lobbyists or their proxies.

FOR ALL THE REASONS ABOVE DOING NEW NUCLEAR BEST IS A STRATEGIC IMPERATIVE FOR THE UK'S ECONOMIC SURVIVAL, so:

To today's nuclear points:

1. *The UK don't need to risk a nuclear design experiment from AREVA at a monopolist's price. Someone else the DECC are in close contact with is already doing the proof of concept of AP 1000 and also creating their own clone, the CP 1400*

Building proven passively safe high burn Westinghouse AP 1000s based on Chinese experience with their current four at a time in four year's build would avoid the inevitable cost overruns of avoidable experiments at the UK's expense. Buying un Cochon dans une Poke is another attempt at a self harming energy policy and an avoidable mistake. Just because we need to do in due course it doesn't mean at any price the generators demand on the assurance it will work, the mistake already made and being learnt with wind that can't.

GET ANOTHER QUOTE?—also forget fiscal price manipulation and offer loan guarantees for all as in 2 below.

It's Mrs T's Sizewell B risk reduction approach. Build what works.

If it takes time then use CCGT gas to decarbonise by coal replacement instead, and wait for the best nuclear design to emerge by tendering for longer?

Tell EDF we may require them or another to put CCGT gas on somewhere else for now while we seek other bids ... can they come back when the plant is better characterised? All should be equal in our eyes, etc. Reduce the nuclear build capital cost and payback time fiscal problem's for generator's bankers as in 2 below and get some more bidders, surely bankers will be drawn by the smell of a small percentage of a great deal of money from an ocean or even two oceans away.?

2. *Strike price is as pre-failed as ROC subsidies on tariffs that reward prescriptive solutions regardless of viability*

WE NEED BETTER FISCAL INTERVENTION THAT IS NOT SUBSIDY AND SUPPORTS WHAT IS BEST FOR US LONG TERM, NOT THEM.

The whole approach of subsidies for tariffs is economically flawed and generator led for easy profit by law. Government should not be in the business of picking winners for life, which the current law has done and failed at as above, to create massive economic waste meeting none of the objectives claimed for it, because of the fiscal intervention approach chosen, changing the laws of physics by parliamentary act or even with money will always fail.

Government should make it possible for the most efficient and cost effective carbon reducing technologies with minimum grid impact to win in an open market, by removing the problems of scale and payback time financiers don't like so the best overall Internal Rate of Return—IRR—will be preferred regardless of front end CAPEX loading or payback period.

Again this is not hard IF it reflects rational economics and comprehends the physical delivery problems. Guaranteeing and even funding CAPEX bank loans using negotiable coupon bearing bond funding (profitable QE opportunity?) that can be repaid from tariffs on supply is NOT a subsidy—if public and private investors get a commercial return.

It's only a subsidy if not repaid, we need to ensure it can be, perhaps with a worst case floor price of £60 or so to the grid for zero carbon generation? I don't really believe in carbon pricing either, politicians distorting the market with ideological subsidies for populist votes based on still unsubstantiated hypotheses is also daft.

eg, anything more that £60/MWh is competitively decided by the energy market so people build winners for us on the science and economics, not the subsidies.

It's a very small risk this can't succeed from what will be guaranteed oligopolist tariff revenues—saving a catastrophic failure*.

NB: *by which I mean operational failure, modern designs with containment have never had an accident that killed anyone directly or indirectly. Just trashed the core. Next Gen nuclear is built to even better designed to both prevent and withstand that. With our environment and regulatory regime such an accident has never happened in Western Europe in 50 years—operating much less well known technology in the beginning. That's the only clear but very small risk.

Finally Transactional Analysis tells us it takes a State sized backer to guarantee a State sized risk. That can give the required confidence, not messing with ROCs. A hands-off state scale PFI approach is not even a prudent option for core infrastructure—see Railtrack, etc. And this approach needn't cost the taxpayer a penny and reduces bureaucracy and avoidable and unknowing political interference.

3. *Strategic emphasis and low carbon sustainability*

What Sir Bernard didn't say was it is not in our long term national interests to build gas as an easy (half the carbon) climate change based fix then used as an excuse not to build more difficult to sell to the public long term, affordable, sustainable, zero carbon nuclear—all there is for us when fossil fuel is economically ended. Putting off the inevitable to the next government has been the story of energy policy.

Sustainability well beyond the next ice age is deliverable from new nuclear fuel cycles and also there is plenty more Uranium in the sea at c.$150/pound, three times the mined extraction cost and around 5% of the overall operating cost when the glaciers melt again in another 100,000 years, if there is anyone around interested in extracting it then. We could even leave them some fuel from our surplus in a safe place for when they regain the technology to detect and use it.

Waste is reduced and renewability increased by new fuel cycles, and Fast Neutron transmutation can even make longer lived fission products into something shorter lived and safer as well as regenerating spent fuel. We can become 110% sustainable in nuclear fuel.

KEY POINT: All the nuclear "problems" have technological solutions MUCH less costly than alternative energy solutions that literally aren't.

4. *Nuclear backup for wind farms?*

Why would you power a zero carbon lowest cost nuclear plant up and down to accommodate the output of a MUCH more expensively subsidised and unpredictably variable source? Who said that?

5. *The mix*

The assertion that we need a mix including weak uncontrollable alternatives was again made. Where is the logic in preferring to subsidise expensive unreliable energy when the same investment can generate more energy cheaper and more reliably? Not an economic concept I am familiar with. Only irresponsible profit supports this idea.

Gas replacing coal can meet emissions targets better than "renewables" without CCS till nuclear is deployed—to the 25% CO_2 reduction level if required. No alternatives required.

Wind farms demand that we keep 100% base load (fossil) capacity operational to support their "alternative" output when they aren't producing—for their whole lives. The less we build the more fossil coal and its emissions we can shut down in favour of gas and nuclear and the less we pay in avoidable subsidy for wind.

Why do we need ANY expensive and highly variable duplicative wind farms that are not truly alternative to anything PLUS the massive avoidable cost to the grid of any buffer storage and the environmental vandalism of our country to no true purpose? The faster and better we build nuclear the less of this pain we will suffer.

6. *Westinghouse*

Maybe we should buy the Toshiba share in Westinghouse (which we used to own, I think) while its cheap—before fossil does get seriously expensive? The leading economies of the next world order will all be nuclear powered, and supplying the lesser ones nuclear power, after exhausting the fossil to get there, they won't be wind powered. Energy use is directly proportional to GDP. More is more. We can be a part of this IF we declare energy UDI from the EC and get on with what works (and decarbonises best and cheapest BTW).

7. *Strike price again*

In the late Dave Allen's words, WHAT'S DAT!

I think you were close to, and Sir Bernard nearly said, the idea that it's a really bad idea for consumers for government to artificially make Nuclear as expensive as wind power so as to bribe generators with easy profits to build it, as was done with wind power.

Levelling the tariff playing field by filling it with our money to the highest level is really mad economics. Been there, done that already, with "alternatives". The only outcome for the consumer from such ideologically justified fiscal market distortion is energy poverty that enriches only generators.

We should be levelling the playing field with an aggressive roller to flatten out the bumps to the lowest achievable level. Marginal cost of production concept, etc.

All tariff based subsidies—something currently awarded for life for less value in return—are essentially economically unsound, and work against building what delivers the most adequate, affordable, sustainable electricity for the people of the UK.

We have a better choice, the gas then nuclear with no alternatives route, which is also the very obvious, quickest and cheapest route to decarbonisation that prescribed alternatives expensively drag on. The simple maths is easy to do. The massive burden of fossil dependent ROCs getting two or three times their worth for nothing back, ever, is self evident.

Thanks for getting this far, that was about the symptoms of existing energy policy you were dealing with—the rest is about the fundamental physics and economics.

I am a retired, independent and experienced professional physicist, engineer and businessman. I have studied the energy topic for four years, and the writings of independent academics including the current DECC Chief Scientist David MacKay.

It became clear to me current energy law is supporting so called alternatives that in fact are of such low energy intensity and high variability they are physically incapable of being alternative to fossil on their own. A clear technical dichotomy. Then I found academic thinkers had known this for years and been ignored by politicians and civil servants when the laws were made, because private profit at public expense became the driving force behind the legislation.

Alternatives as politically blessed can meet none of the policy criteria claimed for them of producing adequate, affordable, sustainable electrical energy, and are in fact subsidised to deliver the opposite on each of these criteria—with almost zero carbon reduction taken as a system with the essential fossil backup they depend on. Its a 100% deception.

Only intense nuclear energy, at > 10,000 times the energy density of exhausting fossil energy, can power a developed UK economy affordably into the future and competitively into the future when fossil is economically exhausted.

We will need twice as much electrical energy by 2050 and three times by 2100 to replace its use in transport and heating, not a bit less expensively rationed—per DECC and others. Rationing and conservation arguments conveniently ignore this massive and absolute reality.

To survive as a developing economy we need to harness ever more concentrated sources of affordable power. Not the, weak, variable sources we gave up at the industrial revolution.

Prof Colin McInnes is very succinct on this (v), also his reference Marchetti (ii) on decarbonisation and intensity in case you are unaware of this crucial point and its inevitability, a point also made by Jim Al-Khalili when wrapping up last week's BBC Big Science programme. Intense, adequate, controllable, affordable electrical energy is non-negotiable to remain a developed economy when fossil has gone. The simple question is how to reach this position most affordably while decarbonising?

I submit, purely on the physics and economics, that nuclear energy is the only long term solution, and CCGT gas offers a terrific interim "get out of jail affordably card" to take our time to implement the best nuclear generation, most affordably and predictably for the UK economy.

All of the above can be fully supported as required using DECC reports and DUKES and Platt's data to which I can also direct members, and by myself in person. I have covered core related issues in the summary Addenda below.

ADDENDUM A

THE ELEPHANT IN THE ROOM—RADIOACTIVITY

My experience includes seven years as a Radiation Protection Physicist at the RPS and NRPB. I have no concerns regarding the safe management of radiation in the UK, having done it for a job for seven years as well as seven years in medical imaging at EMI and GE. Further I am now aware of the science on low level radiation hazards, which is not what the now obsolete regulations assumed decades ago. We are naturally radioactive and live on a radioactive planet, eat radioactive bananas and nuts and absorb more radiation voluntarily for medical purpose than any other single source. The clear result of the research since the LNT hypothesis was suggested before low level data was tested and used to set "safe" levels without any corroborating evidence IS that there is a clear threshold at a high level relative to current limits, probably a hormetic dose level below which we get more cancer. It's to do with the effectiveness of the immune system to deal with the 10,000 mutant cells we naturally produce per day. No one will die from radiation related illness at Fukushima, where primary containment worked as designed and Iodine was issued to the population as necessary as a largely preventative measure. Only 50 short term and less that 10 longer term related deaths resulted from the uncontained core dispersal with no Iodine treatment for the population at Chernobyl. Thousands are still not dieing as the extremists claim 30 years on. The death print from coal is massively bigger, from extraction industry accidents and early death in the general population from health related effects. Nuclear is a clear winner on health and safety grounds over all other modalities. It seems that in energy policy, every reality is alternative. Prof Wade Allison, an Oxford Radiobiologist is a useful independent expert on this subject, there are many others. The work of Prof Bernard Cohen in the US led to the better dissemination of this work into the public domain. His '97 seminar is even on You Tube.

ADDENDUM B

"THE CHALLENGE(S) WE FACE"

The challenge the UK faces face is ipso facto not global climate change, which arises from fossil burning fossil the little UK can barely affect at 2% of the total. It is, rather, our ability to continue as a developed economy when the other countries have burnt it all.

- — Defence of the realm depends on defence of the economy and GDP is 1:1 dependent on energy use.
- — We need more, cheap, adequate, and controllable electrical energy, sustainable and zero carbon would be good. No "renewables" can deliver this under current energy policy and its subsidies.

Blair and Brown authorised the new nuclear and gas builds that could deliver while Ed Milliband was pontificating about alternatives that can't at the new DECC bureaucracy. If only DECC public utterances had any relationship to their excellent data. "Opposing wind farms is anti social" was one such, thus accusing every honest, rational and concerned scientifically literate individual who had tested the alternative data and found it unproven of being anti-social—on a subject he clearly still doesn't understand, by formation or utterance. I shall draw a discrete veil over the dreadful Chris Huhne, preferably quite tightly. An awful person, a hectoring spokesman for something he was unqualified to and clearly didn't understand. We need better leaders of greater wisdom, substance, objectivity, understanding and probity than any we have had to date deciding the future of our the national infrastructure that is increasingly becoming the major source of power enabling our continuation as a technological society.

- — To get this right energy policy must be a responsibility above party politics, or the irrational belief systems that currently direct it.
- — The physics and economics of what can actually work must now take precedence over undeliverable ideology in Energy policy, long term for our children's future and short term our fixed income/poorer pensioners standard of living.
- — The nation can't afford and should end the subsidy regimes, and meet our policy goals with unsubsidised modalities, which it can more easily do in fact.

Nuclear is the most crucial part of this long term, the only capable alternative we have left when fossil is gone.

CCGT Gas can also do a lot to decarbonise and facilitate a well managed transition from coal to gas to nuclear, on existing or vacated coal sites, we don't have to be told what EDF will charge us as some quasi monopolist, we should be picking the best amongst offers after careful independent scrutiny of costed tenders.

- — Generators have already exploited politicians belief in their ability to change the laws of physics by law for too long, through the excessive subsidy profits they demanded to support technologies that can never deliver any of the benefits claimed for them, as with wind power, or simply double consumer prices for the same energy from the same power station while increasing CO_2 emissions to burn foreign "BioFuel" instead of coal.
- — The practice of Energy law and pricing being dictated to UK government by lobbyist generators and equipment makers exploiting EC Directives for undeserved profit by law must end, and new policy enacted that is driven by our elected representatives to best meet our goals at the best long term value to UK consumers.

The cost of EC energy law and its subsidies is now well past £1 billion per annum for 25 years and growing fast, for nothing back. DRAX Biofuelling will double that at a stroke—"recarbonising for profit" should be their slogan. Avoidably mad and bad, by legislation that this committee is accepting as its terms of reference/ game space.

- — The required solution is only affordably deliverable by climbing out of the EC Energy Directives box at the European Court, as the Poles already did.

  nb: Merkel is solving her absolutely topsy turvy ideology driven energy policy problem by building coal fired generation massively. A Trillion Euros of PV solar and wind as available doesn't hack it—no nuclear, so...
- — We currently seem to agree we need sustainable decarbonisation AND two times the electrical energy supply by 2050, three times by 2100 (DECC and others).
- — We can get that from gas and then pervasive nuclear. NOT from political alternatives that do nothing to replace fossil energy for their 100 and 200% subsidies, and little to reduce emissions that are their claimed justification.

On the physics and economics nuclear is the only and inevitable long term energy source for electrical generation, the only source capable of replacing fossil generation at the levels that will be required, or, practically, even today's 330TWh. So we had better get the gas and nuclear mix right as its all there is in the end. (iv), (v)

Enough challenges?

ADDENDUM C

JOINED UP WIND POWER REALITIES

The wind is free and sustainable—Energy generated from wind is not.

As an energy source wind power is:

- — weak, not intense enough to ever be realistically alternative to fossil generation to power a developed economy (i), (ii), (iii), (iv);
- — expensive because of the huge resources required to collect enough weak wind energy in remote location and support its variability;
- — Not there when needed—catastrophically variable with the CUBE of wind speed, so its 12.5% the output at half wind speed, dependent on 100% fossil backup, increasingly from foreign countries, and obsolete without it, so:
  - — prolongs fossil emissions of its backup;
  - — unsustainable without it; and
  - — insecure by dependence on foreign fossil.

In practical reality wind generation is parasitic on its majority fossil host, and can only deliver 20–30% of its fossil back up's combined output by shutting down the 50% or 66% cheaper fossil host when the wind happens to be blowing, while barely reducing emissions.

- — Alternative reality is again the opposite of the justification. Its really for profit, and isn't a genuine economically viable or sustainable alternative to fossil generation at all. A fortiore wave and solar.

PUMPED STORAGE ADDS THE COST OF HYDRO TO WIND: It doesn't "store" electrical energy, nor create any. Unusable wind energy is used to pump water uphill to store as gravitational potential energy, which is then used to regenerate the electricity. So it adds the cost of hydro regeneration to the two or three times the price to grid that wind power currently is by ROCs, by bad energy law.

Ask a witness or the DECC how much the existing Pumped storage schemes cost per MWh.... that's on top of the primary generation cost. They are very coy on this.

So that's three and four times today's unsubsidised prices for stored wind energy we don't need. Also we don't want, or even have, many new sites for new hydro schemes on the scale required.

You can have proven nuclear on existing core grid infrastructure locations and rights of way going 24/7 at not much more than today's prices indefinitely, done well. Why pay three or four times more, for less in remote locations as yet not even expensively connected?

Can we please drop the politics and ideology and get on with the only electrical energy generation that can deliver the UK an economically developed future? As an Island with diminishing fossil reserves and nuclear capability we need and should have it sooner than many, just not so fast we compromise the best solution for political expediency, or from generator and lobbyist pressure, however manifested.

Generators and equipment makers will follow our money and build what we pay for, the jobs will move to the chosen solution whatever it is.

The UK nation state must lead and control its energy destiny, rationally.

Thanks if you got this far.

References

(i) Ausubel http://phe.rockefeller.edu/docs/HeresiesFinal.pdf on energy heresies

(ii) Caesare Marchetti on the Decarbonisation of The Energy Supply http://www.cesaremarchetti.org/archive/electronic/ir-decarb.pdf who uncovered these trends back in the 1980s—predicting the rise of methane (and later nuclear) as the next global fuel of choice.

(iii) Smil comes to broadly similar intensity based conclusions http://www.vaclavsmil.com/wp-content/uploads/docs/smil-article-power-density-primer.pdf.

These three authors are independent thinkers, well ahead of their time, applying the absolute energy physics and other science, with no particular axe to grind.

(iv) David MackKay Sustainable Energy—without the hot air Synopsis: http://www.withouthotair.com/Synopsis.html

(v) Prof Colin McInnes on Intensity, probably the most direct and self evident truths on energy generation accessible without any science formation that you can read from an academic polymath. http://www.ingenia.org.uk/ingenia/articles.aspx?index=740

November 2012

Written evidence submitted by David Thorpe (NUC 29)

I wonder if it is possible for me to offer the following input into the above enquiry. I am offering this because I don't think that there has been sufficient emphasis put upon this aspect of the subject, which is to say the creation of new nuclear waste.

My contention is that it would be morally wrong to approve the construction of any further nuclear power stations in this country, until a lasting solution of what to do with all present and future nuclear waste is found. I set out my argument below.

Currently all of Britain's high-level waste is stored above ground in cooling ponds at Sellafield, and looking after it, and other nuclear waste, consumes over 60% of the Department for Energy and Climate Change's budget, or £1.69 billion a year, a figure that is proportionally rising.

The communities of Sellafield, Copeland and Allerdale are the only ones in the running to host the burial of this waste. Yet they are understandably having cold feet because they are being advised that the geology is not suitable.

The area had already been ruled out as a safe site by Nirex, now the Nuclear Decommissioning Authority, in a comprehensive geological survey conducted in the 1990s. This is because of the presence of deep faults and fractures in the underlying geological structure, and underground water flows which could transport dangerous levels of radioactivity out into the environment.

Nevertheless, the Managing Radioactive Wastes Safety Partnership (MRWS), which was set up by the Labour government with the task of re-evaluating its geology, ignored the Nirex study and produced a document, "Initial Geological Unsuitability Screening" in 2008 which identified an area of 23 square kilometres which might be a candidate. This was commissioned from the British Geological Survey with a much narrower scope.

David Smythe, Emeritus Professor of geophysics at Glasgow University, has said that "by proceeding to stage 4 (a desk-based study) in West Cumbria, despite the evidently insuperable difficulties of geology and hydrogeology, the NDA and the local authorities may run the risk of legal challenge".

David Smythe is supported in his assessment that MRWS' survey is woefully inadequate, by several other leading academics, including Colin Knight and Chris McDonald, who were the technical assessor and lead inspector at the original Nirex enquiry.

A former member of CoRWM, Professor Andy Blowers also agrees. Even the International Atomic Energy Authority considers that West Cumbria is an unsuitable site.

MRWS' own Dr Jeremy Dearlove, has attempted to argue that the area has "potentially suitable sedimentary formations".

But his argument has been torn to pieces by David Smythe, who accuses him of using debating tactics and disregarding international guidelines. [http://www.nuclearwasteadvisory.co.uk/docs/scientific-docs/prof-smythes-response-to-dr-dearlove]

Prof. Smythe also accuses the Nuclear Decommissioning Authority of "airbrushing out the history" of the previous attempt to find a nuclear waste repository in West Cumbria, by removing from its website the vast bulk of Nirex documents. He has placed them instead on his own website [http://www.davidsmythe.org/nuclear/nuclear.htm].

Cumbria is exceptionally well understood region geologically, he says, and it is quite obvious that it is unsuitable to be used as a dump.

The principle of choosing the location for a site is, admirably, that a community must willingly volunteer. A dump cannot be imposed on a community that does not want one.

Logically, therefore, it seems that nowhere in the country is there a place that is both geologically suitable and where the people are unequivocally in favour of hosting a dump.

We are stuck with the status quo, until a new way of dealing with nuclear waste is found, perhaps with another generation of power stations that can use this waste as a fuel source and render it harmless.

Until science comes up with such a solution, the safest option is to continue storing it overground, at Sellafield, where at least it can be monitored.

Meanwhile, it would be morally wrong to approve the construction of any further nuclear power stations in this country, until a lasting solution of what to do with all present and future nuclear waste is found.

October 2012

Written evidence submitted by Dr James Lawton (NUC 06)

Former Positions held with National Power:

Director of Research;

Director of Corporate Planning; and

Director of Trading on the Electricity Pool.

Executive Summary

Considerable progress has been made in devising contracts for electricity generators. However there has not been the same focus on ensuring that we develop the least cost Power System (Generation and Transmission). The economic advantage of using nuclear power to provide all base load electricity needs to be acknowledged and its ability to operate flexibly needs to be taken into account. This memorandum highlights steps that would speed up investment in nuclear and ensure that the most cost-effective use is made of it. A procedure is proposed that would identify the most economically viable solution to CO_2 abatement and set it within the context of the UK's international competitiveness:

- EdF's monopoly of sites restricts investment opportunities and stifles competition and needs to be broken.
- Competitive tendering is needed to keep pressure on prices and provide insurance against construction delays (EdF's automatic purchase from Areva is unacceptable).
- All generators seeking a guaranteed return on new investment should be required to go to international tender for their plant.

— There is an urgent need to adopt a method for identifying the least cost option for the ongoing development of the Power System.

— Once the details of a strike price and capacity payments are settled, investment in the UK's Power System will be a copper bottomed investment opportunity, which HMG should set in motion through a PPI investment at Wylfa.

1. Introduction

DECC has made significant progress in identifying possible structures for a contract market for electricity that will give confidence to long term investors in electricity generation. However, there is no parallel activity reporting to DECC to provide a rolling plan for developing the Power System with the mix of generation technologies that will produce electricity at the least cost while meeting environmental constraints. Plunging forward with huge long term financial commitments without an answer to this question would be financial irresponsibility on a massive scale.

These issues are addressed under four headings:

— Nuclear Options.

— Competition amongst Nuclear Providers.

— Economic Optimisation and Marginal Cost of CO_2 Abatement.

— The Wider Picture.

2. Nuclear Options

(i) At the Select Committee on the 15 May this year Mr Hendry pointed out that nuclear power is our cheapest source of low carbon energy and the representatives of EON and RWE explained that off-shore wind power is the most costly renewable resource in the Bill and currently too costly for wide scale use.

(ii) It follows that it makes economic sense to aim to install at least enough nuclear generation to provide all our base load requirements—currently around 22GW. Historically, base load demand has remained around 50% of average demand and around 33% of maximum demand. If DECC's aim to further flatten the load demand curve is met, the proportion of base load electricity will rise. Thus the opportunity for using nuclear to reduce costs will increase with time. Why is this cost minimising strategy not prioritised in DECC's planning? On the contrary, the only firm objective is the uncosted aim to produce 15% of our electricity from renewables by 2020—most of which would have to come from very expensive off-shore wind.

(iii) True, wind power in all its forms may well drop in price over time. But, the same can be said of nuclear as new suppliers contend in the expanding global market for nuclear plant. Speculation over future plant price levels is irrelevant to decisions about plant purchases to be made in the immediate future, for these only today's tender prices matter.

(iv) The question of future supplies and costs of uranium is a relevant issue which needs to be assessed and fuel acquisition strategies need to be drawn up. Between 2005 and 2007 the world's known reserves increased by 15%, as a result of increased exploration. Ref: WNA (http:/www.world-nuclear.org/info/inf75.html).

(v) In Para 3 of the White Paper "Planning our Electric Future" July 2011 it is stated that that nuclear plant is inflexible. This is wrong. Modern designs can change load at 5%/minute. The French and Germans regularly flex their nuclear units. On 15 August 2009 the output from one of EdF's reactors flexed between 100 and 15% of full load. This has implications for minimising overall generation costs—to be discussed in section 4. See OECD, NEA updates, NEA News 2011, No. 29.2. (http://www.oecd-nea.org/nea-news/2011/29–2/nea-news-29–2-load-following-e.pdf*)*

3. Competition Between Nuclear Generators

(i) There are nine operating nuclear sites in the UK, of which EdF owns eight and RWE owns one at Wylfa. EON owns one retired site at Oldbury. If EdF succeeds in its attempt to purchase Wylfa, it will own eight of the UK's 10, further reinforcing its monopoly of UK nuclear power. The situation is even more worrying because EdF will purchase only Areva's EPR. This is not surprising since EdF is owned 85% and Areva 90% by the French Government. We are in imminent danger of indefinitely perpetuating a market in which we have to buy the bulk of our nuclear electricity at a guaranteed price from a *de facto* nationalised French monopoly buying its equipment from a *de facto* nationalised French nuclear plant manufacturer. As an illustration of the opacity of EdF's business, there is the unexplained hike from £4 billion to £7 billion in the cost of Areva's plant for EdF's Sizewell site. If we let this go on, we are putting ourselves in the hands of monopolies that are accountable ultimately only to a foreign government—despite all the window dressing to make EdF and Areva look like independent private companies. When HMG negotiates with EdF it is in fact negotiating with the Elysee Palace.

(ii) To avoid this unacceptable constraint on HMG's energy planning two conditions need to be met:

— It should be a criterion that, for an investor to receive income guarantees of any kind, it must have sought competitive tenders for the construction of its power stations.

— EdF's monopoly of sites must be ended. There are several ways of doing this. For example, using monopoly laws, EdF could be obliged to sell some of its sites or allow others to build new nuclear plant on them. The actual operators of these plants could be any competent international nuclear utility contracted by the investors. There would need to be grandfathering of agreements for existing plant and for decommissioning, of course. These are just examples. There are many approaches to this.

The importance of going out for competitive tender is further illustrated by the experience of Areva and Westinghouse, see *footnote*.

(iii) Fortunately, HMG is in a strong position to move forward along these lines. On the one hand, EdF needs to extend the life of existing UK nuclear plant to keep revenues flowing. This has become particularly important in view of the negative views of M.Hollande towards nuclear power in France. On the other, we have the prospect of shale gas to fill in any medium term gap in electrical capacity. So, although HMG rightly wants to press ahead with its nuclear programme, its timescales for decision making are less pressing than EdF's. HMG need not blink first. Failure to take these actions will severely compromise the introduction of economically priced nuclear power at the desired rate and with competitive build times.

(iv) Completing the EMR is essential to attracting investment in UK's nuclear power. Once it is in place UK nuclear power will be as secure a long term investment as can be found and its financing cost will reflect this. It makes one wonder why HMG does not set the nuclear investment ball rolling by creating a PPI to develop Wylfa and follow up with further PPI investments in nuclear infrastructure. It would give a tremendous boost to investor confidence and HMG would acquire part of a reliable income stream, all of which could otherwise go abroad. Mr Osborne's suggested special bonds for infrastructure projects could not find a more rewarding opportunity. The Wylfa site is an obvious target for this money, for two reasons. The first has just been described. Another important factor is that Horizon has gone a long way with tender assessment, all of which would be opened to the PPI partners. This information alone would be invaluable in negotiating a strike price for nuclear. One imagines that EON and RWE, through Horizon, would be quite willing to act as operators of any such new nuclear plant.

Footnote

Areva's first EPR is in Finland, Olkiluoto 3. It began construction in August 2005. Initially it was scheduled to go online in 2009. But after many delays, operation is not expected to start before 2014 with a cost escalation from 3.3 billion to 6.4 billion euros. Costs of its Flamanville plant in France rose from 3.7 billion 6.4 billion euros by June 2010 and completion has been pushed back from 2012 to 2016. However, Areva seems to have learned from these debacles. Its plants in China are faring far better and are currently ahead of schedule due to the Chinese working 10 hour shifts seven days a week. Since cost overruns are usually associated with delays in construction one assumes the costs are on or near to budget in China.

Westinghouse is building four PWRs in China. The first plant, which started construction in April 2009, is on time for 2013—ie, four year construction time. The remaining three plants are also on time for 2014 and 2015. Without delays in construction one assumes that these too are running to budget.

4. Economic Optimisation and Marginal Costs of CO_2 Abatement

(i) The problem with costing variable sources of power such as wind is that their presence on the power system requires capital expenditure on underused reliable back up generation. Without this safety net wind power could not make a significant contribution to total electricity demand. In fact, back up generation could equally well be called back-off generation because it has to cut back production, with the attended loss of revenue, whenever the wind generators come into operation. From an economic point of view this loss of income should fall as a charge on the wind turbines for the service provided to them by the backup plant. This means that the usual practice of expressing the cost of wind power in terms of £/MWh without including these charges is economically misleading and should not be used in cost comparisons with other forms of generation.

(ii) The costs that matter to consumers and, therefore, to the economy are those associated with the whole power system. Numbers such as costs in terms of £/MWh for individual plant are not absolutes. They depend upon the plant's utilisation factor. So they are of no use in arriving at the mix of generation plant that provides the required power that meets environmental requirements at minimum total investment and operational costs. To do this it is necessary model the power system as an integrated whole, exploring the effect on total costs of the system of different mixes of generation plant that meet environmental requirements, security and risk of loss of load targets. In this analysis nuclear reactors need to be treated as flexible plant, contrary to what is stated in DECC documentation. With the aid of National Grid, a competent power engineering consultant could undertake this exercise using various scenarios with ranges of such factors as demand curve, plant mix, plant investment and running costs, etc. This is the only way to understand the costs of the various options for investment that will provide power generation and transmission to meet CO_2 targets. For strategic reasons the minimum cost option may not be chosen. But such a decision would have to be justified. This analysis will also provide the marginal cost of each decrement of CO_2 emissions. These are numbers that should be in the public domain. We, who will have to foot the bill, need to know what we are being asked to pay for and that the government is getting us the best value for our money.

5. The Wider Picture

It is clear that the pattern of climate change will be set by the actions of the USA and the big emerging economies, none of which have signed up to any binding targets for CO_2 emission. However, the USA will move in the direction of CO_2 reduction through the increasing use of shale gas. On the other hand, countries like China and India have no option but to increase their use cheap coal fired power stations.

(ii) These powerful players will also set the global competitive economic conditions within which we must earn our living. All major players are expanding their dependence on electricity, in part because of diminishing oil reserves. So the cost of electricity will play an increasing important role in a country's economic viability. Another new feature is the rapid erosion of Europe's and the USA's monopoly of technological expertise. Competition will be fierce on all fronts, not least on the cost of energy to the end user which will increasingly be in the form of electricity.

(iii) We need to be sure that our investment in CO_2 reduction is proportionate to this situation. Whether we have serious disruption from climate change or not it is only the economically viable countries that will be best able to adapt. The procedures outlined in 4(ii) are crucial for developing policies that ensure that the UK stays a viable economic entity.

June 2012

Written evidence submitted by Martin Blaiklock (NUC 05)

1. Commentary

For the last 30 years I have worked as a project finance specialist across all sectors of international infrastructure and energy, including nuclear power. In general, I conclude that:

(a) Of all types of project, nuclear projects are the most complex to implement. Myriads of technical, safety, environmental and regulatory issues have to be satisfied for such projects to be acceptable. Furthermore, the management of the enrichment cycle, waste fuel and plant decommissioning are additional burdens to be overcome. Consequently, nuclear projects are the most difficult to finance.

(b) The nuclear sector is highly introspective. Notwithstanding efforts in recent years post-Cernobyl and Fukishima for there to be greater transparency and public understanding of nuclear issues, personnel working in the sector have for years been immune to outside comment and intervention.

This has resulted in the industry developing, without constraint, larger and larger reactor-types (eg 1,000–1,500MW EPR and AP1000 units), which are commercially and financially inflexible—and possibly, unfinanceable—whereas competition for Base Load generation has become standardised with conventional 300–500MW units at one fifth of the investment cost per installed MW. Economic and financial logic suggests that the nuclear sector should attempt to compete with alternative power sources, not develop technologies and unit sizes which are unaffordable; and

(c) The nuclear industry has for many years largely ignored the availability and cost (ie terms and conditions) of finance to support new-build projects. [NB. Interestingly, the NAO Brief attached to the Inquiry ducks this issue too!]

As a "project financier" I shall focus my comments to funding issues. I shall also try to be brief! [Apart from the characteristics mentioned above, the nuclear sector produces more paper/documents than any other I know!!]

2. UK Commercial and Financial Perspectives

(a) In the early 1980s a consortium comprising the CEGB, NNC, Babcock & Wilcox, GEC and a City merchant bank (in which I was an employee) attempted to create a "UK Inc" model for building a new family of NPPs** (PWRs) in the UK and to provide a platform for UK exports in this sector. In those days, the UK had the capacity and capability to build NPPs solely with UK resources.

[** NPP = Nuclear Power Plant; PWR = Pressurised Water Reactor.]

(b) The Government of the day declined to support such an initiative, and today, after subsequent Governments failed to implement a long-term Energy and/or Industry Policy, the UK in effect is unable to design and build such projects itself. Indeed, Government policy over intervening years has massacred the sector, and much UK nuclear expertise and industrial capacity has been lost.

(c) Following the privatisation of the REC's (Regional Electricity Companies) in 1990–91 and the later creation of British Energy ["BE"] in 1996, any new-build power stations had to be private sector sponsored, funded either by existing private utilities using the strength of their corporate balance sheets to raise debt, or as IPPs (Independent Power Producers), stand-alone power plants funded in most cases with greater leverage (ie debt) secured by long-term offtake/sales contracts—a structure employed widely and successfully, internationally over the last 20 years.

(d) In the early 2000's, the UK Government changed the system as to how generators sold their power into the market by the introduction of NETA (National Electricity Trading Arrangements). The intention was to provide more demand-side competition—which it did, and UK consumers have enjoyed lower electricity tariffs than their European counterparts ever since—but it also ultimately led to the final demise of the UK power generation equipment sector. Many power generators had their margins and cash-flows squeezed, and sector re-structurings took place with international power utilities picking up existing utilities cheaply. Hence, today we end up with a sector potentially short of Base Load capacity and largely owned by non-UK utilities (eg EdF, RWE, Eon, Iberdrola, Suez, Vattenfall, etc). SSEB and Centrica are the only UK utilities of any significant capitalisation.

(e) In due course, many of the independent IPPs also collapsed, as NETA outlawed the long-term contractual relationships upon which such projects relied to maintain financial feasibility. Investors, utilities and lenders, particularly from the USA, lost a significant amount (£5–7 billion?) on such projects, albeit lenders wrote off such losses against profits, which at that time were healthy. Nevertheless, such disasters deterred many power sector investors from considering the UK as an attractive country in which to invest.

(f) One important outcome of the above progression was that, following privatisation, power utility owners were entitled to buy the power plant equipment from wherever they wished. Not surprisingly, many of the non-UK-owned utilities, who in many cases fall under the influence of their national Governments, purchased plant from their own indigenous suppliers, eg Alsthom, Siemens, ABB, etc, which undermined the market for UK suppliers. Over time, the UK power plant supply base effectively disappeared (Rolls Royce apart). Similarly, the construction, project management and contracting components of such power plant projects went in many cases to non-UK companies, again leading to a fatal weakening of the sector.

[In this context, it is pertinent to make similarity with the current wind power sector, where the UK, I am told, has more wind than any other Western European country, yet we cannot build the turbines with UK-owned companies. Having been born and bred within walking distance of a C.A. Parson plant, where the World's first steam turbines were built over 100 years ago, this is a tragedy for UK innovation and skills.]

(g) Meanwhile, notwithstanding many EU demands, etc, most of the mainland European power generation markets remained closed to non-national companies, which in turn led to the increased corporate power in those markets for a few large utilities, suppliers and contractors. The cost-of-entry into those markets for new players became prohibitive, whereas the UK represented an "open" market to investors, suppliers and contractors. Unfortunately for the UK, the EU Commission remained helpless, or unwilling, to enforce unbundling and the creation of an EU competitive power market.

(h) Overall, during the period 1985–2000 the UK lost the capability to build and complete major power plants, and that situation persists today.

When one also notes that the current Boards of Executive Directors—where the decisions on research, investment and procurement are taken for major projects—in EDF, RWE, Eon, Vattenfall, Iberdrola, ENEL, and Suez do not contain one UK national, not only has the UK lost its capability, but also decision-making influence over what is built where, when, by whom and with what equipment.

Furthermore, at least three out of these utilities are effectively owned and controlled by Governments, so it is indeed not surprising that they sponsor their own industries before the UK's.

(i) Commercially, the UK is "up the creek without a paddle". We/the Government are not in control of our future energy destiny!

(j) In the context of nuclear power, the advent of NETA led inevitably to the downfall of British Energy ["BE"]. Nuclear power represents Base Load capacity and is capital intensive and operationally inflexible. It needs long-term sales arrangements, which NETA outlawed, to sustain financial viability, In addition, reflecting the need for long-term sales contracts, the long-term fuel cycle contracts which BE had with BNFL became unviable as a consequence.

(k) BE collapsed, and the Government stepped in to restructure the finances at some cost to the public purse [Credit Suisse *et al* charged Government (£100 million plus to restructure £3 billion of British Energy loans and bonds (ref *FT* December 2003)]. BE shareholders received a pittance. In 2009, Government sold BE to state-owned EDF, consolidating their position in Europe's nuclear market, cornering out competition.

(l) To rubber-stamp the demise of the UK nuclear sector, over the period 2005–09 Government sold off Westinghouse (the original designers of the PWR) and much of BNFL, representing the core of UK nuclear design and operational experience, to Toshiba *et al*. Later, Government awarded a £1 billion clean-up contract for Sellafield to a consortium led by French state-owned AREVA.

(m) Combined with the commercial demise as mentioned earlier, this reverse out of the nuclear sector by the UK Government could not have been more comprehensive. Our nation's young engineers and scientists will have to look overseas most probably for future employment.

(n) Has this sell-off policy been "in the National Interest", one might ask? Well, no other Western industrialised country has followed suit. Quite the opposite, in fact. We are, indeed, "up the creek without a paddle"!

3. Funding Structure

(a) Globally, all nuclear power plants built to date, bar two (see below), have been funded with equity and debt raised by:

(i) governments, or by government-owned power utilities (eg EDF); or

(ii) major private power utilities, sometimes quoted on a Stock Exchange, (eg Eon and RWE in Germany), where the nuclear new-build is one of a portfolio of power plant assets operated by the utility.

(b) The security for lenders to such projects has been direct and/or indirect government or corporate guarantees. Lenders evaluate the financial strength and creditworthiness of the borrower's balance sheet or alternatively third party guarantees, and are not reliant on the specific cash-flows to be generated by the new-build for the repayment of the loans.

(c) To date, however, nuclear power projects have never been funded by debt secured on a "project financing" basis, ie against the future cash-flows of the project, as have many CCGT-type ("IPP") power plants around the World.

(d) The only (two) exceptions that I am aware of are:

(i) EDF's NPP Dunkerque, which supplies power to the local Pechiney aluminium smelter. The debt was secured against cash-flows supported by long-term alumina supply and aluminium sales contracts (albeit controlled by Pechiney, a French state-owned company at the time!). In effect, the underlying funding structure was viewed by financiers as a French Government liability; and

(ii) Finland's 1,600MW NPP Olkiluoto-3, where the shareholders supported and committed to long-term dedicated sales contracts to secure debt funding. However, this project has yet to become operational.

Both these can be considered as "special cases".

(e) With respect to a "project financing" alternative for the UK, creating such a funding structure and mechanism for the first time in this sector would be treading new ground and carries with it significant additional risks, which probably, in the event, will prove insurmountable.

(f) Typically "project financings" take twice as long to arrange as for conventionally-funded projects (ref & cf HM-Treasury's PFI/PPP Review, *PFI: Strengthening Long-Term Partnerships*, March 2006). Hence, "project financing" is not "a quick fix".

(g) Furthermore, for such "project financed" deals to be viable, they need to be underpinned by contractual arrangements. The Government has attempted to solve this issue via the CfD (Contracts for Difference) in the EMR (Electricity Market Reform) discussions, but the mechanism proposed is untried on the scale proposed, appears inordinately complex, and lacks the transparency the sector, investor and public requires. Furthermore, the credibility and creditworthiness of the CfD counterparty is far from certain.

(h) For a Government seeking quick results once the NPP approval decision has been taken, therefore, this funding route—"project financing"—is not the answer compared to conventional utility/corporate guarantees to secure debt.

(i) Hence, the new generation of UK nuclear power stations can really only be funded by existing major utilities who can secure the debt against their balance sheets.

4. Availability of Finance: Equity

(a) Typically, major power utilities comprise 50–60% long-term debt in their Balance Sheets. Hence, if they are to invest in a new NPP costing £5 billion, they need to commit £2–2.5 billion of shareholder equity and expect to raise £2.5–3 billion of debt.

(b) Secondly, such utility investors will not obtain any return on their investment for the four to five years that it takes to build such NPP's. Many other investors, eg "private equity", which comprises life insurance and pension fund investors, will shy away from such investments. They seek long-term low-risk investments, which infrastructure assets provide, but they also need income (ie dividends) to satisfy customers. Utilities, therefore, will to a large extent have to fund the equity for such projects out of their own corporate treasuries.

(c) Have these utilities got the financial strength to undertake such investments?

Over the last 1–2 years, many European power utilities including EDF, Suez, RWE, Eon, Iberdrola and ENEL have all seen their share prices fall by around 40%. This drop has been due to a number of factors:

(i) the economic climate in the Eurozone after the 2007 Financial Crisis;

(ii) the perception in the bond markets—the main source of debt for such utilities—as viewed through ratings by S&P, Fitch, etc, that the underlying cash-flows from utility operations are being squeezed; and

(iii) the need to de-leverage power utility Balance Sheets through asset sales to restore credit ratings: many such utilities embarked on ambitious international acquisitions in Latin America, Asia, etc, in the early 2000's, funding such acquisitions with cheap debt.

Hence, not many European utilities are fit and ready to embark on major new project investments, particularly nuclear, in any country when investor returns will not be generated for some years.

More specifically:

(d) *EDF* (state-owned) has currently 58 operational NPP's, of which many are coming to the end of their useful (licenced) life. Given the larger size of the EPR reactors to those previous built, a like-for-like re-build program would require around 42 units over the next 20–25 years. Assuming France decides to develop more renewable plants as alternatives**, this figure might drop to 25–30, ie one new-build committed each year for the next 20 years. Also, some existing NPP's may have their licences extended to put off the day when they need to be replaced.

[** Renewables are not a direct alternative to nuclear; nuclear is Base Load.]

With a utility leverage of 55–60% and a construction period for each plant of 4–5 years, this program will require a commitment of £12–15 billion of EdF capital before any return is obtained for EdF shareholders/owners… and this is just to satisfy the needs of the French domestic power market.

Given the indebtedness of the French Government, etc, the ability of EDF to fund any NPP elsewhere, eg the UK, must be put into question. On the other hand, AREVA, the state-owned French nuclear power designer/contractor are desperate to have some additional projects to demonstrate their EPR model… but that does not provide equity.

(e) *Suez* is another contender in the nuclear field and may, in the event, take up any slack in the French new-build program, which EDF cannot support. However, Suez, arguably commercially more dynamic than EDF—albeit there is a French Government "golden share" in its corporate make-up—has other international ambitions in gas/LNG and conventional power (via International Power, which it bought control of recently), which will take up much of any spare capital.

(f) *RWE & Eon:* both these utilities have been hit by the withdrawal of Germany from nuclear power and, indeed, from the UK nuclear new-build scene. This withdrawal has cost both utilities many €billion, and they will need to fund the conventional replacements for their NPPs closed down early. They are both also going through a program of asset sales due to ambitious acquisition programs earlier in the 2000's. Their current financial standing, therefore, is not conducive to their being a serious player in the current UK nuclear initiative.

(g) *Vattenfall* (Sweden) is state-owned and operates 10 NPPs providing 40% of domestic Swedish demand. Many of these NPPs need to be replaced, which will keep Vattenfall's capital tied up for some years. Their UK interest to date mainly lies in Renewables (wind), not nuclear.

(h) *Iberdrola (Spain)* and *ENEL (Italy)* operate NPPs in Spain and Slovakia respectively, but do not have the capacity to lead any new NPP initiative in the UK.

(i) Similarly, *Centrica* and *SSEB* are possibly participants in any new UK NPP initiative, but not as lead investors. They also are more interested in developing conventional and renewable energy resources with shorter term investor return horizons.

(j) Finally, there has also been some recent discussion as to the possibility of Sovereign Wealth Funds ("SWF"s), eg Abu Dhabi, China, etc investing in the sector. By their very nature, such funds have a political agenda and their presence will not negate the need to have in any UK consortium an experienced nuclear operator.

(k) Overall, therefore, not only is there a dearth of equity capital to fund a new UK NPP initiative, but the decision to proceed and the resources needed to implement such projects lies largely outside UK Government control.

The phrase: "we are up the creek without a paddle!" rings true!

5. Availability of Finance: Loans

(a) With respect to debt funding, *prima facie* each new NPP will require £3 billion of debt finance per plant. This is not an insignificant sum, and will require a large syndicate of banks to source, ie it will not be "a quick fix". In addition, the project might not generate cash-flows for six to seven years, so interest will have to be capitalised. This will raise the actual debt outstanding at project completion to close to £4 billion Per NPP.

(b) Clearly, this increases the leverage or debt/equity ratio of the sponsoring utility, and lenders may insist that the equity proportion is increased due to the inherent risks of a long construction period. Additionally, without the support of firm off-take, or sales, agreements, lenders will not be comfortable with such a financing.

(c) Power projects, nuclear or conventional, have long project lives. Typically, the debt funding will have overall maturities (construction plus repayment period) of at least 12–20 years or so. NPPs require such maturities.

The introduction of Basel III regulations relating to the capital requirements of banks makes lending longer than 10 years expensive and not attractive. As 10 year loans are insufficient for NPPs, such loans would have to re-financed, at the latest, in Year 10, and to date there is no guaranteed mechanism that such re-financing can be achieved.

(d) Export credits are another long-term source of loans to supports NPPs, and under the Consensus there are special terms for such funding for NPPs. However, the UK is too rich to benefit from such credits.

6. Other Sources of Finance: Capital Markets

(a) Promoters of new UK nuclear power plants, eg utilities, may perceive that the capital or bond markets may be more receptive to NPP's. After all, the long-term funds available in the bond markets are believed to be much greater than for long-term loans, and such bonds have been commonplace in US energy and infrastructure financings for years.

(b) Unfortunately, not so! Bond purchasers are more conservative than commercial lenders, and such funding is more cost effective for projects once completed, ie for re-financing existing operational utilities.

(c) Further, to rely on a bond financing, where there always remains uncertainty until the bond is issued and placed in the market, is a high risk strategy, *viz* the Channel Tunnel Rail Link financing debacle, which relied upon a bond issue subsequent to the outset of project implementation.

(d) The basic principle of project financing is that all funding—debt and equity—must be in place and committed before construction starts. This principle should be upheld at all times. Hence, a project with a long and complex construction schedule, such as a nuclear new-build, is unsuitable for bond financing, unless the re-financing of the initial loans with bonds on project completion can be guaranteed.

(e) This is the same problem that the UK Government/HM Treasury are grappling with over PFI/PPP, and so far no mechanism has been developed.

7. Project Size

(a) Twenty years ago the standard size nuclear plant was 660MW. Since then, the market has been dominated by 350MW unit CCGT's, etc, which are more flexible, affordable, less complex to build, and easier to finance than NPPs.

(b) For inexplicable reasons, possibly due to an industry which at times has tended to bury itself in its own problems, unaware of how power markets now operate, the nuclear industry has directed its efforts towards bigger (ie 1,600MW) and less flexible and financeable units.

(c) If the nuclear industry could offer developers and utilities a power unit comparable in size to an "off the shelf" 350MW CCGT, many financing difficulties as described above would diminish significantly.

(d) Smaller projects would attract more investors and lenders, and the sector become more competitive, with a concomitant impact on prices. The future of the sector would look much brighter!

8. Concluding Remarks

(a) The conclusion arrived at is that funding new UK nuclear power plants exclusively through private sector capital and initiative will be a difficult task and, possibly, insurmountable. We are entering new territory, so to speak.

(b) Government support will be needed not only to facilitate a planning process which allows private capital to be made available at reasonable cost, but also to cover those risks which cannot be valued (e/g/nuclear catastrophe).

(c) As it stands today, the main nuclear option for the UK to replace existing base load capacity comprises the construction of (at least) one EPR by EDF, supported by a group of international investors. In other words, this option is based upon:

— the decision to proceed or not being dependent on a foreign Government, which already is highly indebted;

— a commercially (today) unproven reactor design;

— a project design for which fixed cost estimates cannot be given;

— an unproven CfD mechanism to support lenders and investors;

— a timetable which will take at least five years before we know whether this option is successful or not; and

— minimal UK industrial and construction participation.

Overall, this option, to me, seems high risk and makes only limited contribution to the nation's industrial base. Hence, it is of little value to the national interest. Strategically, it is also putting "all the UK's (nuclear) eggs into one basket".

(d) Is there an alternative, one might ask? Is there a " Plan B"? [Probably, not!!]

(e) I would like to suggest that a lower risk and more certain way forward for the UK to replace existing Base Load nuclear capacity would be to:

— Implement a short-medium term program of CCGT's—hopefully, using UK-built gas turbines—which could be spread around the UK to ease the current imbalances in the UK Grid system, complemented by a program of renewable energy and energy efficiency projects, when viable. In fact, currently I am informed that Centrica has around 3GW of CCGT capacity mothballed in the UK. This represents two EdF-sized EPRs in capacity terms. At little cost, such CCGT's could be brought back into service as an interim measure; and

— Use some of the £1 billion monies awarded to Rolls-Royce recently to develop the next generation of NPP's for the propulsion of the UK's nuclear deterrent program to develop small NPP's for electricity power generation.

It is interesting to note that the Russians are building six x 30MW NPP's on barges for use in distant parts of Russia and the USA is also developing such smaller units. It makes both economic and financial sense, although there will be some competitive cost disadvantages due to the loss in economies of scale compared to EPRs and AP-1000s.

(f) In the long-term such a "Plan B" might benefit UK industry much more, be lower risk, and so be more in the National Interest.

I have worked in the field of energy and infrastructure project financing both in the UK and overseas since 1973. My nuclear activities have included:

— undertaking an assignment for the market impact of heavy water reactors for BNFL in the early 1970's;

— employment by Kleinwort Benson 1974–1985, where assignments covered: (a) the development of the original financial structure for Urenco-Kleinworts was Financial Adviser to the multinational Urenco consortium—(b) the financing of CANDU power stations in Canada, and (c) a major initiative for building a program of PWR's in the UK and for export in the early 1980's;

— employment with EBRD, 1991–95, where I was Director, Power & Energy Utilities and grappled with the issues of the nuclear legacy in Central Europe, eg NPP Mochovce & NPP Bohunice (Slovakia), NPP Ignalina (Lithuania); NPP Temelin (Czech Rep); etc (I have even been inside a reactor core!!); and

— working on schemes for the replacement power plants for NPP Ignalina (Lithuania: 2001) and nuclear units in N Korea (2005).

Since 1995, I have operated as an independent consultant in energy and infrastructure financing, following closely developments in the nuclear field as they arise.

I also have undertaken more than 70 three to four day Courses on "Energy & Infrastructure Project Finance" for Governments and banks over the last three to four years, including three on "Financing Nuclear Power".

July 2012

Written evidence submitted by GE Hitachi (NUC 22)

1. About GE Hitachi

GE Hitachi Nuclear Energy (GE Hitachi) is a world-leading provider of advanced reactors and nuclear services. Established in June 2007 after several decades of business collaboration, a global nuclear alliance was created by General Electric Company (GE) and Hitachi Ltd. (Hitachi) to serve the global nuclear industry. The alliance offers customers around the world the technological leadership required to effectively enhance reactor performance, power output and safety.

GE built the first commercial nuclear reactor over 55 years ago and now, together with Hitachi, continues to build them. GE Hitachi's current portfolio of reactor technology consists of three main designs: the Advanced Boiling Water reactor (ABWR), the Economic Simplified Boiling Water reactor (ESBWR) and the Power Reactor Innovative Small Modular (PRISM). All three of these reactors can be built using modular processes to improve build efficiency.

The ABWR is the world's first and only Generation III reactor with operating experience, based on a proven design that has been successfully built to time and to budget. The ESBWR builds on the ABWR's proven advanced technology and introduces passive safety systems which keep the reactor core cool without the need for operator action nor AC power. PRISM utilises evolutionary sodium-cooled technology, which is based on decades of US technology development and more than 30 years' operating experience. It is a simplified reactor design to preclude the possibility of a loss of coolant accident and incorporates advanced passive safety systems. PRISM has been designed with modular construction in mind enabling higher quality components, safer work environments and cost certainty from the reduction of on-site work and efficiency of factory production. PRISM is ideal for fissioning plutonium, recycling of used nuclear fuel and generating low carbon electricity.

A global infrastructure and finance company, GE is proud of its presence in the UK since the 1930s. GE currently employs over 18,000 people across the UK and has invested over £14 billion in GE's UK-based businesses since 2000.

2. Summary

- GE Hitachi is pleased to contribute to the Energy and Climate Change Committee Inquiry into Building New Nuclear—the Challenges Ahead. We welcome the UK's continued commitment to the new nuclear build programme as part of the overall effort to decarbonise the economy.
- As a world-leading provider of advanced reactors and nuclear services to a global customer base, GE Hitachi is engaged in supporting the operation of both existing plants and in developing new nuclear build. GE Hitachi based technology provides approximately a third of low carbon nuclear generation around the world.
- To support new nuclear build, clarity around current electricity market reforms (EMR) in the UK will be vital. Other factors needed include a roadmap for the future nuclear fuel cycle, streamlined licensing and planning processes and a robust supply chain.
- The current debate relating to the management of the UK's existing nuclear legacy is also central to the wider discussion about investment in new nuclear. Politicians and the public are acutely aware that a new generation of nuclear plants will have long-term cost and environmental impact for the UK in terms of waste, and these issues must be taken into account in any consideration of the case for new build. The debate on new build therefore necessarily includes the reuse and reduction of the UK plutonium stockpile, plus the future nuclear fuel cycle strategy and nuclear advancement in the UK.
- GE Hitachi sees the UK's stockpile of civil plutonium, which is the largest in the world, as both a resource and an opportunity. We have brought forward a design based on GE Hitachi's commercially available PRISM technology which we firmly believe provides a safe, cost-effective, feasible solution to the UK's plutonium management challenges. PRISM can be part of the new nuclear build programme and at the same time utilise the legacy plutonium to provide low carbon electricity generation.
- The UK Government has taken positive steps to consider the reuse of the UK's plutonium and wider investment in new nuclear build. However, the details involved and the practical application of these steps will be paramount.
- GE Hitachi is pleased to be working with the Nuclear Decommissioning Authority (NDA) to enable a more detailed assessment of our PRISM reactor in a number of areas, including the proposed commercial structure, the disposability of the fuel, the risk transfer model, the costs and licenseability.

3. GEH Response to the Inquiry Terms of Reference

Q. *The Committee is aware of the significance of the electricity market reform process in determining the viability of investment in new nuclear power stations. What other factors contribute to investment decisions for new nuclear?*

The Government's political mandate to press ahead with a new generation of nuclear power must be based on firm public confidence in the UK's ability to responsibly and cost-effectively manage nuclear decommissioning. The on-going debate relating to the management of the UK's existing nuclear legacy is therefore central to the wider discussion about current investment in new nuclear build. This includes the reuse and reduction of the UK plutonium stockpile, plus the future nuclear fuel cycle strategy and nuclear R&D in the UK.

GE Hitachi would welcome progress towards a preferred policy of plutonium reuse that provides equal preference for alternative technology solutions capable of providing better value for the UK taxpayer.

With regard to the deployment of PRISM in the UK, additional basic research is not required to support plant construction or operation. Due to the extensive amount of engineering and testing completed to date, the start date of the project is almost totally dependent on stable Government policy framework and project funding. Project duration is most influenced by obtaining a Government nuclear license from the Office of Nuclear

Regulation. Though GE Hitachi cannot guarantee a start date in the absence of UK licensing engagement, we believe the time required is broadly consistent with the licensing of a new MOX (mixed oxide) plant.

In order to support wider new-build, GE Hitachi believes the UK Government has taken a number of positive steps to encourage investment. However, the further practical application of many of these steps is paramount. The implementation of electricity market reforms is vitally important to this process. Other key factors needed include a clear roadmap for the future nuclear fuel cycle, further streamlined licensing and planning processes and a strong, well-integrated supply chain.

Q. *What have been the political and policy impacts of the Fukushima incident?*

Many Governments, including in the UK, have carried out in-depth analysis into the Fukushima Dai-ichi incident. Whilst this has revealed no fundamental safety weakness in the UK's nuclear industry, it has underscored the importance of learning lessons that can contribute to making the nuclear industry even safer. While the Weightman Report has been an important exercise in reassuring the general public of the safety of the UK nuclear industry, Fukushima has undoubtedly refocused public attention on the safety of nuclear power.

In its consideration of new build options, the Government should take care to demonstrate a preference for technologies with particularly advanced safety features which can offer the most robust reassurance in this area. The industry will continue to implement safety enhancements to deliver continued safe operation of the nuclear fleet and consequently the role of passive cooled nuclear technology will become more advantageous in future. In particular, we also welcome the World Association of Nuclear Operators (WANO's) efforts to support nuclear safety and security.

The GE Hitachi proposal for PRISM can fulfil these aims by re-using plutonium to generate low carbon electricity and, with PRISM's simplified design to prevent a loss of coolant accident and use of advanced passive safety features, it can achieve this safely and securely. It is important to note that the incident at Fukushima Dai-ichi does not remove the pressing need for low carbon electricity, nor to safely and effectively manage the UK's existing nuclear legacy. We see the UK's stockpile of civil plutonium, which is the largest in the world, as a potential resource and an opportunity for the UK to tackle three major challenges: (a) the need to slow down/reverse climate change; (b) the need to prevent possible future energy shortfalls; and (c) the need to reduce a significant component of the costs and hazards associated with the nuclear legacy.

The closure of the UK MOX plant at Sellafield in 2011 was a significant consequence of the reactor shut-downs in Japan following the nuclear accident at Fukushima. What happened at Fukushima led not only to a rethink of nuclear power around the world but had important commercial implications for the UK's approach to re-using plutonium fuel. There is clear evidence of a diminishing global market for MOX fuel. The UK will be pursuing a high risk strategy if their preferred option relies on a strong revival of this market.

Q. *What lessons can be learnt for building new reactors to timetable and within budget from the experiences of France and Finland and elsewhere?*

GE Hitachi believes that among the lessons learnt are that simpler, innovative reactor designs are crucial to achievement of on-time, within budget performance.

GE Hitachi's ABWR is the only generation III reactor already built and in operation today. Four ABWRs have been brought into operation and to date these have provided more than 40 years of operational experience since 1997. A further four ABWRs are under construction and these projects include the Ohma-1 ABWR, Shimane-3 ABWR and Lungmen—1 & 2 ABWRs. Based on design simplification, proven innovation, and modular build, GE Hitachi is the only company to have completed a Generation III plant on schedule and on-budget. The average build time equates to less than four years.

GE Hitachi sees a well-established global supply chain for new build as a key factor crucial to meeting build times. In the UK, GE Hitachi has recently signed a memorandum of understanding with the National Nuclear Laboratory (NNL) and with Manchester University to provide expert technical input towards the potential deployment of GE Hitachi's PRISM reactor to address the UK's growing stockpile of civil plutonium. These build on an MOU signed last year with the CAP alliance to look at working together in developing PRISM in the UK.

After 30 years of development, GE Hitachi's world-leading experts are confident PRISM is ready to be commercialised and can be operational within the same timeframe as other potential plutonium reuse options.

Like all potential options for treating Plutonium, PRISM will undergo a stringent regulatory approvals process. However, because of PRISM's simplified fuel technology, it is highly time-competitive for achieving the UK's end objective of reducing plutonium risk.

From a commercial perspective, GE Hitachi is proposing an innovative approach for safely and effectively managing the UK's plutonium stockpile, namely, the UK Government will pay a plutonium disposition fee in exchange for the materials being processed and proliferation risk being reduced. The UK Government will neither own nor operate the facilities and therefore help to minimise the risk to the Government and UK taxpayer.

Over the lifetime of the plant, PRISM is more cost-effective than alternative technology options. It also has a guaranteed market for its product—low carbon electricity which we would expect to be treated in accordance with the EMR arrangements that are to be put in place for low carbon generators.

Q. *What impact might global demand for nuclear power put on plans to build new nuclear power stations in Britain (there are currently 60 new nuclear power stations under construction worldwide and a further 150 planned)?*

As the global demand for nuclear power increases, nuclear suppliers are firmly aware of the benefits of growing and maintaining supply chains. However this does not remove the potential risk that supply chains and qualified construction teams could be absorbed by projects taking place in other jurisdictions. Should the UK choose to develop PRISM for plutonium re-use, the viable option of re-using plutonium as metal fuel in a modern sodium-cooled reactor presents the UK with an important opportunity to take a global lead in responsible management of legacy nuclear materials, in proliferation risk reduction, and the development of next generation reactors. It can also manage the UK's plutonium stockpile efficiently, securely and safely while generating approximately 600MWe low-carbon electricity at the same time.

Q. *Are there any other potential barriers to the construction of new nuclear power stations in the UK?*

The main factors that we consider important to support new nuclear include: a clear roadmap for the future nuclear fuel cycle and associated R&D; streamlined planning and licensing processes with available resources for efficient implementation; and a vibrant supply chain to enable development of the UK's infrastructure. Investors require stable policy and measures to encourage investment in capital-intensive infrastructure projects.

In relation to plutonium re-use, a challenge to policy development is the often repeated assumption that re-using the plutonium in the form of MOX (mixed oxide) fuel is the only available technology for plutonium reuse.

The Nuclear Decommissioning Authority (NDA) took a preliminary view to rule out fast reactors as a credible option on grounds the technology was immature and the market did not expect them to be commercially viable for several decades. GE Hitachi outlined the reasons (and supporting evidence) for our opposition to this view in our submission to the UK Government consultation into management of plutonium stocks (February to May 2011). We see PRISM as an entirely feasible and economical solution for plutonium management that produces low carbon electricity, and can pre-treat used light water reactor fuel for disposal to increase available UK energy reserves.

Q. *Other than reforming the electricity market and planning process, what steps could the Government take to remove barriers to the delivery of new nuclear power stations in the UK?*

The UK NDA has commissioned a report from GE Hitachi to enable a more detailed assessment of our proposal for a PRISM fast reactor. The report (not yet published at the time of this writing, but which we would be happy to share with the Committee in due course subject to NDA approval) considers a wide range of factors including: commercial structure and implementation; safe disposability of the fuel; the risk transfer model from Government to the private sector; and the feasibility of licensing.

GE Hitachi's approach clearly shows how the UK can use the plutonium to generate low carbon electricity by employing a proven technology with a well understood costs base. It also provides a cost-effective solution, with an innovative commercial model which minimises risks to the UK Government and ultimately the taxpayer. GE Hitachi believes that the PRISM reactor could be licensed and built in around 10 years—allowing five years for licensing and five years for construction. Under our proposal, the UK Government will neither own nor operate the facilities and therefore help to minimise the risk to the Government and UK taxpayer.

One of the key benefits of this technology is its improved economic performance compared to other methods of plutonium disposition. PRISM is a small, modular reactor designed to maximise the efficiencies of fabrication in a factory environment, and its fuel is designed to be simple to fabricate. Also, PRISM's low carbon electricity product helps to offset costs. All these factors result in strong cost performance compared to other plutonium alternatives.

July 2012

Written evidence submitted by Gwyn Evans (NUC 31)

This letter expressing my views has not been asked for by the committee. However, I hope that its content can help in your deliberations.

Retired from electricity supply, I started an interest in combating the anti-nuclear panic peddling by the FoE and Greenpeace in 1990, later joining SONE. BBC Bristol Radio, local members of the Foe and the Green Party have heard my views. The national press and media gave no space to nuclear energy.

Accidents

When one of the two reactors had a meltdown at Three Mile Island in 1979 there was a small release of radioactive gas causing no harm to any person. The panic caused 140,000 children and pregnant women to be evacuated for three weeks, and the trauma may well have caused health problems to them or their families.

In 1986 the meltdown of a reactor at Chernobyl, there was widespread release of radioactive gases and according to UNSCEAR, resulted in 31 deaths plus about 24 of the 6000 whose thyroid glands were treated.

In the 11.3.2011 Japan quake of the 16000 recorded deaths, not one has been caused by radiation.

A NUCLEAR EXPLOSION is not possible at a power station because the radioactive part of the uranium fuel has too small a part in the mix.

THE UK HPA. Health Protection Agency publishes figures on any relevant problems. UK residents receive an input of 2.7mSv (milli Sieverts) from nine sources. 50% is from radon gas. Less than a thousandth is from nuclear energy. The nuclear energy industry uses effective screening to ensure that no employee or member of the public is affected by radiation. This applies to all its plants, processes, fuel stores, used fuel or "waste".

So, the UK resident receives a dose of under 3 millionth of a full radiation unit (Sievert) under normal conditions. It is unlikely that the anti nuclear lobby can point to any radiation deaths.

If a person accidently receives an input of one full radiation unit there is a view that there follows a 5% chance of cancer arising.

COST of Generating Electricity in £ per MWh

2007—38 nuclear is the lowest said John Hutton in his 2007 White Paper.

2008—38 nuclear page 1131 of Hansard 11 Nov. Minister Neil O'Brien nuclear 38, coal and gas including carbon tax 51 and 52, wind 72 onshore and 92 offshore.

2010 March 31 letter to me via my MP DECC Secretary Lord Hunt—Nuclear 51, Gas 53, Coal 54, both fossil fuels including carbon tax, Wind including ROC subsidy Onshore 74–103, Offshore wind 112–131, Biomass 114–146, Tidal stream 191, Wave 240.

Late 2011 DECC's Charles Hendry lifetime levelised three costs:

Nuclear 66 (one of a series)—76 (first of its kind)
Gas 78/Onshore wind 90/Offshore wind 135
Coal CCS 110–137 Severn Barrage 64–90.

As the present government appears ready to force electricity consumers to pay large subsidies to the owners of wind turbines EDF is now considering charging £140/MWh for its nuclear energy.

Future

It was a bad day when Blair and Brown forced down the price which British Energy Ltd charged the Grid for its nuclear energy. The company was sold to EDF. Other firms and research facilities were also sold off.

In worshipping "Green" and "renewable" energy costs will be high, more people will be in fuel poverty and British manufacture will be less competitive. Skills will be lost. If the three lectures at Bristol University, who I found to be Green, are typical the prospects for change are poor.

WHO states that three million people die each year from breathing air polluted by the burning of tobacco, coal, oil and petrol. This death rate could be matched by 150 Chernobyls every day.

Nuclear energy is clean, safe, reliable and available. It its reputation is to be restored a lot of open discussion, debate and education needs to happen.

October 2012

Written evidence submitted by Horizon Nuclear Power (NUC 25)

Introduction

1. Horizon Nuclear Power is a 50:50 joint venture between E.ON and RWE, formed in January 2009. On 29 March 2012 E.ON and RWE announced that they no longer intended to pursue nuclear new build in the UK, and that they were seeking new ownership for Horizon. Whilst at the time of this submission the sale process is still in progress, Horizon remains a going concern with plans in development to deliver around 6GW of new nuclear capacity at Wylfa and Oldbury.

2. We welcome the opportunity to respond to the Committee on the matters raised in this inquiry.

3. The UK faces pressing challenges in its energy supply as it seeks to de-carbonise the economy, ensure security of supply and maintain affordable energy. This challenge is in the context of the closure of 11GW of fossil plant by 2015 to meet the Large Combustion Plant Directive and the requirement for over 20GW of fossil plant to either comply with the Industrial Emissions Directive or close by 2023. Moreover, we expect the last of the AGR plants to have closed by 2030, leaving Sizewell as the UK's only operating nuclear power plant.

4. New nuclear power can play a vital role in providing secure, sustainable and affordable electricity to the UK as part of a balanced energy mix. It is the UK's main economically viable large scale, base-load low carbon generation technology.

5. In our response below we have grouped questions 1, 5 and 6 to avoid repetition.

Q1. *The Committee is aware of the significance of the electricity market reform process in determining the viability of investment in new nuclear power stations. What other factors contribute to investment decisions for new nuclear?*

Q5. *Are there any other potential barriers to the construction of new nuclear power stations in the UK?*

Q6. *Other than reforming the electricity market and planning process, what steps could the Government take to remove barriers to the delivery of new nuclear power stations in the UK?*

6. A substantial amount of work has already been done by this Government, and its predecessor, to de-risk the nuclear development process and thereby remove barriers to investment in the UK. This has been done through a programme of facilitative measures comprising the creation of the Generic Design Assessment process; reform of the nuclear regulator; approval of the industry's Regulatory Justification submission; reform of the planning process for major infrastructure projects and commitment to Electricity Market Reform. It is worth noting that our shareholders—E.ON and RWE—have made clear their reasons for withdrawing from the UK nuclear new build programme. They have stated that these did not relate specifically to the attractiveness of the UK as a market in which to invest.

7. The completion of the process to establish the Office for Nuclear Regulation (ONR) as an independent statutory body, outside the Health and Safety Executive (HSE) remains critical to ensuring the continued effectiveness of a strong and independent nuclear regulator. Whilst the publication of the draft Energy Bill is clearly an important step in this process, we believe that early clarity on timescales is also essential to maintain momentum.

8. The skills agenda and supply chain readiness remain important factors. We welcome the good work that has been undertaken in both areas through bodies such as Cogent, the National Skills Academy for Nuclear (NSAN) and the Nuclear Industry Association (NIA), and will continue to work closely with these bodies and others to maximise readiness for a new build programme. Horizon notes, in particular, the regional opportunities for the development of high value training and a sophisticated, long-term skills base centred on the construction, commissioning and operation of Nuclear New Build. However there is still a substantial amount of work to be done in this area and continued focus from Government is required. The nuclear new build Programme Management Board, created under the auspices of the Nuclear Industry Association, will continue to play an important role in this process.

9. We recognise that detailed evidence on the Electricity Market Reform process is being considered by the Committee as part of its pre-legislative scrutiny of the draft Energy Bill but it is important to note here that the Government has clearly recognised the need for reform to underpin investment. We welcome both the progress made and the objective of the draft bill in introducing mechanisms to provide greater certainty. It is essential that swift progress is maintained and further clarity is brought to a number of issues which are critical to successful progress on a new build programme, for example the nature of the CFD counterparty, negotiation of strike prices for individual projects, and identifying realistic inflation indices and a transparent and fair reference price. We will continue to engage with officials at DECC as our thinking develops to ensure that the views of an independent nuclear generator are understood.

Q2. *What have been the political and policy impacts of the Fukushima incident?*

10. We believe that the UK Government demonstrated an appropriate and measured response following events at Fukushima. Swift commissioning of the Weightman Report—and the widespread acceptance of that

report's recommendations by industry—has demonstrated the clear priority given to safety and independent regulatory scrutiny. Critically, Dr Weightman did not propose any reason for the UK to depart from its new build plans, its existing siting strategy or the multi-plant site concept. Horizon is fully committed to addressing the recommendations made by Dr Weightman and will commence this process once active development resumes under new ownership.

11. We note the strong political and public support that remains for nuclear new build in the UK. Recent polls show that public support for nuclear energy has returned to the level reached before the Fukushima incident in March 2011; with 50% supportive of replacement nuclear build and only 20% opposed (Ipsos MORI, December 2011). Meanwhile in Westminster both Government and opposition, and the Welsh Government in Cardiff remain strongly supportive of nuclear new build. With investments of this timescale, long-term commitment is critical to investment confidence and the support seen in the UK is reassuring. The extension of the timetable for the Generic Design Assessment process for candidate reactor designs, whilst Dr Weightman's analysis was conducted, was appropriate.

Q3. *What lessons can be learnt for building new reactors to timetable and within budget from the experiences of France and Finland and elsewhere?*

12. The key lessons relate to the need for designs to be mature, and established to the satisfaction of the regulator, prior to construction. This is expected to be a significant benefit of the UK's Generic Design Assessment process. In addition, it is essential that the supply chain for new nuclear build in the UK is identified in detail and can deliver to time, cost and quality.

13. Should Horizon develop reactors in the UK that have been deployed elsewhere in the world, a high priority will be placed on incorporating detailed lessons learned from specific projects to minimise first of a kind design risks.

14. Horizon would expect to draw on its own, and its partners' and suppliers', experience and understanding of supply chain development and construction project management to ensure best practice is adopted to minimise construction risk.

Q4. *What impact might global demand for nuclear put on plans to build new nuclear power stations in Britain (there are currently 60 new nuclear power stations under construction worldwide and a further 150 planned)?*

15. Whilst the global capacity to manufacture reactor pressure vessels, turbine generators and very large forgings has limitations, pressure has decreased following a scaling back of global nuclear programmes in some areas, in part due to high volume production of shale gas in the US and due to national energy policy changes following the events at Fukushima in March 2011. Furthermore the international supply chain is capable of increasing capacity in response to demand: we do not believe that limitations on resources are necessarily an obstacle to the delivery of the new build programme in the UK. This programme, and associated supply chain development would, however, be best served by the early delivery of a programme of new nuclear power stations in the UK.

Q7. *How feasible is the Government's indicative timeline, which shows the first new nuclear power station being built by 2019? And what level of nuclear capacity is likely to be available by 2025?*

16. Pending resolution of the ownership of Horizon, our intention would be to commission the first unit in the early 2020s. We are not party to the detailed plans of other developers and therefore cannot comment in detail on the feasibility of first new nuclear being built by 2019. Clearly the progress of the Electricity Market Reform policy, and in particular the Energy Bill, will be critical in enabling investment decisions. With that in mind, the slippage of the expected date for Royal Assent from spring 2013 (as stated in the Energy White Paper) to "the end of next year" (as stated by the Secretary of State for Energy and Climate Change in his evidence to the Committee on 26 June) may present risks and the Government should make every effort to keep any delay to the original timetable to a minimum.

Q8. *What will be the consequences of failure to deliver a first new nuclear power station by 2019? Should any contingencies be put in place?*

17. This is a question best addressed in detail by Government, and by EdF as promoters of the first new nuclear project. While it is important that the appropriate time is taken to de-risk projects, close adherence to the timetable for a final investment decision for the first project will help demonstrate to investors and stakeholders the robustness of the UK's facilitative programme for new nuclear. It will also build supply chain confidence which is important to the ongoing success of a UK new build programme. The ability of the supply chain to deliver to time, cost and quality will be critical in the ongoing delivery of a UK new build programme.

Q9. *What are the prospects for extending the life time of existing reactors?*

18. Horizon does not operate existing reactors and therefore we offer no comment in response to this question.

July 2012

Written evidence submitted by the Institute of Physics (NUC 14)

The Institute of Physics is a leading scientific society promoting physics and bringing physicists together for the benefit of all. It has a worldwide membership of around 40,000 comprising physicists from all sectors, as well as those with an interest in physics. It works to advance physics research, application and education; and engages with policy makers and the public to develop awareness and understanding of physics. Its publishing company, IOP Publishing, is a world leader in professional scientific communications.

What have been the political and policy impacts of the Fukushima incident?

1. In the UK, the Office for Nuclear Regulation (ONR), the Government's nuclear regulator, has investigated and evaluated the special circumstances involved (eg a severe earthquake followed by an extraordinary tsunami and inadequate protection of emergency electricity supplies from the impact of the tsunami), and has reviewed the design criteria of reactors and nuclear sites more generally. It was concluded that the Fukushima incident should provide no reason to inhibit a new nuclear programme in the UK. The response of several nations to phase out or abandon nuclear technology is not easy to justify on any technological or siting grounds. This is not generally reflected in media coverage and, as a consequence, public perceptions of nuclear technology are being distorted in a way that could certainly have political consequences.

2. Therefore, it is vital that the Government should stress publicly that nuclear power station sites in the UK are in no way comparable to Fukushima and that the safe design of nuclear power stations in the UK together with their emergency electricity supplies is, and will continue to be, fully appropriate for UK conditions. The designs of the proposed new fleet of power reactors are going through detailed assessment by the ONR which takes account of the recent events and other "stress tests". These assessments underpin the safety of the proposed designs, including the ability of the plant to withstand naturally occurring events such as those that led to the Fukushima incident.

3. The impact of the Fukushima incident on policy making in the UK is to ensure that the UK's high safety standards are maintained and that new reactor designs meet the stringent safety criteria set by the ONR. The ONR needs to remain a strong and impartial regulator, setting the standards and ensuring that the nuclear industry continue to meet them. The IOP supports the professional way in which both the ONR and the nuclear industry reacted to the events in Japan.

What impact might global demand for nuclear power put on plans to build new nuclear power stations in Britain (there are currently 60 new nuclear power stations under construction worldwide and a further 150 planned)?

4. Neither of the new reactor designs which are being adopted by developers in the UK are of UK origin: the UK has lost the ability to produce such designs and will now be dependent not only on overseas companies for designs but also for the construction engineering of any new nuclear power stations. This means that the UK now faces the challenge of competing with other nations for developing new nuclear reactors in the UK and the ability of the UK to be "owners" of the plant, to build and operate it according to UK requirements.

5. The UK is also facing a critical skills shortage in the nuclear technology sector. Currently, many experienced nuclear engineers in the UK are over the age of 50 and thus likely to be retiring within the next decade. All the engineers involved in the original planning and building of the UK's nuclear power stations (the first of which opened in 1956) have already retired. There is also a possibility that expertise will be lost rather than passed on, particularly given the high proportion of freelancers in the sector.

6. Due to a lack of investment in the UK's nuclear skills base, any short-term work force would need to be supplemented by the international supply chain. However, it would be wrong to assume that there is an international pool of staff from which the UK could easily recruit since the increased global demand will draw heavily on that pool of talent. Rather, we are behind the game and will have to compete even to retain scientists and engineers trained in the UK from working overseas. There will be intense international competition for skills.

7. Therefore, there is an urgent need to maintain and develop a nuclear skills base, particularly in the core sciences (eg physics and chemistry), engineering, materials science, mechanical and control engineering, project management, and technician level skills. It is important to note that significant areas of nuclear power technology (its full life-cycle including waste-handling and decommissioning) are underpinned by physics, such as reactor technology, nuclear data measurement and evaluation, safety, criticality studies, and materials properties.

8. Graduates employed in the nuclear technology sector build upon their initial undergraduate training by obtaining specialist industrial skills in reactor technology, for instance, through in-house training and university postgraduate courses. An important contribution made by the UK's nuclear physics research community to the nuclear technology sector is in the provision of highly-skilled people via MSc and PhD programmes.

9. Currently, there is no clear funding mechanism to support MSc courses and a solution to this problem needs to be found urgently. The research councils were tasked with working with the research community towards raising awareness of the issue, and exploring opportunities for Government funding by the EPSRC/STFC Review of Nuclear Physics and Nuclear Engineering.[1] However, the research councils have stated that there are no prospects of obtaining support for these MSc courses in the current financial situation. This is regrettable as there is a great deal of interest from industry in expanding the provision of MSc courses in nuclear physics and nuclear engineering in the UK; the long-term solution to this problem lies with industry funding such courses (as some do now), but in order to accelerate the expansion of provision, initial funding from the Government is necessary.

10. Furthermore, HEFCE has proposed changes to the support it will provide for postgraduate training resulting in reduced support for MSc programmes for 2012–13, coupled with great uncertainty for 2013–14 and beyond. The IOP is of the view that HEFCE should provide funding support for taught postgraduate courses at the previously provided level. In addition, to encourage further participation, HEFCE should also work with the Government to support MSc courses of strategic importance through an extension of the undergraduate loans scheme or similar low-cost financial support, particularly in areas valued by industry such as nuclear physics and nuclear engineering.

Are there any other potential barriers to the construction of new nuclear power stations in the UK?

11. One significant barrier is the long-term nature of the investment required for new nuclear power stations, with utility companies indicating that they require a higher level of confidence in the returns they are likely to make in the electricity markets of the 2020s, 2030s, 2040s and beyond. Current reforms of the UK Electricity Market are intended to achieve this, but the details are not yet finalised which is causing uncertainty.

July 2012

Written evidence submitted by the Nuclear Industry Association (NUC 11)

1. The Nuclear Industry Association (NIA) welcomes this opportunity to provide written evidence to the Committee on this issue.

2. The NIA is the trade association and information and representative body for the civil nuclear industry in the UK. It represents over 270 companies operating in all aspects of the nuclear fuel cycle, including the current and prospective operators of the nuclear power stations, the international designers and vendors of nuclear power stations, and those engaged in decommissioning, waste management and nuclear liabilities management. Members also include nuclear equipment suppliers, engineering and construction firms, nuclear research organisations, and legal, financial and consultancy companies.

Overview

3. The NIA strongly agrees with Government that the UK needs credible plans to decarbonise the power sector if it is to meet its energy security and climate change targets. Over the next decade and a half all but one of our existing nuclear stations could close, along with much of our coal fired capacity. It is therefore vital that a start is made soon on building low carbon technology. Delays in taking decisions now could result in the UK becoming locked into a high carbon energy scenario.

4. As a producer of safe, reliable, low carbon energy a nuclear new build programme has a key role to play in the UK's future electricity generation infrastructure. It will help strengthen UK energy security, and provide insurance against price volatility. Importantly it will also be a major engine for growth at a critical point in the economic cycle—a recently published IPPR[2] report estimated it could boost UK GDP by up to 0.34% per year (equivalent to £5.1 bn in 2011) for 15 years. However this will not happen unless urgent progress is made.

5. The UK is seeing a substantial commitment to new nuclear build, with EDF Energy and Centrica targeting the final investment decision on the first of two new projects at the end of the year. The Iberdrola/GDF Suez NuGen joint venture plans to build 3.6GW at Moorside in Cumbria, and Horizon has developed plans for further units at Wylfa and Oldbury, although new owners are currently being sought for the project.

6. However significant funds will be required to bring these plans to fruition, and new build investment will only proceed if the returns on that investment are economically attractive. This will only happen if the electricity market is transformed to reward low carbon generation, and specifically to provide the stable, predictable returns required to finance long term capital intensive low carbon projects.

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1 http://www.epsrc.ac.uk/newsevents/cons/Pages/nuclear.aspx
2 Benefits from infrastructure investment: a case study in nuclear energy June 2012

7. We therefore very much welcome last month's publication of the Government's draft Energy Bill. We believe the proposed reforms go some way to creating a package that could provide investors with the certainty they need to proceed with the construction of the plant that is critical to meeting the UK's goals on carbon emissions and security of supply.

8. Despite the Government's progress there is still insufficient detail and certainty to allow investment decisions to be made. It is vital that the outstanding issues are resolved quickly: new nuclear build will not become a reality without investment confidence in the proposals, and that will not exist until robust, long term, transparent, secure and Government backed arrangements are agreed.

Q1. *The Committee is aware of the significance of the electricity market reform process in determining the viability of investment in new nuclear power stations. What other factors contribute to investment decisions for new nuclear?*

9. Other key factors include a stable long-term policy framework, a rigorous and efficient regulatory regime, and an effective planning regime. We believe that the current administration, along with its predecessor, has made major progress in putting these in place. However, some investment uncertainty has been caused by changes to the investment framework for renewables, and it is essential that the Government continues to seek long term, consistent and wherever possible cross-party support and regulatory stability for nuclear power.

10. More generally no new nuclear programme can go ahead unless it has strong political support. We therefore welcome the fact that there is cross party support for the Government's approach to the nuclear issue, which is broadly reflected in public attitudes. An Ipsos Mori poll[3] taken in December last year showed that public support for new nuclear build had reached 50%, compared to 20% against.

11. However although this is a positive indicator, public and political support cannot be taken for granted. It is vital that the Government continues to be unequivocal about the energy challenge, presenting the case for nuclear in an objective way, and that it is seen to be acting in the best interests of both the UK electorate and electricity consumers.

Q2. *What have been the political and policy impacts of the Fukushima incident?*

12. The international reaction to the Fukushima accident has been very mixed. Although much publicity has been given to the decisions of Germany and Switzerland to phase out their nuclear programmes, worldwide many more countries with existing or proposed nuclear programmes are continuing with their plans. These include the USA; Russia; China and India, as well as France, Finland, Poland, Czech Republic, Slovakia and Lithuania in Europe, and several countries in the Middle and Far East.

13. In the UK the Government took a measured course of action following the event. Its response, importantly supported by the Opposition, was to commission the Chief Nuclear Inspector Mike Weightman to review what happened at Fukushima and to consider whether there were any implications for the UK. Dr Weightman's review subsequently concluded that there was no need to close British stations, that there were no fundamental weaknesses in the UK licensing regime, and that the strategy on siting of new nuclear power stations is sound. He did however note that there were several important lessons to be learned from the accident, and made a series of recommendations that the industry is now in the process of implementing.

14. We believe that his conclusions have reaffirmed the UK's excellent nuclear safety record and that this approach has helped maintain political and public support for new nuclear, as reflected in the opinion polls noted above.

15. Clearly an important commercial impact of Fukushima has been the decision of RWE and E.ON to sell their Horizon joint venture. Both E.ON and RWE have been very clear that their decision not to proceed was influenced by wider circumstances facing both companies at a global level, rather than on issues they faced in the UK; and specifically not the attractiveness of the UK for investment in nuclear new build.

Q3. *What lessons can be learnt for building new reactors to timetable and within budget from the experiences of France and Finland and elsewhere?*

16. Large civil engineering projects are complex, and delivering on time and on budget is not always achieved: the difficulties of cost overruns are not limited to the nuclear sector alone.

17. That said, construction times and budgets are primarily an issue for the new build consortia and vendors of nuclear power systems.

18. However it is worth noting that there are a number of new build projects underway in China and Korea that are progressing to time and to cost. The key is that the UK will build international designs which have been built elsewhere before they are deployed in the UK. Industry is learning lessons from those programmes, and for example is taking note of the issues encountered at Olkiluoto and Flamanville. These lessons will be applied in the UK, which will help to reduce the "first of a kind" problems associated with new designs. It is important to note, however, that to maximise learning from projects overseas it may be necessary and

[3] IPSOS MORI Nuclear Update 2011

advantageous to the UK new build programme to bring experienced staff from those overseas sites to work on the developments in the UK.

19. As mentioned above the UK has also implemented a number of programmes that are operating in parallel to help ensure that the build process can move forward in a timely manner. These include the Generic Design Assessment (GDA) process, the reform of the planning system, and the Funded Decommissioning Programme (FDP) arrangements that will help ensure we can deliver these projects to time and to cost. The GDA process in particular is proving critical to the successful delivery of the new build programme as it is allowing emerging issues to be addressed at the design stage before projects proceed to construction.

20. The UK civil engineering and construction industry is keen to demonstrate its capability to deliver major infrastructure projects on time and within budget. With this in mind both clients and contractors in the civil nuclear industry are actively seeking to ensure that the principles of best practice are applied to the new build programme.

21. The NIA is working closely with Government on its Supply Chain and Skills Action Plan, with the UKTI on promoting the nuclear sector in overseas markets, with other organisations such as the Nuclear Advanced Manufacturing Research Centre and the National Skills Academy for Nuclear as well as with our members to ensure that a vibrant and capable supply chain and workforce will be available to take on and overcome the challenges that Britain's nuclear business—be it in current operations, decommissioning and waste management or in delivering the new build programme—will demand.

22. We are all working towards the same objectives of ensuring that there will be no delays to nuclear new build in the UK due to the quality and capacity of the domestic supply chain, that the domestic nuclear market provides a platform for export, and that UK economic activity from the nuclear sector is maximised.

Q4. *What impact might global demand for nuclear put on plans to build new nuclear power stations in Britain (there are currently 60 new nuclear power stations under construction worldwide and a further 150 planned)?*

23. Whilst it has been suggested that a major worldwide nuclear renaissance could lead to some pinch-points—for example in the supply of very large forgings for reactor pressure vessels and turbine generators—in practice global capacity has increased and sensible advance ordering (in EDF's case by Areva) should avoid this. Industrial capacity is not a fixed sum and we do not believe that limitations on resources will be an obstacle to the delivery of the new build programme in the UK. That said, clearly it would help avoid potential bottlenecks if the UK were to be at the forefront of new build.

24. More generally the UK nuclear supply chain has significant relevant experience and expertise, and the NIA is in the process of updating its earlier (2006) report into the UK's ability to contribute to the UK new build programme. The report has not yet been published but it concludes that whilst there are specific elements of a nuclear power plant that cannot be supplied from the UK, including the reactor pressure vessel, steam generator and turbine and the associated ultra-large forgings, UK industry is capable of supplying and installing most of the plant and equipment required for a new plant, together with all of the civil engineering and construction. In this context we would note that, with the support of Government, the NIA has been pursuing a Nuclear Supply Chain Development Programme (SC@nuclear) which is designed to raise awareness of the opportunities and to help strengthen and promote the capability of the UK supply chain so that UK companies can play a full role in future nuclear developments at home and overseas.

Q5. *Are there any other potential barriers to the construction of new nuclear power stations in the UK?*

25. We believe that the facilitative actions being taken forward by successive Governments—for example in ensuring that the regulators, primarily the Office of Nuclear Regulation (ONR), are adequately equipped and that legislation is in place for funding decommissioning and waste management liabilities—will remove many of the barriers. We support the creation of the ONR as an independent statutory body outside the Health and Safety Executive, and support the principle in the Funded Decommissioning Programme that nuclear operators should pay the full costs of decommissioning and their full share of waste management costs.

26. It is clearly important that the UK should have the necessary skills base to deliver a new nuclear build programme. The Government and industry are working closely to address this issue, for example through the work of Cogent and the National Skills Academy for Nuclear. EDF Energy have made major investments in the Somerset area to enhance skills around the Hinkley Point C new build project, and Horizon continues to support the North Wales Apprenticeship Agency and works closely with Coleg Menai. Several major contractors are investing in facilities and training programmes.

27. We welcome the formation of the Nuclear Energy Skills Alliance. It would be helpful if, through this initiative, more could be done to facilitate access to funds from Government which will help young people to develop the skills they will need.

Q6. *Other than reforming the electricity market and planning process, what steps could the Government take to remove barriers to the delivery of new nuclear power stations in the UK?*

28. If the UK nuclear new build programme is to progress quickly it is important that EDF Energy should be in a position to take its investment decision on the project at Hinkley Point, as proposed, by the end of this year. Given that the Energy Bill will not become law until 2013 it will be important to have transitional arrangements in place before then—and we understand that Government is working with developers (through the Final Investment Decisions Enabling process) to achieve this. It is crucial that both Contract for Differences (CfD) and Investment Instruments, irrespective of when they are signed, are legally robust for the long term.

29. More generally the Government needs to continue to progress the various facilitative measures referred to above. It also needs to ensure that the UK's energy policy objectives are taken into account in relevant EU decision making, and more broadly that nuclear's carbon reduction, energy security and competitiveness benefits are recognised in EU energy policy formulation.

30. On a separate issue, the Committee may be aware that DCLG has been considering how communities hosting national infrastructure development might further benefit from such projects, and last year put out proposals for business rates retention for local authorities. In this context we have been arguing that their proposal to allow local authorities to keep the business rates from renewable projects should be extended to include retention of some of the business rates from new nuclear generation. In our view the rationale is the same—nuclear like renewables will help achieve the UK's energy security and carbon reduction targets, and importantly in the current climate, will help drive investment in new jobs and businesses.

31. Looking further ahead we agree with the House of Lords Science and Technology Committee that more consideration needs to be given to the role for nuclear power in the longer term. As the cheapest low-carbon form of energy, nuclear will be vital for our energy needs and security going far beyond 2025, and it is important that a long-term energy strategy is set out now to avoid making short-term decisions later. We therefore welcome the Government's recent commitment in their response to the Committee to publish a long-term strategy on the role of nuclear this autumn, including an R&D roadmap. The NIA is represented on the Advisory Board that has been set up under Sir John Beddington's chairmanship to take this forward.

Q7. *How feasible is the Government's indicative timeline, which shows the first new nuclear power station being built by 2019? And what level of nuclear capacity is likely to be available by 2025?*

32. This is essentially a question for the new build operators. EDF have said that they will be in a position to provide a completion date for the first new plant at Hinkley Point C when they have made their final investment decision towards the end of this year.

33. The level of capacity available by 2025 will depend on the progress made by the new build developers in taking forward their plans. Through swift progress on the EMR process and remaining facilitative measures, government can maximise the opportunities for private developers to deliver in this timescale. Clearly a major factor will be the future of Horizon, although as indicated in paragraph five new owners are currently being sought to take the project forward. It would be anticipated that any new owner would be able to avoid unnecessary delay by building on the important development work already undertaken.

34. In the EMR White paper of June 2011 the Government set out a timetable of Royal Assent for the enabling legislation by spring 2013. This deadline must be met.

Q8. *What will be the consequences of failure to deliver a first new nuclear power station by 2019? Should any contingencies be put in place?*

35. The nuclear new build programme is vital if the UK is to meet its energy security and carbon reduction targets, and maintaining momentum is extremely important. That said the 2019 target for the operation of the first new unit is not the primary goal. The key point is that a start should be made as early as possible on the first new nuclear project, and that there should be a national commitment to a programme of nuclear new build projects. This will boost confidence; encourage investment by supply chain companies and lead, over time, to export growth opportunities.

Q9. *What are the prospects for extending the life time of existing reactors?*

36. This is primarily a matter for the operators. The NDA have announced that the remaining reactor at Wylfa is expected to run until 2014. EDF Energy has said that, subject to the necessary formal reviews and approvals, they are expecting an average life extension of seven years across the AGR fleet, and that the strategic target for Sizewell B remains a 20 year life extension. Running the existing power stations for longer than originally envisaged will require investment, and provide opportunities for the UK's nuclear supply chain.

37. Given these timescales it is clear that life extension, whilst desirable, is not a substitute for nuclear new build.

July 2012

Written evidence submitted by Nuclear Issues[4] (NUC 03)

ANSWERS TO QUESTIONS:

The Committee is aware of the significance of the electricity market reform process in determining the viability of investment in new nuclear power stations. What other factors contribute to investment decisions for new nuclear?

There is no need to consider anything else. We need to get on with it not talk about it.

What have been the political and policy impacts of the Fukushima incident?

Ridiculous over reaction to an accident which was due to an extreme event beyond anything we are likely to experience.

What lessons can be learnt for building new reactors to timetable and within budget from the experiences of France and Finland and elsewhere?

French and Finnish construction is suffering from cost overruns and delays which are sadly symptomatic of nuclear projects but they are still committed to the projects and they will eventually make respectable profits.

What impact might global demand for nuclear power put on plans to build new nuclear power stations in Britain (there are currently 60 new nuclear power stations under construction worldwide and a further 150 planned)?

Hopefully somebody will notice the large global efforts and will encourage us to follow suit.

Are there any other potential barriers to the construction of new nuclear power stations in the UK?

None except the desire to talk about everything first.

Other than reforming the electricity market and planning process, what steps could the Government take to remove barriers to the delivery of new nuclear power stations in the UK?

Urge everybody of the need to get on with it.

How feasible is the Government's indicative timeline, which shows the first new nuclear power station being built by 2019? And what level of nuclear capacity is likely to be available by 2025?

Not feasible unless we do something now rather than talking about it. By 2025 we might only have about 1,600 MWe unless we get a move on.

What will be the consequences of failure to deliver a first new nuclear power station by 2019? Should any contingencies be put in place?

Disastrous increase in the cost of electricity. There is nothing else that can supply large amounts of low cost, clean and affordable electricity.

What are the prospects for extending the life time of existing reactors?

Possible but not enough.

May 2012

Written evidence submitted by Peter Mellor (NUC 10)

1. It is with considerable regret and some fear that I have to accept the need for new nuclear generation of electricity in the UK. It has become necessary because so little has been done throughout decades to develop wave power. Both Governments seem to have been beset by wind and solar power; the energy industry finds it easier and presumably more profitable to develop 20th century technology. It still claims to put safety as its first priority when that is not true.

2. Since nuclear power was introduced the government and industry have not been honest with the public about risks and costs. This has resulted in considerable disquiet about the forthcoming re-introduction of nuclear power into the mix of fuels. The doubts are compounded by the present desperation of the government relying on the private sector who have often run rings around government regulators and politicians.

3. I regard a Uranium-fuelled PWR as doubly dangerous and only kept "safe" by extreme engineering which works under the conditions anticipated when the plant was designed. The double dangers will be set out below.

[4] The monthly newsletter on facts about nuclear power.

4. Three Mile Island and Chernobyl were both the result of experimental tests which were not anticipated at the design stage and inadequately understood by those in charge. The technology then available and the safeguards built in were not able to identify the real cause and find a solution until too late. Indeed, the wrong measures were taken which made the situation worse.

5. Fukushima was the result of a massive earthquake and tsunami: both could have been anticipated and provided for. However, hindsight is easy to understand and is not available at the time of design.

6. Many argue that Fukushima was not a nuclear accident (or incident) but they should recognise that the tsunami struck a wide length of the coast where the damage was considerable to those living there. However, it was the damage to the nuclear plant that made Fukushima a much more serious situation. Although the nuclear plant was not the primary cause of the accident it was centrally responsible for the massive damage, and cost (in so many ways) actually incurred. If the Japanese Government had not demanded human intervention into a highly radioactive area the outcome would have been even more serious.

7. The inherent dangers of the nuclear plant at Fukushima, which shares many similarities with other plants, changed a serious earthquake into a very bad incident. We do not yet know the loss of health and life due to the nuclear addition to the tsunami. However, it is likely that an area of land will be unusable for a considerable period. Both Germany and Japan have stopped further investment in nuclear power (at least temporarily) whereas my Government is keen to subsidise it, not out of Government funding but as a swinging tax on the electricity bills for generations.

8. In the UK we are less likely to experience a major tsunami and many have written Fukushima off as irrelevant. Fairly small modifications are proposed at our existing nuclear stations and we are not told what changes will be required for new nuclear stations. At Sizewell B the main change is the addition of an "Emergency Centre" which includes a diesel generator on higher ground. The details are still sketchy but it is very important that the connections and control systems are of adequate integrity, certainly not relying on radio control of any sort. If any fault occurred which made the site as dangerous as at Fukushima there needs to be the ability to get water cooling pumps working, preferably without any actual human intervention in high radiation areas.

9. The UK has made many enemies around the world and our nuclear power stations are possible targets. Any action, by physical invasion or personnel infiltration, which can circumvent the engineering safety measures could result in an incident ranging from bad to catastrophic. Consider the loss of an area within 19 miles (the Chernobyl Evacuation Zone) of any of our UK nuclear power stations for hundreds of years and the increase in radiation affecting a much wider area.

10. When a Uranium reactor is "shut down" the heat output falls to between 5% and 10% of rated power. For a 1,200MWe reactor the maximum heat output would be about 3,000MW so the "shut-down" heat output would be between 150 and 300MW—a considerable amount of heat. If this residual heat cannot be removed the reactor temperature will rise to dangerous levels resulting in hydrogen generation and possible meltdown. This is exactly what happened at Fukushima—the shut-down controls worked perfectly but the external electricity supply and pumps, required to remove the residual heat, failed. Thus a uranium-fuelled reactor is inherently very dangerous and only made acceptable (to some) by the most elaborate and complex engineering. Any situation not thought of by the design engineers is likely to result in some level of catastrophe. The extreme complexity means that the normal operating staff may be able to cope if the automatic regulators fail. Any proposals to use ever-more sophisticated computer control, possibly remotely, is really asking for trouble. Radio control of important facilities should be outlawed because of their susceptibility to failure and hacking.

11. Nuclear reactors have to run at high temperatures to generate sufficient power efficiently. Liquid water can only exist at such high temperatures at high pressures, typically 2,500—3,000 psi. The Pressurised Water Reactor was designed for nuclear submarine propulsion where there was little alternative. A large vessel at such a pressure is a second danger which requires amazing integrity of engineering and constant monitoring to keep it safe, particularly from any external influence which could penetrate those safeguards and cause a serious disaster. The containment building might cope with the volume of gas released but not a hydrogen explosion—as seen at Fukushima. If a vessel did fail, due to a fault, mismanagement, external instability or terrorism then a massive radioactive release would then be inevitable. Any leak, explosion or intentional venting takes with it radioactive material usually into the atmosphere or sea.

12. Since nuclear electricity was first considered there has been a safer alternative but uranium was chosen in favour of thorium to provide nuclear materials for military purposes and I hope that this is not a present reason for its continued use. Stocks of uranium and their cost look likely to become at some risk as the number of uranium-fuelled power stations increases, along with the accompanying risks for military uses.

13. Thorium is more plentiful than uranium and yields something like 200 times the energy per unit of mass so its availability and cost looks much better for the foreseeable future.

14. By contrast with a uranium-fuelled reactor, a thorium reactor can be closed down to a level which requires no external intervention so the problems of inadequate cooling such as at Fukushima simply would not happen. The advantage applies also to the possibility of alien attack or human mistake.

15. There are versions of thorium reactor which could be designed to use an admixture of uranium and actually use uranium waste products—thus helping to solve an outstanding major problem for which we have no satisfactory solution.

16. Molten salts can exist at high temperatures at ambient pressures and offer a much safer reactor coolant—often referred to as the Molten Salt Reactor (MSR).

17. The avoidance of high pressures offers the possibility of great simplification of a nuclear power station; possibly allowing smaller units to operate much closer to the use of electricity. If or when this were to become a commercial reality large users could install their own generators and leave consumer-subsidised central power stations under-utilised. The present Government proposals, to subsidise the profit of builders of new nuclear power stations, would then be left high and dry with the majority of consumers continuing to pay the profit subsidy unnecessarily for decades—worse even than PFI.

18. A Thorium reactor design is not yet available for a major power station but it never will be if the past decades of concentration on last century uranium-fuelled reactors goes on. Small and medium thorium reactors have been operated for several years. Similarly the use of molten salts has been trialled successfully. India, China and others are currently researching the development of a Thorium MSR but I hear of little Government understanding in the UK. The nearest UK offer is probably a proposal to develop a Thorium reactor with fission initiated by externally generated neutrons. That would need very careful consideration of the practicality and reliability of a very large accelerator.

19. The use of Thorium has been presented to the UK Government but neither it nor any of the likely suppliers—EDF & Horizon (whoever they may now be) are seen to be taking it seriously yet. Thus the UK Government is proposing to rely on foreign-imported wind turbines, foreign-imported solar panels, foreign-imported photovoltaic panels and foreign-imported old-fashioned uranium PWRs. No wonder we suffer a balance of payments deficit and always will.

20. If another PWR is built at Sizewell I would hope that it would be safer than all earlier stations but the Phase 3 technology for uranium-fuelled reactors is a substantial departure in design from Sizewell B, no doubt supported in glowing terms by both submissions. Thus, even a near-repeat of last century's technology is not without risks. Phase 4 uranium-fuelled reactors look like attempts to head off the Thorium alternative and will no doubt be adopted by my Government if our foreign nuclear suppliers, such as in (19), are still stuck with uranium-fuelled reactor technology. It is clear that EDF and my Government would prefer a tweak of the previous design to the development of a design which is inherently much safer.

21. Many Thorium reactors have been successfully operated in the past decades so the stretch in technology to realise full-scale power generators should now be quantifiable. China, India and the USA are all taking Thorium seriously leaving the UK waiting until we can import a working design from them.

22. Thorium MSRs are obviously not yet available for immediate construction and even I concede that additional base-load power generation will soon be required in the UK. That leaves three immediate alternatives, all designed to give us more time: (a) to construct an existing design (or something said to like it) with all haste, knowing that better, safer technology is available; (b) to maintain the existing nuclear power stations for additional years and (c) to build more fossil fuel stations. This latter option might seem contrary to our obsession with greenhouse gases but it is worth remembering that the UK only contributes about 4% to the global problem so a small fractional increase can be justified. However, buying a few years could only be justified if a longer-term plan were established and agreed, preferably across all parties and the people.

23. The current issues centre around the expectation that large nuclear power stations will continue to be required in the foreseeable future. However, Thorium MSRs and even Phase 4 uranium reactors are showing the possibility for smaller designs closer to the demands for electricity instead of within populations of "lesser importance". One private company in USA (Flibe) is developing Thorium MSRs of smaller size (20 to 30 MW) and planning for a product in 2021. Thorium reactors could also be considered for high energy processes that now use electricity. In such an important area it is worth a careful look at the effect of small reactors on the long-term large scale nuclear energy plans now being considered in Westminster (particularly noting the view expressed in (17) above.

June 2012

Written evidence submitted by Professor Steve Thomas, University of Greenwich (NUC 04)

Executive Summary

The promise of successive UK Governments that nuclear power plants could be built without public subsidy was never realistic partly because the economics of nuclear power are poor but mainly because the economic risks are too high for the utilities to bear. If the risk falls on the utilities, financiers will not be willing to lend the large sums of money needed to finance The Government's strong support for nuclear power put it in a weak bargaining position with the utilities who are still able to walk away from their UK plans at relatively low cost. As we near the point where the utilities must actually place the orders, the negotiations on the terms they will require are reaching a head.

Electricity Market Reform, especially the introduction of Contracts for Differences, gives the scope to shift the risks from the utilities to future taxpayers and electricity consumers. Whether these would amount to a public subsidy may be determined by the European Competition authorities. However, the potential financial burden of shifting the risk to the public for future generations to bear, decades into the future could be extremely high.

Experience at Olkiluoto and Flamanville and the uncertainties raised by Fukushima give little confidence that new nuclear power plants could be built to time and cost in the UK. Until the remaining regulatory issues in UK and USA are resolved and there are EPRs that have been built to time and cost (preferably in the West) and are operating reliably, there must be a serious question mark against the technology. Of the potential developers, EDF/Centrica looks the most likely but there are doubts marks against even their ability to proceed.

Failure of the nuclear programme would not jeopardise electricity supply security because the alternatives all have much shorter lead-times than nuclear power. However, if nuclear is not going to prove viable, it would be better to take the decision as soon as possible to avoid a larger volume of new gas-fired plants, which would operate for several decades, being built.

Introduction

1. This evidence is divided into five main sections:

- Nuclear economics;
- The potential technologies;
- The potential owners;
- How can new nuclear build be financed?; and
- Conclusions.

Nuclear Economics

2. To carry out a comprehensive analysis of the economics of nuclear power is a complex task requiring the forecasting of a large number of complex variables. However, the fixed costs arising from the construction account for a large proportion of the cost of a kWh of nuclear electricity so this evidence concentrates on the factors that determine these fixed costs. Other costs are relatively small, for example, fuel costs, or because of the way conventional accounting deals with long-term liabilities (eg, decommissioning), have little impact on a corporate analysis of nuclear economics. Liabilities are recorded as the "net present value", which is effectively the amount of money which, if invested today would grow sufficiently to meet the liability when it falls due. For example, if we assume an EPR would cost £5 billion to build and £2.5 billion to decommission, if decommissioning is carried out as quickly as 100 years after plant start-up and funds are assumed to earn the Treasury's recommended real discount rate of 2.5%, the net present value of the decommissioning liability would be about £200 million, only 4% of the construction cost. While these costs are not significant in investment appraisals, they are of concern to Government because if the funding method fails, as it consistently has in the UK, future taxpayers will have to bear the full undiscounted liability.

3. The fixed costs associated with construction are determined by three elements: the construction cost excluding finance ("overnight" cost); the cost of capital; and the reliability measured by the load factor.[5] High plant reliability cannot be assumed and, for example, the UK's AGRs have the poorest reliability record of any nuclear technology worldwide. The lifetime load factor of the Dungeness B AGR plant over 30 years is 45%, about half the level expected of it. There is no operating experience with the EPR or the AP1000 so there is no evidence they will be reliable.

4. For analytical purposes, the overnight construction cost should be used, usually quoted in $/kW of installed capacity, so, for example, a 1,500MW reactor costing $3 billion would be quoted as costing $2000/kW. Inevitably there are difficulties in making comparisons because of the effect of general inflation (for example, 3% inflation over 10 years would increase nominal prices by a third) and currency movements (for example, in the past 10 years, the pound/dollar exchange rate has varied from £1=$1.36 to £1=$2.10). This means any very precise comparison of international nuclear costs should be treated with scepticism.

5. When the new generation of nuclear designs, of which the EPR and AP1000 are part, was mooted a decade ago, it was predicted the construction cost would be $1,000/kW or less. Since then, the expected cost has continued to escalate to about $6,000/kW, a much higher increase than could be accounted for by general inflation or currency movements.[6] Despite this, in the Government's 2008 White Paper on nuclear power, it was assumed the construction cost would be only about $2,000/kW.[7] In May 2012, the *Times* reported that the expected cost of the two reactors at Hinkley Point was £14 billion. It is not clear if this is an overnight cost but if we assume the reactors are 1,700MW each and the exchange rate is £1=$1.55, this equates to

5 The number of kWh produced in a given time period (usually a year or sometimes plant lifetime) as a percentage of the power that would have been produced if the plant had operated uninterrupted at its full design power rating.

6 For an analysis of construction cost trends, see M Schneider, A Froggatt & S Thomas (2011) "Nuclear Power in a Post-Fukushima World" Worldwatch Institute, Washington, 85pp.

7 Department for Business, Enterprise and Regulatory Reform "Meeting the energy challenge: a white paper on nuclear power" Cm 7296, HMSO, London, p 61. http://www.berr.gov.uk/files/file43006.pdf

$6,400/kW, three times the level forecast by Government four years earlier. Real construction costs have escalated throughout the half a century life of the nuclear industry, the opposite of experience with most technologies where learning, technical progress and scale economies are expected to sharply reduce real costs. There is no sign that nuclear costs have stabilised, much less fallen and the Fukushima disaster can only increase costs further.

6. The cost of capital will depend almost entirely on how risky to the plant owners the project is perceived to be by financiers. The issues around risk are discussed in detail below.

The Technologies

7. When the Blair Government announced its nuclear programme in 2006 a central pillar of the programme was that a full Generic Design Assessment (GDA) would be completed by the safety regulator on several modern designs before construction was started. This was meant to ensure all significant design issues would have been resolved before construction start, thus avoiding some of the problems that had caused delays and cost escalation worldwide when design issues arose in mid-construction. Certifying several designs would mean that there would be competition between designs.

8. This process followed practice in the USA since 1992. However, it has not been adopted in other countries and, for example, the Olkiluoto EPR in Finland and the Flamanville EPR in France are being built without a generic design assessment with design issues being resolved during construction. Whether and how far this has contributed to the delays at these sites is hard to determine.

9. The GDA was commenced in 2007 with expected completion in June 2011. Four designs began the process: the Westinghouse AP1000; the Areva EPR; the GE ESBWR and the AECL ACR1000. The latter two designs have received no orders worldwide and they were soon withdrawn from the process.

10. Even before the Fukushima disaster, it was clear the GDA would overrun and final design approval could not be given on time. In December 2011, Interim Design Acceptance Certificates (IDACs) were issued for both designs, but with a list of issues still to be resolved. The IDAC has limited use for developers because until the design is finalised, it would be premature to place an order. Westinghouse placed its application on hold then and will not attempt to resolve these issues until it has a firmer UK customer. It did, however, receive generic design approval from the US authorities in December 2011.

11. The design issues for the EPR were expected to take about a year to resolve from December 2011. The parallel generic review process for the EPR in the USA was started in 2007 but completion has been continually delayed and in June 2012, estimated completion date was extended more than a further year to December 2014. Four firm orders have been placed for EPRs two for China and one each for Finland and France. Construction work on the Chinese plants started in 2009 but there is little reliable independent information on progress. Construction at the Finnish and French plants has gone dramatically wrong. Both plants are 4–5 years late and costs are currently expected to be about double the pre-construction estimates. Olkiluoto is at least two years from completion and Flamanville is four years from completion so there is no reason to assume there will be no further delays and cost overruns. There does not appear to be any dominant factor causing the problems, rather a long series of issues of various types from construction errors, to design problems.[8]

12. At present, the UK authorities are likely to be the first to complete a generic review of the EPR perhaps three years ahead of the country of origin, France, not a position the Office of Nuclear Regulation is comfortable to be in.

13. Any design other than the EPR and AP1000, for example, a Russian, Japanese or Korean design would need to go through the GDA process and, on past experience, this would take five to six years. So in the short- to medium-term, the EPR and the AP1000 are the only options.

The Developers

14. There was also a strong Government objective to have competition between nuclear developers. Three main consortia have been formed to build plants in the UK: the EDF bid (in which Centrica has a 20% stake; Horizon; and NuGen.

15. When EDF took over British Energy in 2009, Centrica took a 20% stake and Centrica also said it would take a 20% stake in new nuclear plants built by EDF. EDF plans to initially build four EPRs, two each at Hinkley Point and Sizewell with the first currently expected on line at Hinkley Point in 2019. There have been persistent rumours that Centrica may exit the agreement and even EDF's ability to finance these plants has been questioned because of the high level of debt the company is suffering from and because there are urgent calls for capital for its 58 operating reactors in France to meet post-Fukushima regulatory requirements.[9]

16. The Horizon consortium, a 50/50 joint venture between the two largest German energy companies, RWE and EON, was formed in 2009 combining earlier independent initiatives by the two companies. They expected to build four reactors, the first two at the Wylfa site (completion in 2019) and the second at the Oldbury site (2025). In March 2012, RWE and EON announced their intention to withdraw from the joint venture, but,

[8] S Thomas "The EPR in crisis" PSIRU, Greenwich.

[9] The *Times* "Soaring costs threaten to blow nuclear plans apart" 7 May 2012, p 29.

despite press reports of interest from Russia, China and Japan, no buyer had come forward by June 2012. It is not clear how long Horizon will continue in business if no buyer is found. The German companies cited difficulties of raising finance as the main factor behind their withdrawal. The Horizon consortium had continually delayed announcing whether it favoured the EPR or AP1000 and this remained unresolved when EON and RWE announced their withdrawal.

17. The third consortium, NuGen, was set up by GDF Suez, Iberdrola (owner of Scottish Power) and Scottish & Southern Energy (S&SE) in 2009 with an objective to build two reactors at the Moorside site at Sellafield by 2023. S&SE withdrew from the consortium in September 2011 and S&SE is now highly critical of the UK nuclear programme.[10] NuGen has not made its reactor choice yet and its plans are far less advanced than those of Horizon or EDF.

18. The "big six" UK energy companies (EDF, RWE, EON, Iberdrola, SSE and Centrica) are the most logical candidates to build new nuclear plants in the UK and all are or have been already involved in consortia to develop nuclear power. In Europe as a whole, there are five dominant companies (EDF, RWE, EON, GDF Suez and ENEL), the smallest of which is more than twice the size of the next largest group of companies (Centrica, SSE, Iberdrola and Vattenfall). Of these companies, only ENEL (Italy) and Vattenfall have not been involved in a UK consortium. With no future for nuclear power in Italy, ENEL is unlikely to want to pursue nuclear in the UK. Vattenfall, the state-owned Swedish company was reported to be interested in being part of a UK consortium early on but has shown little interest recently. Outside Europe, China and Russia are mentioned as possible developers. Russia would almost certainly want to use Russian technology and the GDA process would mean they could not start building before about 2020 at the earliest. For China, the plants it is building are all of imported design (an old French design probably not licensable in UK, the EPR and the AP 1000). China would therefore need to work with Areva or Westinghouse if it was to try to operate in the UK.

19. In the short- to medium-term, EDF with the EPR appears to be the most realistic developer of nuclear power in the UK.

How can nuclear power plants be financed?

20. Prior to the liberalisation of electricity markets, financing nuclear power plants was easy because there was an implicit guarantee that consumers would pay whatever costs were incurred. This meant the risk that banks would not be repaid their loans was minimal.

21. As soon as the guarantee of cost pass-through was not there, finance became a problem. In the USA, ordering came to a sharp halt in 1979, not due to Three Mile Island, but because regulators were increasingly unwilling to pass on cost overruns to consumers, requiring utilities to take them out of their profits. This resulted in an end to ordering for more than 30 years and the cancellation of more than 100 orders many of which had already seen a significant amount of construction.

22. The privatisation of the UK electricity industry and introduction of a competitive electricity market effectively ended the nuclear power construction programme in the UK. Elsewhere in Europe, the few nuclear orders placed in the past 20 years have been in countries where there is still a *de facto* electricity monopoly (EDF in France) or where the output of the plant is contracted at cost-plus terms for the life of the plant (the Olkiluoto plant).

23. Electricity liberalisation raises three risks: unprofitability, market risk and technology risk.

Unprofitability

24. If nuclear is not competitive, it is relatively easy in principle to deal with. Some form of support—essentially a subsidy—for example, the Government's Carbon floor price or its proposed Contracts for Differences (CfDs) can be used to make up the difference between nuclear's costs and the cost of the cheapest option. Under European Union competition law, such subsidies may be regarded as unfair state aid and would be illegal. The UK Government is reported to have been lobbying for nuclear power to be given similar status to renewables such a solar and wind and therefore be eligible for subsidy.[11]

Market Risk

25. Market risk arises because in any competitive commodity market, prices are unpredictable and typically follow a "feast and famine" pattern. The structure of nuclear costs is ill-suited to deal with this pattern because its cost structure is rigid, being dominated by fixed costs. This means that, unlike fossil fuel plants that can save most of their costs (fuel) if they are not operated until prices recover, nuclear plants incur most of their costs whether or not they operate. This means that in periods of low prices, nuclear cannot survive by shutting down (even if that was physically desirable) and will have to operate at prices that do not cover all its fixed costs and will ultimately fail. Even though the operating costs are low, they are not trivial. In 2002, British Energy's operating costs (about 1.6p/kWh) fell below the market price for electricity and the company collapsed. It was rescued by taxpayers taking on about £10 billion of liabilities and costs. Since its re-launch in 2005, its operating costs have continued to rise reaching nearly 4p/kWh in the year before its takeover by

[10] *The Daily Telegraph* "SSE attacks secrecy of talks on nuclear subsidy" 13 June 2012, p 5.

[11] *Deutsche Welle* "Four countries call for EU subsidies for nuclear power" 13 April 2012.

EDF in 2009. Fortuitously, the market price of electricity rose slightly faster so the company remains profitable. If operating costs continue to rise and the market price does not keep pace, the plants may have to be retired. This may be a more important determinant of plant life than licensability. Market risk can be dealt with by taking nuclear plants out of the market. For example, the proposed CfDs guarantee the income of the plant will be at a certain level regardless of market prices but they may not be acceptable under EU legislation.

Technology Risk

26. Technology risk arises because of the poor record of nuclear power plants being built to time and cost, and operating reliably. It is not unusual for nuclear plants to take more than 10 years to build, to cost several times their estimated cost and to produce 20–30% fewer kWh than expected. As nuclear power economics are dominated by the fixed construction costs, poor performance in these areas mean the fixed cost per kWh will be much higher than expected and, in a competitive market, the project will fail. The new generation of nuclear designs, brought to the market in the past decade, including the EPR and the AP1000 were claimed to have been designed to overcome these problems being simpler, therefore cheaper and easier to build than their predecessors as well as being safer. However, they are not cheaper and on the limited evidence from Olkiluoto and Flamanville, not easier to build. Their reliability remains untested. Until there is solid evidence that the problems of the past have been overcome, financiers will not be willing to be exposed to the technology risk.

27. For some technologies, the vendor will be willing to take on the technology risk by offering a fixed price contract (turnkey) for the whole plant so the customer knows exactly how much the plant will cost it and also performance guarantees. However, nuclear power plants are complex pieces of equipment requiring the involvement of many contractors in their construction as well as being dependent on the input of the customer. The main vendor is not in control of the whole process and price and performance guarantees too risky. So whole plant turnkey contracts are a rarity and performance guarantees have never been given. The Olkiluoto plant was sold under a turnkey contract but when costs began to escalate, the vendor, Areva, was unwilling to honour the contract and the issue of who will bear these extra costs will be settled in the Stockholm Court of Arbitration.

28. The only way to deal with technology risk is full cost pass-through to consumers. In the UK context, this could be done through escalators in the CfDs so that if construction costs did overrun, the price paid would cover these additional costs. When the UK electricity industry was privatised, the Government imposed CfDs on the distribution companies and the two generation companies (National Power and PowerGen). The detailed terms of these contracts were not made public and it seems highly unlikely that the terms of any nuclear CfDs would be made public. Even though the costs will be imposed on consumers it will be claimed they are commercially confidential.

Conclusions

29. Even if the Government's optimistic estimate of construction costs had been realistic, the promise that new nuclear power plants could be built to compete in the open market without subsidy could never have been fulfilled. Financiers are not willing to be exposed to the economic risks that building and operating nuclear plants entails.

30. The Blair Government's strong commitment to nuclear, confirmed by later Governments, put the Government in a very weak negotiating position in relation to the utilities. There was inevitably a period of at least six years from the Government's decision in favour of nuclear power to the point where utilities would have to make a serious financial commitment to nuclear projects. Until a firm order is place, involving a commitment of more than £10 billion, utilities would need to spend only a few hundred million pounds, a sum they would be prepared to write off if the terms offered were not attractive. By contrast, the Government would have committed six years of resources and political prestige to the project. Utilities therefore had an incentive to claim the nuclear plants could be built at the start, in the knowledge it was a promise they could not be held to and in the expectation the Government would be forced to offer concessions to keep the nuclear programme from collapsing.

31. We are now approaching the inevitable endgame as utilities and financiers try to negotiate terms that will leave as little as possible of the economic risk with them passing it on to taxpayers and electricity consumers.

32. It is too early to judge what the impact of the Fukushima disaster will be but, like Three Mile Island and Chernobyl, they will, for most countries, not be the turning point they are often seen as. Ordering in the USA stopped after Three Mile Island and in Europe after Chernobyl because of underlying techno-economic problems that had been building up. The accidents accentuated these problems but did not create them.

33. Even before Fukushima, the forecast date of first power in 2019 looked optimistic and is now unrealistic. Uncertainties about the technology, the developers and the viability of CfDs mean that there is a serious risk no plants will be built at all. The remaining life of the existing plant will depend partly on their continuing licensability but also on their economics and it may be that, even with a guaranteed Carbon price, their costs will be too high for them to continue in operation. What will replace them and the expected contribution from new nuclear plants if this does not materialise will depend on Government policy, but the options, gas, renewables and energy efficiency, all have much shorter lead-times than nuclear and with many new projects at the planning stage. So the collapse of the nuclear programme should not jeopardise supply security.

34. To have to admit failure with the nuclear programme would be a bitter blow for the Government to swallow. However, if that ultimately has to be the decision, it would be better if it was taken now rather than carrying on a long-running and ultimately fruitless negotiation with the utilities. The Government could then give much stronger support to the alternatives, energy efficiency and renewables that will be most effective in helping us meet our climate change objectives.

June 2012

Written evidence submitted by the Royal Academy of Engineering (NUC 21)

What have been the political and policy impacts of the Fukushima incident?

The most significant impact has been the decision by the German owned utilities E.ON and RWE npower to withdraw from nuclear power in the UK, leaving Horizon Nuclear Power (owners of Wlyfa and Olbury nuclear sites) to seek new owners. This will undoubtedly result in a significant delay in progressing what should have been a second programme alongside that of EDF and Areva at Hinkley Point.

It has significantly increased concern in the supply chain regarding the number of reactors which might be built and their timing. There is likely to be an unwillingness by the UK supply chain to invest, in advance of firm decisions being taken to proceed. So if the UK does not move reasonably fast, the supply chain capacity may be diverted to projects elsewhere and this could affect the schedule for nuclear build in the UK.

Public opinion polls indicate that although support for nuclear power dropped in the immediate aftermath of the accident at Fukushima, the effect was short lived and within six months had returned to a similar, if not higher level.[12]

The review by the UK Regulator was thorough and well received, indicating no major reasons to halt progression of new build or to limit the operation of the existing units. Some recommendations for action to further reinforce capacity to withstand extreme events were readily accepted by industry. The work being done by the UK in assisting Japan has been very well received and could result in substantial benefits through contracts for UK companies in Japan.

What lessons can be learnt for building new reactors to timetable and within budget from the experiences of France and Finland and elsewhere?

The *Engineering the Future*[13] publication *Nuclear Lessons Learned*[14] set out some of the key findings from the experiences of developing new reactors in France (Flamaville) and Finland (Olkiluoto). The Academy recommends the report to the committee as being an authoritative review of the lessons learnt from nuclear build.

What impact might global demand for nuclear power put on plans to build new nuclear power stations in Britain (there are currently 60 new nuclear power stations under construction worldwide and a further 150 planned)?

Resources in the two main vendors Areva and Westinghouse Electric Company may become stretched as their order books increase and they may decide that other markets are more attractive business propositions than the UK. Some key items such as reactor pressure vessels and steam generator tubing may be pinch points in the global supply chain for heavy components.

Are there any other potential barriers to the construction of new nuclear power stations in the UK?

Given the large up-front capital costs of a nuclear plant, financing will be the major barrier to the construction of new plants in the UK. This will become increasingly difficult for each successive unit should a programme of several plant be attempted. Investors will be seeking confidence in the long-term stability of energy prices and, in particular, the rules on emissions targets and carbon price. Fear of rule change could be a significant deterrent to obtaining finance for nuclear projects.

How feasible is the Government's indicative timeline, which shows the first new nuclear power station being built by 2019? And what level of nuclear capacity is likely to be available by 2025?

Given a typical build period of around five years, it should be possible for the first new nuclear plant to be built by 2019—but only if no further delays are encountered. The issue of planning remains an important one and is unresolved following the closure of the Infrastructure Planning Commission.

In 2025, the only nuclear plant that is expected to still be operating is Sizewell B; however, it is possible that other plants may have their lives extended with Heysham 2 and Torness being the most likely candidates given that they are expected to shut down only two years earlier in 2023 (see below).

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[12] www.ipsos-mori.com/researchpublications/researcharchive/2903/Nuclear-Energy-Update-Poll.aspx
[13] www.engineeringthefuture.co.uk
[14] www.engineeringthefuture.co.uk/government/pdf/Nuclear_Lessons_Learned_Oct10.pdf

It is possible (although by no means certain) that new plant could be operational at Hinkley Point C and either Wylfa or Oldbury amounting to over 6GW but that is dependent on EDF taking the decision to proceed and new owners being found quickly for Horizon Nuclear Power. Further units may be possible in that timeframe but any estimates would be purely speculative as there are no concrete plans for development of any other sites.

What will be the consequences of failure to deliver a first new nuclear power station by 2019? Should any contingencies be put in place?

The major consequence of failing to deliver a new fleet of nuclear plant will be the UK's ability to meet its legally binding commitments to reduce greenhouse gas emissions. Central to these plans is the need to decarbonise the electricity grid by 2030 and nuclear has a proven track record of providing predictable, low-carbon electricity. A future energy mix without nuclear would put the stability and security of the grid in jeopardy with potentially serious consequences for business, industry, health and wellbeing and standard of living.

There are, of course, alternative sources of low-carbon electricity including renewables and CCS as well as demand reduction and management. The target is very challenging in terms of deliverability and it is difficult to see how it would be achieved without substantial nuclear power.

What are the prospects for extending the life time of existing reactors?

The prospects of extending the life of existing plants are increasingly limited due to issues with the structural integrity of the graphite cores and issues with the boilers. There is still more that can be done to find ways of life extending the UK's AGRs. Ability to extend lives will depend very much on EDF's ability to make the safety cases for continued operations. Very detailed and sophisticated analysis and materials testing will be required in areas where the UK only has a small number of suitably experienced experts.

July 2012

Written evidence submitted by Sir Donald Miller (NUC 07)

1. In the Consultation paper on Electricity Market Reform the Government recognised the failure of the present electricity market to provide the required mix of generating plant with adequate margins of security and proposed to correct this by offering potential developers financial inducements in the form of Capacity or Premium payments. The Royal Academy of Engineering in a joint paper with the Institute of Engineering and Technology warned about the dangers of unintended consequences with this approach.

2. The draft Bill goes further, giving Government powers to require all suppliers to purchase shares of the energy output from plant constructed under Capacity Payments arrangements. The price for this energy is to be fixed by Government as a Contract for Differences of some 30 years duration. Producing robust and competitively priced long term contracts with so many variables potentially affecting the cost structure will be an immensely difficult if not impossible undertaking.

3. The plan presupposes that enough generators will be prepared to invest in high capital nuclear plant on which there will be no return for six years even though other competing generators confine their investment to heavily subsidised low business risk wind turbines with a pay back beginning after only two years. Investing in nuclear under these conditions would have implications for the share price of the investing company with the risk that there will be insufficient interest from private sector companies in providing this capacity at competitive prices.

4. There is no indication in the Bill or in the Ministers letter of 16 May to the Committee that these Problems have been recognised or how they will be dealt with. Clearly it is not in the consumers' interest to see incentives for good performance weakened or to pay the inflated prices required under this system to induce developers to construct new nuclear plant. Developers will be aware these arrangements will put them in a strong negotiating position; EDF have recently increased the estimated cost of their new nuclear by 40%.

5. It is not clear that Government appreciate just how weak their (or their agents) negotiating position will be in agreeing Capacity Payments and Contracts for Differences with the difficulty this poses for safeguarding Consumers' Interests. Government need the nuclear capacity but there is no necessity for any generator to provide it—only for suppliers to purchase the output if and when the plant is running and at whatever price Government agrees with the developer. This would mean even less competition than pre-privatisation when two Generating Boards vied in construction and operating performance.

6. In summary under these proposals the Government would:

(a) Determine how much nuclear we need.

(b) Have no certainty that developers will offer the required capacity at acceptable prices.

(c) Seek to substitute negotiated settlements instead of relying on market disciplines and competition to safeguard consumers' interests.

(d) Take powers to compel all suppliers to purchase shares of the energy output at defined rates.

(e) Risk unintended consequences which cannot be foreseen, such as the effect it would have on the earning power of plant not constructed under the capacity payments regime

The proposals in the Bill will prove excessively complex to operate and the risk that the required outcomes will not be achieved is high. Other more straightforward approaches which do not involve Government in the commercial negotiations do not appear to have been adequately considered.

7. For example Government, while prepared to take powers to compel Suppliers to purchase shares in nuclear output under a specified CfD, have nor apparently considered taking powers to encourage developers to provide the required mix of generating plant without Government themselves getting involved in the pricing mechanisms. It is not clear why it should be more appropriate to require Companies to sign up-front long term contracts purchasing the output at prices over which they have no control rather than taking powers, using a mix of incentives and penalties, to induce the Companies to participate in the financing of the required generation, especially when the large Generators and Suppliers are effectively the same Companies. The large Generators could fulfil their obligations by taking a share in a construction project or, failing that, by participating in the funding of a new plant constructed by others. It is to be expected that faced with these alternatives, generators would prefer to be active partners in consortia undertaking the construction of new projects. In either case they would then be entitled to a share in the energy production at out-turn costs. No difficult (impossible?) price negotiations by Government would be required and normal market disciplines would safeguard consumers' interest.

8. For the first of the new projects to be constructed in the UK it seems probable that some form of financial assurance will be required from Government. With this backing, since the large generators are also suppliers with established customer bases, their balance sheets should be sufficiently robust to allow non-recourse project financing using a mix of equity and debt, so limiting the liability of the parent companies to their equity investment stakes. It is noted that debt finance for new nuclear in the USA is to be backed by Government in the form of loan guarantees. Such assurances would result in better terms for borrowing (to the advantage of electricity consumers) and also provide safeguards against future policy changes which might impact on the profitability of the developments.

9. In the National interest the aim should be for the generators to form two nuclear groupings concentrating respectively on the Westinghouse and the Areva designs. This would afford a level of competition while restricting demands on engineering resources and fostering the build up of expertise in the design and construction teams. Equally vital, if the programme is to succeed, is to ensure continuity of energy policy and restrict design changes in successive projects.

10. As to construction of new nuclear to time and cost, concerns in this area should not be overdone. The UK's follow-on AGRs nuclear plant had a creditable construction record (for example; those of which I have personal experience; Hunterston, although virtually a prototype, was less than a year late with cost overrun under 10% while Torness , although constructed after a long nuclear moratorium, came in on time and budget.). Both the Westinghouse and the Areva designs of PWR should on balance be easier to construct but success will depend on the forethought and care with which the projects are set up and manufacturing requirements addressed before the start on site. With Hunsterston most of the delay was due to the need to design and manufacture replacement core insulation after tests showed the initial design to be inadequate. For Torness (and its similar CEGB station Heysham) much care was taken in setting up the projects, for example. The SSEB jointly with CEGB carried out in-depth assessments of the various manufacturing areas and then, in advance of orders, financed the provision of the long lead time production facilities (gas circulators, graphite machining, and core insulation). This was successful and no delays occurred from late delivery of components to site. The importance of this pre-project work seems to have been recognised in respect of Rolls Royce for the nuclear submarines but strangely not in the case of Sheffield Forgemasters in respect of the civil programme.

11. To change course now to a more certain and effective approach for reforming the electricity market may be difficult but much less embarrassing to do so at this time before Government is forced to abandon their proposed system after all its complexities and high costs for consumers become apparent. To change now will also avoid further damaging delays in bringing much needed new nuclear stations into service.

June 2012

Written evidence submitted by SSE (NUC 28)

1. SSE is a UK owned and based company. Its core purpose is to provide the energy that people need in a reliable and sustainable way. Operating across the UK and Ireland, SSE is involved in the generation, transmission, distribution and supply of energy. It is currently the UK's second largest generator, and the largest generator of energy from renewable sources.

2. In 2011 SSE exited the NuGen consortium which is developing new nuclear at Sellafield, this was principally due to economic considerations.

3. SSE is concerned that mechanisms are being designed in the Energy Bill specifically to support new nuclear but that this will be at the expense of other low carbon technologies and consumers. The proposed CfD is well suited to nuclear generation, but less so for renewables, which have very different characteristics, or CCS which is still in its demonstration phase.

4. SSE therefore believes that different low carbon technologies should be supported by mechanisms which take into account their different characteristics and stages of development. This would mean separate mechanisms for renewables, CCS, and, if necessary, new nuclear.

5. If the Government believes that new nuclear requires support over and above the Carbon Floor Price then it should be explicit about the need for this support, and design a specific mechanism accordingly. One way of doing this would be to explicitly address the construction risk of building new nuclear through targeted support.

Energy Bill Proposals

6. The draft Energy Bill contains details of how the Government is intending to support new nuclear in the UK in the short term. In summary the Bill proposes a "behind-closed-doors" negotiation process to agree Investment Instruments between nuclear developers and the Government before the Energy Bill receives Royal Assent.

7. This negotiation will decide on key terms including the contract strike price; the contract length; penalties; and "get-out" clauses.

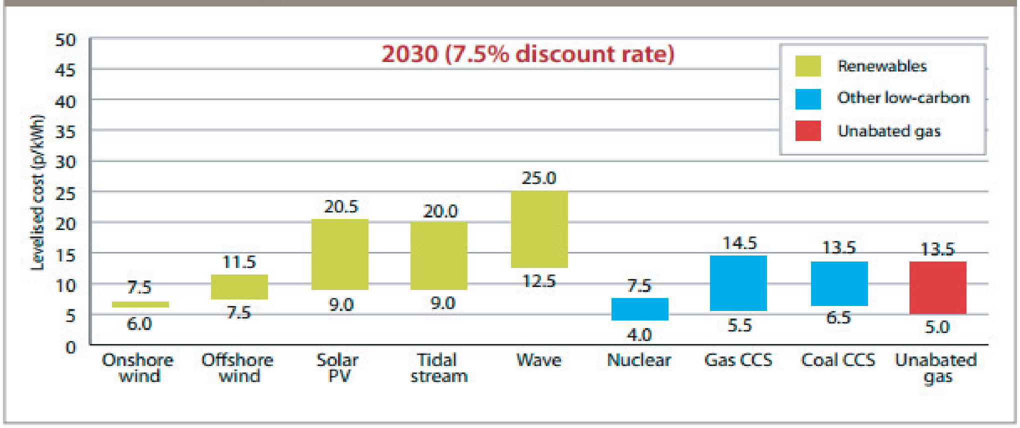
8. Given the opaque nature of this process there are concerns that the end result will be long-term contracts for nuclear being agreed by the Secretary of State with only limited detail of how much is being paid, why it is being paid at a particular level, or the contract terms.

9. There is also concern that Government will be at a disadvantage when negotiating contract terms for nuclear, both in the short term through Investment Instruments, and the long term through CfD contracts, because of the limited number of competition in the new nuclear market. This could mean that strike prices will be set higher than is needed to achieve an acceptable rate of return, and consumers will be locked into paying higher than necessary prices for considerable periods.

10. Another issue to be considered is that new nuclear developers will have to build the risk of: a) not getting State Aid approval, b) not getting a final contract for a number of other reasons, into their Investment Instrument strike prices. Clearly such risks have a cost and will only add to the "strike" price levels required.

11. Once CfDs are introduced the key challenge for Government is to avoid "under or over rewarding" nuclear through the subsidy regime that is constructed. In order to do this then SSE believes that the strike prices for new nuclear should be in line with independently conducted research, such as that carried out by the Climate Change Committee whose graph in figure 1 demonstrates their proposed cost range for all low carbon technologies.[15]

Figure 2: Estimated cost ranges for low-carbon power technologies at 7.5% discount rate (2030)



Source: CCC calculations, based on Mott MacDonald (2011) *Costs of low-carbon generation technologies.*
Note(s): As Figure 1, with 7.5% discount rate.

12. In SSE's view all technologies should receive a standard contract (which is publically available) and each technology should have a "strike" price. Only if a developer can accept those terms will it build a project. This would create an open and transparent framework.

13. Others in the industry have expressed similar concerns. In the Draft Energy Bill Select Committee evidence sessions, Keith Anderson, ScottishPower, told the committee: "the detail of these conversations [over

[15] See "The Renewable Energy Review", Committee on Climate Change, 2011 page 19.

the strike price] need to be made public". Furthermore, John McElroy, RWE npower, said: "it is important that there is sufficient transparency around what happens. We'd like to see the terms and conditions that are offered."

July 2012

Written evidence submitted by Tim Deere-Jones (NUC 33)

PREFACE

This Submission of Evidence to the Select Committee is based on work carried out over the last two years for a series of Consultation Responses made with specific regard to applications by NNB Genco to discharge liquid radioactive wastes from the proposed new Hinkley C Reactors on the north Somerset coast of the Bristol Channel.

Production of those Consultation Responses (hereafter referred too as Previous Consultation Responses) was jointly sponsored and funded by the UK and Irish Nuclear Free Local Authorities, CND Cymru, Friends of the Earth Cymru and the Stop Hinkley campaign. Those organisations have given their permission and support for the use of some of the research data, contained within the Previous Consultation Responses, to produce the following Submission to the Select Committee.

Readers will note high frequency reference to environmental and radiological work carried out in the Bristol Channel in the context of proposed new build NPS in that sea area. This has occurred in the context that the proposed Hinkley Point C nuclear power station is the first to be the subject of a development proposal.

However it is the intention of this Submission to address issues relevant to the entirety of the UK Nuclear New Build programmes and its possible impacts upon the entire range of UK marine and coastal environments and the human populations which will be exposed to radioactivity in those environments as a result of the discharge of radioactive wastes to sea from proposed new build NPS.

Tim Deere-Jones
Marine Pollution/Radioactivity Consultant

November 2012.

PRINCIPAL CONCLUSIONS

This Submission to the Select Committee identifies:

(a) Failures of scientific rigour in the scientific and technical contribution of both Developers and Regulators to the consideration of issues relating to radioactive waste discharges to the marine environment from proposed Nuclear New Build, leading to.

(b) A series of major flaws and data gaps in the understanding of the behaviour and fate of radioactive wastes discharged to the range of UK marine environments (sections 1 to 4).

(c) A series of major failures and inadequacies in the programmes put in place to monitor and analyse the behaviour, fate and concentrations of radioactivity in the range of UK marine environments (sections 5 to 9).

(d) Draws attention to the fact that those data gaps, failures and inadequacies must inevitably militate against the construction of accurate hypothetical models of radiation exposure pathways and dose rates to the public (sections 9 to 18).

(e) And the absence of discussion of post LOCA highly radioactive pollution of marine waters (Fukushima) (section 19 and Annex 1).

THIS SUBMISSION THEREFORE CONCLUDES THAT:

1. In the context of the conclusions listed above, proposals and decisions to proceed with Nuclear New Build developments are premature in the extreme.

and that

2. No decisions on UK Nuclear New Build, and subsequent discharges of nuclear wastes to the UK marine environment should be taken until the issues set out in this Submission have been settled.

1. *The original hypothesis (Nuclear Industry and UK Government) for the behaviour and fate of sea discharged radioactive wastes.*

1.1 In 1952, when the first sea pipelines for the discharge of liquid nuclear waste were commissioned at Windscale/Sellafield for the commencement of the UK's programme of discharges of radioactive wastes to sea, there was no scientific understanding of the behaviour and fate of radioactive wastes in the marine environment because such a programme had never before been undertaken. In the absence of any scientific data, the UK Government and the Nuclear Industry, in accord with international nuclear bodies such as the IAEA, appear to have adopted a hypothesis for the behaviour of radioactive wastes in coastal and marine environments.

1.2 The hypothesis postulated that long lived, non-soluble nuclides such as the alpha emitting actinides like Plutonium (Pu) and Americium (Am), would become adsorbed to the surface of sedimentary particles in the marine water column, sink to the sea bed and there remain permanently bound and immobilised in seabed (subtidal) sedimentary deposits isolated from human populations and their immediate environment. Less conservative nuclides, such as Caesium (Cs), would dilute and disperse through the water column until they reached "background" concentrations.

1.3 This hypothesis supported the adoption of the proposal that the behaviour of radioactive wastes discharged into the marine environment was such that "they can be diluted and dispersed so that the radiation to which any single individual would be subjected would be negligible". (Ref 1)

1.4 It was upon this hypothesis that the scientific and ethical justifications for the sea disposal of radioactive wastes were based and permission for the discharge of radioactive wastes from Sellafield was granted. In later years, as the UK's civil nuclear programme continued to evolve, the hypothesis also provided the scientific justifications for the sea disposal of radioactive wastes from the UK civil nuclear power stations, the great majority of which were sited on (or close to) the UK coastline and provided with pipelines which facilitated the sea disposal of radioactive wastes.

1.5 *N.B. Sea discharged radioactive wastes from reprocessing sites and civil reactors are generally referred to as "liquid" or "aqueous" wastes but in fact they are not composed entirely of liquid matter. Although, in terms of bulk or volume of discharge, they may consist of a high percentage of radioactively contaminated liquids such as secondary coolant, such discharges also contain a range of radioactive solid particles including pieces of irradiated fuel, metallic particles from reactor internals, pieces of radioactively contaminated discharge pipe line and other items. The records show that the majority of these items are micro-particles small enough to be suspended in discharge streams and the water column of receiving water bodies.*

1.6 The hypothesis appears to have been the basis for subsequent programmes of marine environmental sampling, analysis and monitoring of the behaviour and fate of sea discharged radioactivity in the marine environment. These marine environmental monitoring programmes have subsequently been the source of the basic data inputs to the hypothetical models of human population exposures to, and doses of, radioactivity from the marine environment (via a number of exposure pathways).

1.7 However, the real scientific ignorance of the subject was so great that, in 1958, the UK industry and regulators were forced to admit that the whole issue of sea disposal of liquid radioactive waste, particularly in the Irish Sea, had really been an enormous research project. (Ref 2)

Despite this admission, the original simplistic hypothesis appears to have remained the dominating historical justification for the discharge of liquid radioactive wastes to sea.

1.8 I have not found any over-arching statement from industry or UK government agency or regulatory bodies that has subsequently denied, revised or refuted this basic hypothesis. Thus, it is to be presumed that

(a) the hypothetical model has continued to be the basis of the UK nuclear industry's and the UK Government and Government Regulatory Agency position with regard to the behaviour and fate of liquid radioactive wastes discharged into the UK marine environment; and

(b) no evidence accrued as a result of the post 1952 research project has been of sufficient significance to change the industry, government or regulatory agency position on the discharges of radioactive wastes to sea.

2. *The current academic understanding of the behaviour and fate of both soluble and non soluble radioactive materials in marine environments.*

2.1 According to the International Council for the Exploration of the Seas, the fate of pollutants discharged to sea is dependant on the environmental conditions at the time of release and for a few months afterwards. (Ref 3)

It is now understood that soluble nuclides such as Caesium 137 can remain in solution in the seawater after discharge to sea, and may thus travel in the water column for both extended distances and time scales and still be detectable.

2.2 The marine distribution of Caesium 137, discharged from the Sellafield sea pipes, has been widely mapped in order to study its distribution and dilution in the Irish Sea and further afield.

This work demonstrates that soluble radio nuclides discharged to sea can be detected many hundreds of kms distant from source. Furthermore, this work demonstrates that such "soluble" radioactivity spreads out of one distinct sea "area" (the Irish Sea) and into other more distant sea areas (eg the Southern North Sea). (Ref 4)

2.3 Other work has demonstrated that insoluble radionuclides (such as those produced by the irradiation of uranium and other artificial elements), discharged to sea from the Sellafield site, can also travel hundreds of kms from source. Radio nuclides, such as Plutonium 239 (with a half life of 24,110 years), adsorb strongly to the outer surface of particulate matter suspended in the water column wherein they are available for transport in the water column (over extended distances and time scales) and subsequent deposition into fine sediment deposits such as estuarine and coastal mudflats and salt marshes. (Ref 5)

2.4 The 2009 monitoring of Irish Sea sediments, records the presence of the Sellafield derived actinides Plutonium, Americium and Curium isotopes in fine sediment deposits (salt marshes and mudflats) on the Irish Sea coasts of Cumbria, Lancashire, S.W. Scotland, North Wales and Northern Ireland. (Ref 6)

UK Marine monitoring reports invariable allude to the detectable presence of Sellafield derived Plutonium as far away as the Bristol Channel and the Southern North Sea.

2.5 Thus there is no doubt that both soluble and insoluble radio nuclides discharged to sea are physically adapted to being transported for:

(a) extensive time periods; and

(b) over extensive distances from point of discharge.

2.6 Thus there is now conclusive evidence to demonstrate that the original proposed model was over optimistic and simplistic with respect to the distribution of both soluble and non-soluble nuclides.

3. Radioactivity and Marine Sediments

3.1 There is now a strong and long established consensus that some radioactive materials closely associate with fine sediment particles suspended and/or deposited in marine/coastal/estuarine environments (by adsorbing to the outer surfaces of the particles). This is particularly noteworthy in the case of actinide/alpha emitters such as those listed in 2:4 above. (Refs 7&8)

3.2 One of the basic principles of marine sedimentary science is that fine particle material suspended in the water column is available for transport in marine water columns prior to eventual deposition into various environments under the influence of a range of parameters including the mixing of fresh and saline waters, flocculation and a range if other hydrodynamic factors.

Such deposition is shown to occur in both estuarine sediments, estuary fringing mudflats and salt marshes (Ref 9) and some offshore sediment deposits which are usually formed under the influence of slack tide and/or gyre type phenomena.

3.3 However such deposited material is subject to a number of phenomena (trawling, earthquakes [surprisingly frequent in UK coastal waters], storm surges and surface waves) that have an influence on shallow water sea beds and are capable of re-suspending and re-injecting sediment into the water column where it is once again available for further transport.

Heavier suspended particles and/or flocs (aggregates of suspended particles) have been shown to deposit out of the water column relatively quickly. However, finer particles may travel through the marine environment for more extended periods before deposition.

3.4 Because a given volume of finer/lighter particles have a relatively greater surface area than the same volume of coarser/heavier particles and because the fines tend to preferentially gather in the least dynamic, more low energy, sheltered and inshore environments it is usually the case that:

(a) samples taken from mudflats and salt marshes in such low energy environments consist of these finer particles; and

(b) these fine sediment deposits are generally found to contain the highest concentrations of adsorbed radioactivity and other pollutants.

3.5 Thus, in the Wigtown Bay/Cree Estuary area of the Solway coast of Scotland, monitoring of Sellafield derived radioactivity is carried out several inter tidal sites (ie estuarine shoreline sites which are exposed at low tide). This work demonstrates that the concentrations of the Sellafield derived actinides Plutonium (Pu) 238, Pu 239, Pu 240 and Americium 241 sampled at more "inner" estuary/bay (fine sediment) sites are markedly elevated over those sampled from the stony bottomed Garlieston Harbour at the mouth of the estuary/bay. (Ref 10)

N.B. Detailed reading of Ref 10 (and indeed any of the various aquatic environment monitoring reports) shows this to be a common feature through the entirety of the UK coastline.

3.6 The paragraphs above thus provide evidence for:

(a) the transport of non soluble nuclides away from the point of discharge and into distant environments; and

(b) the fact that non soluble nuclides become more concentrated in estuarine (fine) deposits as a result of their adsorption to the outer surface of fine sediment particles and their subsequent deposition in fine sediment deposits; and

(c) the fact that non-soluble nuclides are not isolated from human populations and their immediate environment by being "locked" into sea bed sediment deposits (as the original justifying hypothesis had proposed), but have been a long term feature along estuarine shorelines where they are thus in the exposed intertidal environments situated adjacent to local populations.

4. *Mechanisms and factors of reconcentration of radioactivity in the marine environments*

4.1 Studies conducted in the laboratory and in the marine environment have demonstrated that Irish Sea surface micro layers (only thousandths of a millimetre thick) become enriched with fine particle sedimentary material and their adsorbed radioactivity. These studies have shown Irish Sea micro layers to be enriched with non soluble Plutonium and Americium (associated by adsorption to fine sediment particles) by factors of four to five (relative to concentrations found in the ambient seawater) (Ref 7)

4.2 The above referenced study also reported on investigations of the enrichment of marine aerosols (generated by bubble production in breaking waves and the surf line) with non soluble nuclides (associated by adsorption to fine sediment particles).

The study reported enrichment factors (EFs), relative to ambient seawater, of:

(a) EF 291 for Pu 238.

(b) EF 347 for Pu 239.

(c) EF 347 for Pu 240.

(d) EF 583 for Am 241.

In marine aerosols generated 10 km offshore of the Sellafield sea discharge pipelines.

4.3 Other studies report EFs (relative to ambient seawater) of 812 for Am 241 in aerosols generated in the inshore surf zone along the Cumbrian coast. It is reported that this evidence implies that coastally generated aerosols may produce higher enrichment factors than those produced in more open sea environments (because of the higher ambient fine sediment loadings of inshore waters) and it was estimated that about 2 curies of Pu 239 and 240 had been transferred from the sea to the land over a 14 year period. (Ref 8)

4.4 There is a marked paucity of study of other potential marine enrichment mechanisms such as fog production, evaporation from sea surfaces and evaporation from exposed mud flats. However it has been calculated that algal blooms in the open sea may concentrate Plutonium by factors of up to 26,000 relative to concentrations in ambient sea water. (Ref 11)

4.5 It has also been demonstrated that soluble nuclides such as Caesium 137 become enriched in wet marine sediments in UK coastal and inshore waters (relative to concentrations in ambient marine water).

Thus, monitoring carried out in the marine environment adjacent to the Hinkley Point discharge pipeline reports:

— (a) seawater concentrations of Cs 137 (taken at the pipeline) of less than 0.33 Bq per kg; and

— (b) sediment concentrations of Cs 137 (at four Bridgewater Bay sites) ranging from 7.7 to 28 Bq per Kg. (max enrichment factor of 84)

(Ref 12)

4.6 It is thus a well reported and well understood fact that there are mechanisms of re-concentration in the marine environment for both the soluble and non-soluble radioactive wastes discharged into the sea and as a result of this phenomena there are sites where radioactive materials of both types accumulate/reconcentrate to levels many times higher than ambient sea water.

In this context, the original simple hypothesis that discharged liquid radioactivity will dilute and disperse until it reaches "background" concentration is now shown to be both simplistic and deeply flawed.

4.7 It is plain that the behaviour and fate of sea discharged radioactive wastes is actually far more complex than originally postulated and that a number of environmental parameters provide the opportunity for a range of intermediate and long term re-concentrations of radioactivity in inshore and coastal environments and media (sediment deposits, seaspray and aerosols)

5. *Monitoring radioactive wastes discharged to the marine environment*

5.1 As explained in earlier sections (above) the annual monitoring programmes carried out by government agencies remain rooted on the simplistic hypothesis that discharged radioactive wastes will dilute and disperse in the marine environment or remain bound to immobile marine sediments. Thus the major investigative effort is focussed on "near field" impacts close to the point source of discharge where, according to the hypothesis, radioactivity concentrations are likely to be at their highest and exposure of the public at its greatest.

5.2 Thus, contemporary monitoring reports such as "Radioactivity in Food and the Environment, 2010. (RIFE 16)" still explain that

— (a) "Most of the monitoring carried out and presented in this report concerns the local effects of discharges from nuclear licensed sites in the UK." (page 17).

— (b) There is "some ongoing monitoring of Chernobyl impacts" (page 17).

— (c) "Monitoring of food and the environment remote from nuclear licensed sites is also carried out, giving information on background concentrations of radio nuclides" (page 9).

NB these clauses are listed in their chronological order of presentation, which demonstrates their order of priority. Furthermore, the use of the words "background concentrations" in the third clause implies an expectation of very low levels similar to those that might be experienced from "natural" radiation.

5.3 RIFE 16 (page 9) also states that: "The data from the programmes will also act as a baseline against which future discharges from any new or existing nuclear power stations can be judged".

5.4 Recent desk reviews, carried out during production of Previous Consultation Responses related to the Hinkley C proposal, have provided a detailed case study of concerns related to the proposed marine environmental monitoring programmes for the Hinkley C PWR station set out in NNB Genco's Environmental Monitoring submission (NNB-OSL-REP-000137) and those long established programmes carried out by the UK regulating agencies and reported in the annual RIFE monitoring reports

5.5 Page 4 of the NNB Genco monitoring document submission (NNB-OSL-REP-000137) states that: the programme outlined for Hinkley Point C "is informed by the Environmental Monitoring Programme ongoing for Hinkley Point A and B power stations" and then (page 5) states that, with reference to the atmospheric monitoring at the A and B stations:

"A common strategy for collecting terrestrial samples is to divide areas into an inner zone, which is 1 to 6km from the station and an outer zone, which is 6 to 19km from the station" and argues that "This division helps to distinguish effects that might be due to power station operations from those attributable to external effects (non-site operations)."

5.6 Page 6 of the Monitoring document, still referencing the A and B stations but describing the marine sampling offers no comment on the zonal division, based on distance from the site, for the collection of marine samples. Thus there appear to be no identified inner or outer zones for marine samples.

No comment is given as to why such a policy is considered useful for the terrestrial monitoring programme, but not considered useful for the marine environment.

5.7 Fish and Shellfish monitoring

Para 1.2.2 (page 7) of NNB-OSL-REP-000137 says that fish and shellfish are indicator species because they are foodstuffs and because "they essentially sample the local water and consume other organisms". This is an imprecise statement that lacks scientific rigour, because it should have been made clear that different fish and shellfish sample different component sections of the local water.

The annual RIFE Reports for the Hinkley site present marine foodstuff sampling and monitoring outcomes in relation to the discharges from the currently operating Hinkley Point A & B NPSs. A review of the marine monitoring at and around Hinkley Point shows that the sample base is by no means extensive. Thus, it is the current practice to monitor only 1 or 2 samples of fish and shellfish (1 cod sample, 1 bass sample, 2 shrimp and 1 limpet samples) taken from just one area (Stolford).

5.8 Additionally, the RIFE reports fail to clarify whether the cod and bass were actually caught at Stolford or whether they were merely landed at Stolford, having been caught elsewhere. Cod and bass are both migratory fish (feeding on less sessile species than some other predatory fish), and the simple fact of their capture does not guarantee that any 1 individual of either species has been in the Hinkley area for any specific time period, nor indicate that they have fed on local prey species. Therefore, the claim that the monitoring of the cod and bass samples "essentially samples" the local water and marine food chain cannot be justified, lacks scientific rigour and is false.

This Submission proposes that sampling of a round fish species such as grey mullet (resident and feeding in estuaries and inshore waters), or demersal flat fish which habitually feed on or close to the seabed on relatively sessile (non-migratory) species, may present more appropriate monitoring species.

5.9 No detail is provided of the number of individuals in each "sample". There is no evidence that 1 sample of each of 2 pelagic fish species (living and feeding in the water column away from the seabed) represents a legitimate sample base for regional fin fisheries. The general and consensual assumption would be that the larger a sample base can be, the better (more representative), the data outcomes are likely to be.

Such a small sample base offers only a poor data outcome, thus lending more support to the contention that the seafood sampling lacks scientific rigour and provides inaccurate data outcomes.

5.10 It is thus the contention of this Submission that the fin fish sampling and monitoring programme for the existing Hinkley Point A and B stations does not provide a useful or accurate record of the representative radioactivity concentrations to be found in locally caught marine fin fish, hence the dietary dose calculations for locally caught fin fish are flawed.

The same flawed methodologies for sampling and monitoring programmes are proposed for deployment in respect of Hinkley Point C and will similarly fail to provide a useful and accurate record of maximum radioactivity concentrations from the proposed EPR reactors in locally caught finfish.

5.11 The Hinkley Point shellfish monitoring programme reported in the RIFE reports is little better than the fin fish programme. It is based on 2 samples of shrimps and 1 sample of limpets, again from Stolford. No details are provided of the constituents of a "sample" (numbers of individual animals, weight of sample etc)

Since limpets are widely recognised to be both sessile (immobile or at least highly localised) and very commonly distributed, at least it can be assumed that the limpets were indeed harvested at Stolford.

5.12 Limpets are not a significant or popular form of human dietary shellfish, normally favoured only by extreme survivalists, and thus have little relevance as a general seafood dietary indicator species.

Limpets are vegetarians and hence can be said to "essentially sample" the seaweeds at Stolford and to provide some insight into the Stolford seaweed based marine food webs.

However, 1 sample cannot be fully representative of the entirety of the Stolford limpet population, let alone the Hinkley Point regional population. It is therefore the contention of this Submission that that the Hinkley limpet sampling does not provide a useful and accurate data base representative of regional shellfish.

5.13 Shrimp are a popular decapod crustacean human dietary item. 2 samples of shrimps from Stolford are taken for the Hinkley station monitoring programme. It remains unclear whether the shrimp samples were captured at Stolford or were captured elsewhere and landed at Stolford.

Shrimp tend to be relatively sessile, have a small home range and are generally omnivorous. Hence shrimp samples will be representative of conditions at their (very limited home range) place of capture only. Additionally, 2 samples, attributed to 1 specific site (Stolford) fail to be representative of the entirety of potential crustacean/shellfish dietary items likely to be impacted by the Hinkley Point liquid radioactive wastes

5.14 This Submission concludes that the entirety of the fin fish and shellfish sampling and monitoring programme for the existing Hinkley Point A and B stations does not provide a useful or accurate record of the representative radioactivity concentrations to be found in locally caught marine foodstuffs, hence any dietary dose calculations (based on the monitoring outcomes) for locally caught sea foods are flawed and lack scientific rigour.

This Submission concludes that the same flawed methodologies for sampling and monitoring programmes are proposed for deployment in respect of Hinkley Point C and will similarly fail to provide a useful and accurate record of radioactivity concentrations, from the proposed EPR reactors, in locally caught seafoods.

6. Marine Water and Sediment Sampling

6.1 Para 1.2.3 of NNB-OSL-REP-000137 (page 7) correctly reports that radio nuclides can become attached to silt particles and that "the smaller the particle size the greater the surface area and hence the greater adsorption capacity".

The entirety of the current Hinkley Point marine monitoring activity takes 2 "sediment" samples from each of 9 sites spread across approximately 25 miles of coast between Blue Anchor Bay (about 11.5 miles to the west) and Weston Super Mare about 13.5 miles to the east of the Hinkley Point site.

Thus it is based purely on potential near field/local impacts and discounts the need to monitor further afield despite the evidence set out in earlier and later sections to demonstrate that reconcentration occurs at sites distant from discharges.

6.2 The term "sediment", as used in oceanography and coastal morphology work, is a very broad term which is loosely refined by the use of the terms cobbles, pebbles, shingle, sand and mud or silt and very precisely defined by use of the Wentworth Scale which defines the "grain size" of sedimentary particles by mms and fractions of mms.

Thus, the finest sediments or "muds" which would be expected to hold the greatest concentrations of Hinkley Point derived marine discharged radioactive wastes, would consist of particles with grain sizes at or below 0.075 mm.

Such material is characteristic of much of the material found in seabed and intertidal deposits in the nearshore zone around the Hinkley site (Bridgwater Bay) and through out much of the Bristol Channel coastal fringe (especially those areas downstream (ie closer to the Severn estuary). The Bristol Channel water column is also characterised by its very high suspended particle content, composed of material in that grain size range.

6.3 However the RIFE reports fail to provide individual descriptions or definitions of the nature of all but one of the sediment sample sets taken. Only 2 individual sediment samples are given a definition other than "sediments" and these are the "Mud" taken from Watchet Harbour (approx 8 miles to the west of Hinkley Point). The remaining 8 sample sets are not given a more precise definition and:

(a) may thus have not consisted of fine grained material;

(b) may not have been subjected to grain size analysis; and

(c) may thus have generated essentially meaningless results because not attached to any useful sediment descriptor.

6.4 Thus it remains unclear:

(a) exactly what type of sediment the RIFE reports have been monitoring at eight of the nine sample sites; and

(b) whether those responsible for taking and monitoring the samples have a record of the sediment types sampled at those other eight sites.

6.5 In addition to their failure to record the precise (grain size) nature of the "sediments" sampled, the RIFE reports fail to provide an extensive suite of highly relevant supporting data as follows:

(a) are the sediment samples taken from the inter-tidal zone or the sub-tidal zone. If taken from the intertidal zone are they taken from the upper, mid or lower sector of that zone?

(b) in which season of the year are the sediment samples gathered (highly relevant to near shore sub-tidal and inter-tidal sediments since seasonal dynamic fluxes exercise strong influences such as accretion/erosion cycles and winnowing and sorting of grain size on such sediments)

(c) what were the ambient weather and sea conditions at the time of sample collection and during the immediately preceding period: this too may exercise strong influences on sediment deposits (as described in b: above) and also because of the potential impact that terrestrial freshwater runoff (rainfall/flood etc) may exercise on both the radioactivity content of the measured samples and also the particle size of the relevant samples.

(d) what were the ambient (high/low: spring/neap) tidal conditions at the time of sample collection and in the immediately preceding period (relevant for the same reasons as b and c above)

(e) whether the same conditions (listed above) were operating at each site, each time the samples were gathered there (in order to maintain coherence across the historical annual results)

Without this supporting data the reported sample radioactivity concentrations are of relatively little relevance and represent little more than a collection of random results with geographical location the only chronological common factor

6.6 The strikingly small sample number base for sediments also militates

against a thorough reportage and understanding of radioactivity concentrations in the Hinkley Point marine environment, because there can be no scientific justification for proposing that 2 samples from annually from each of 9 small sites (across a 25 mile stretch of coast) represent anything other than a very "brief-period" spot sampling exercise.

Certainly such work cannot be claimed to be representative of the entirety of seasonal and annual conditions that will be experienced at those sample sites.

6.7 Thus the strikingly small sample number base and the lack of data and clarity of the sediment monitoring programme plainly militate against a precise understanding of the radioactivity concentrations across the range of "sedimentary" marine and estuarine environment types to be found across the approximately 25 miles of coastline covered by the sediment monitoring programme.

6.8 Noting that the Hinkley monitoring programmes are essentially replicate in principle by those at all other NPS, this Submission concludes that the sampling and monitoring programmes currently undertaken, and proposed for deployment in the case of monitoring future new build NPSs, lack scientific rigour and do not provide the requisite amount, or quality, of data on which to base an understanding of the behaviour and fate of radioactive wastes discharged to sea from the proposed new build Nuclear Power Stations.

This Submission further concludes that the programmes are not appropriate to the task of providing the necessary data inputs to hypothetical models/projections of potential pathways of exposure and dose rates to the public.

7. Other Monitoring Issues

7.1 In addition to the issues raised above in relation to all existing and all New Build sites, there 2 further monitoring issues which are relevant to all sites where the ERP and AP1000 reactors are proposed:

The Developers of stations where both the EPR and the AP1000 reactors may be deployed have both stated that the Environmental Monitoring Programme discussed in their proposal documents will only take account of routine releases from normal plant operation.

7.2 *The absence of any discussion of the provision of Emergency Situation Monitoring Programmes (such as that occurring at Fukushima) is a matter of considerable concern since, without some degree of prior planning any emergency response is likely to be constructed and initiated under extreme pressure and without the benefit of rational analysis and discussion or the prior construction of equipment stockpiles.*

7.3 Pulsed discharges

Developers of sites where the deployment of UKEPR and AP1000 reactors is proposed have stated that discharges of some radio-nuclides will be intermittent, thus delivering pulsed peaks and troughs of input.

This fact is not addressed in NNB Genco's Hinkley C Monitoring document NNB-OSL-REP-000137. Thus it may be concluded that there are no plans to construct the proposed marine monitoring programmes for Hinkley C in such a way as to take account of the several implications of pulsed discharges.

Similarly such issues are not referenced in the RIFE reports.

7:4 While of relevance to all nuclides entrained within the proposed pulsed discharges, the issue is particularly important in relation to Tritium because

(a) Tritium is specifically indicated as one of the radio nuclides intended for pulsed discharge

(b) Tritium has a short life and hence peak concentrations in environmental samples (following pulsed discharges) may not be recorded by the proposed very low number/low frequency monitoring programmes based on those already in existence

(c) Tritium is shown to very rapidly incorporate into marine samples (including foodstuffs) and thus the proposed low frequency/low number sampling programme will not be geared towards capturing peak tritium concentrations in foodstuffs.

(d) thus, due to a: and b: (above) marine food pathway doses to exposed critical populations will not be effectively and accurately calculated each year, nor on a year on year chronological basis.

8. *Where should the programmes monitor?*

8.1 Page 11 of NNB-OSL-REP-000137 explains that the geographical locations at which samples and radiation dose rate measurements are taken is an important part of the Environmental Monitoring programme and offers explanations for, and guidance on, the choice of sampling and monitoring sites in relation to NPS.

It is specifically stated that the programme "must provide representative data about the levels of radioactivity in the local area and ensure that locations where higher results might be found are sampled."

8.2 The principle of providing representative data has been alluded too above in the context of sediments and sedimentology where it was explained how the principle is not adhered to by the current monitoring programmes.

8.3 NNB-OSL-REP-000137 states (page 10) that fine grained sediments "accumulate particle reactive nuclides present in the water".

This Submission has already explained, and provided examples of, how this mechanism leads to re-concentration of various nuclides in the sediments (with higher levels in fine sediments) when compared to concentrations in ambient seawater.

This has been widely demonstrated in many studies, including the RIFE reports, and is a particularly significant factor in the relatively high concentrations (compared to ambient seawater) of alpha emitters and actinides found in sediment deposits in UK waters.

8.4 In the context of sediment accumulation of nuclides, it is evident that the optimum methodology for thoroughly examining the outcomes and extent of this particular parameter is to base the identification of sample sites on a thorough understanding of the grain size of the coastal and estuarine sediments in the vicinity of NPS. This can best be done if it is based on studies utilising Wentworth Scale grain size analyses (see above).

Only then can "representative data about the levels of radioactivity in the area" and "locations where higher levels might be found" be accurately gathered.

8.5 The statement that the programme "must provide representative data about the levels of radioactivity in the local area and ensure that locations where higher results might be found are sampled." is contradicted by NNB Genco's other statement that "The locations should be evenly located around the station and be at appropriate distances" (Page 11 of NNB-OSL-REP-000137).

8.6 The two statements are mutually exclusive, since there is absolutely no evidence that there has been any grain size analysis work, nor any other scientific work, to justify an assumption that "evenly located" and "at appropriate distances" sample sites provide an accurate (or even approximate) representation of "representative" or "higher results".

8.7 In fact, without grain size analysis, marine, coastal and estuarine sample site choice is an essentially hit or miss operation not based on scientific rigour and incapable of providing the required "representative data about the levels of radioactivity in the area" and "locations where higher levels might be found"

NNB-OSL-REP-000137 (page 12) proposes that the sampling locations used for the current Hinkley A and B stations monitoring are relevant to the proposed Hinkley C monitoring programme. In the context of the findings above, it is evident that the proposed Hinkley C monitoring will be as inappropriate and irrelevant as the current programme is for the A & B stations.

8.8 NNB Genco's proposed sediment monitoring programme in relation to the proposed Hinkley C liquid discharges (based on current Hinkley A and B monitoring programmes) is strictly restricted to near field observations (maximum of about 13 miles from the site).

Thus, an extensive area of "down stream" Somerset coast, including relatively populated and popular coastal areas between the eastern extent of Hinkley sampling (Weston Super Mare) and the Oldbury discharge point, remains un-sampled and un-monitored for radioactivity from the Hinkley Point site.

8.9 In addition, virtually all the South Wales coast (again densely populated and popular with visitors) also remains un-sampled and unmonitored (other than the relatively small area around Cardiff where sampling is undertaken specifically to detect the impact of medical diagnostics factories operating in Cardiff).

8.10 This is particularly relevant and significant in the case of the extensive inter-tidal fine sediment deposits of:

(a) the Avon Estuary;

(b) the estuaries of the south Wales rivers;

(c) the extensive inter-tidal mud flats fringing the Severn coast of Gwent and Glamorgan; and

(d) the extensive fine sediment deposits of Swansea Bay and Carmarthen Bay.

Where sediment associating radio-nuclides (especially the long-lived alpha emitters/actinides) may have already begun to appear as a result of the current and historical discharges of the existing Hinkley and Oldbury reactors and may further concentrate if the proposed Hinkley C and Oldbury B stations begin discharges of liquid radioactive wastes.

8.11 Similarly, the surface waters, which have travelled past, and received the radioactive waste discharges of, the Hinkley and Oldbury sites, may also be of radiological significance.

It can be seen that the NNB GENCO statement is merely an echo of the policy/strategy carried out by the UK Regulating Agencies responsible for the production of the annual RIFE reports, itself based on the original flawed hypothesis for the behaviour and fate of sea discharged radioactivity.

8.12 This Submission concludes that, in the context of the lack of such monitoring in such areas it is legitimate to state that there is a wide swathe of ignorance concerning the radiological impact that the exiting stations may be making on those areas.

It is thus imperative that, at the very least, a wide ranging and detailed baseline survey of radioactivity in the South Wales and Avon sedimentary and water column environments be carried out prior to the initiation of discharges of radioactive waste from the proposed new reactors.

8.13 Similarly it is imperative that an ongoing sampling/monitoring programme should be maintained in order to investigate and quantify any ongoing effects of those proposed new discharges of radioactive wastes in far field environments such as those of the south Wales coast.

9. Data Gaps and "unknowns"

9.1 From the detailed desk research which underpins the Previous Consultation Response it has become apparent that there are a number of highly relevant scientific issues where there are a wide range of "unknowns" across a wide range of technical fields. Some examples are discussed below.

9.2 **Marine hydrodynamics**

From the tone of both the nuclear new build developers proposals to discharge radioactive wastes into UK coastal waters and the regulatory agencies reporting of marine monitoring, it might be assumed that all of the relevant marine scientific parameters likely to govern, drive and influence the behaviour and fate of radioactive wastes discharged to sea are fully understood.

However, this is very far from the case and there are, in fact, many important areas where marine scientists are at pains to point out that the science is poorly understood and that much research is needed before a full understanding is gained

9.3 Mapping of UK seas and marine hydrodynamics remains a still un-completed project. The most recent publication of such research created by a relevant UK Ministerial Department was the 1981 MAFF "Atlas of the Seas around the British Isles" which, when addressing the issue of water body movements (upper half of the water column) constantly reminds the reader of

(a) "the lack of systematic, long term data collection in almost all areas"(for the English Channel and the North Sea); and

(b) for the Irish Sea says "It would appear that more often than not there is a south to north flow to the west of the Isle of Man but the circulation shown for the region to the east of the island is still a matter for argument".

NB these statements were made nearly thirty years after the commencement of discharges from Sellafield.

(Ref 13)

9.4 Tracer study research in the Bristol Channel, using marked fine sediments, have indicated that most of the fine sediment transport occurs within the Bristol Channel turbid (high sediment load) water mass and propose that the most significant sinks (areas of deposition of fine sediments) are probably

(a) Bridgwater Bay (the receiving area for the Hinkley liquid radioactive waste discharges)

(b) the peripheral areas of the Parrett and Avon estuaries (Somerset and Avon coasts)

(c) the Wye and Usk estuaries and their associated salt marshes (south east coast of Wales)

(d) and a few offshore sites such as the Newport Deep and Nash Passage (off the welsh coast)

(Ref 14)

NB: In this context it is important to remember that pollutants associate strongly (by adsorbtion) with fine sediments. This evidence highlights the importance of the lack of radiological monitoring for these substances (as highlighted in preceding paragraphs).

9.5 In the case of the Bristol Channel marine environment, designated to receive discharges of liquid radioactive wastes from the proposed Hinkley C reactors, a 2010, in depth review, presented in the peer reviewed Marine Pollution Bulletin highlighted a number of highly significant unknowns regarding crucially important aspects of marine environmental science relevant to the behaviour and fate of pollutant wastes discharged into that specific sea area. (Ref 15)

9.6 The Marine Pollution Bulletin review concluded that the strength of currents and their distribution are, ultimately, the principal drivers determining long term sediment transport, deposition and erosion (either in suspension or as bed load) in the Bristol Channel/Severn Estuary system and that the "hydrodynamics also directly influence (and perhaps dominate) the dispersion of discharges".

9.6 The review also stated that: "a better understanding of these features and their linkages would improve management options for the system".

9.7 Noting that flocculation (aggregation of fine particles) "is a principal mechanism which controls how fine sediments, and thus contaminants, are transported",

the review reported that

"the interpretation of the significance of this process is only just beginning to emerge."

(Ref 15)

9.8 The Marine Pollution Bulletin review further noted that, with respect to understandings of the sediment dynamics and physical processes, much of the research and data collection was undertaken several decades ago and now there is a requirement to:

(a) investigate how flocculation of suspended sediments responds to different degrees of turbulent mixing;

(b) develop better sediment transport models to quantify settling of flocs, erodability of bed sediments and the settling of sediments during different tidal conditions;

(c) examine how the mineralogical composition of muddy sediments influences their capability to both flocculate and adsorb/release pollutants;

(d) Map the extent and magnitude of salinity intrusions and the turbidity maximal, including depth profile measurements in order to provide representative distributions of both suspended sedimentary matter and salinity on seasonal and neap/spring tidal cycles and time scales;

(e) to determine the extent to which biological processes affect the behaviour of sediments and the bio availability of sediment associated contaminants

(Ref 16).

9.9 In the context of the statements set out in the preceding paragraphs, this submission concludes that there is, at the least, a 5 clause degree of UN-certainty about the behaviour and fate of radioactive wastes discharged into the Bristol Channel marine environment from both the existing NP stations and the proposed new build NP stations.

9.10 This submission reiterates the fact that the most recent authoritative description of UK wide marine environmental parameters (the MAFF Atlas) is very careful to point out the lack of data and the wide range of uncertainties about such parameters.

9.11 This submission draws attention to the fact that

(a) neither NPS new build developers NOR UK government regulatory agencies have referenced these scientific and technical uncertainties; and that

(b) they have both preceded with applications and GDA as if there were no such uncertainties and all those marine environmental parameters relevant to the behaviour and fate of sea discharged radioactive wastes were fully marshalled and understood.

Accordingly this Submission concludes that neither developers nor regulators have proceeded with appropriate diligence and scientific rigour.

10. Unknown//un-Quantified Discharges of Alpha Emitters/Actinides

10.1 Developers proposing construction of NPS using both the UKEPR and the AP1000 reactors report their intention to discharge liquid fission and activation products. Among these products are various actinides and alpha emitters produced by the irradiation of "tramp" uranium contamination of the outer surfaces of fuel pins, or of uranium leaking from inside the fuel pins.

10.2 Developers have provided only minimal detail on the constituent components of the actinides and alpha emitters to be discharged. EDF, the manufacturers of the UKEPR, and NNB Genco the developers of NPS proposing to deploy those reactors have not provided full details of the alpha/actinide wastes to be discharged in their liquid waste streams.

10.3 However, Westinghouse, the manufacturers of the AP1000 reactor, have provided a Table detailing the constituent components of their proposed liquid radioactive waste discharge streams.

The Table lists 12 individual actinide/alpha emitters : 5 isotopes of Plutonium, 3 isotopes of Uranium, 2 isotopes of Americium, and 2 isotopes of Curium as components of the "expected annual radioactive effluent discharges".

(Ref 18)

10.4 An (unreferenced) 1989 Table entitled "Assumed Isotopic Composition of Annual Liquid Discharges from the Hinkley Point C": issued by the CEGB (to the 1989 Hinkley C PWR Inquiry) in relation to the proposed fleet of PWRs similar to that at Sizewell, lists 17 actinides including 6 isotopes of Plutonium, 5 of Americium, 3 of Curium, 2 of Uranium and 1 of Neptunium.

(copies available from this consultant)

10.5 NNB Genco state that "alpha activity is not presented as a significant group of radio nuclides for GDA, and measurements carried out at PWR units do, in fact, confirm that discharges are always below detection limits" (Ref 17).

NB Previous Consultation Responses previously have sought a clarifying definition of these "detection limits" from the regulatory GDA and to date have not been provided with one.

10.6 Similarly, but with one exception, the Westinghouse document (Ref 18) also refrains from offering quantification of their listed alpha/actinide discharges from the AP1000 reactor, but (unlike the EDF/NNB Genco documentation) they do state that the discharges of the 12 individual listed isotopes are expected to be "negligible" and they define "negligible" as "less than 3.7E + 4 Bq" (less than 37,000Bq per year).

(The AP1000 NPS will have three reactors, thus the aggregated "negligibility" will be 110,000 Bq per year.)

10.7 The Westinghouse document does not provided a scientific or technical justification for defining 37,000 Bq per year of alpha/actinides as negligible, nor does it clarify if this turn of phrase refers to each individual isotope or to the aggregated yield of the 11 isotopes.

10.8 The Westinghouse exception is for Plutonium 241, which is described as "significant" because it has a long half-life and may persist and/or accumulate in the environment.

This Submission assumes that the "significance" of the Pu 241 is also derived from the fact that Westinghouse predict that that the annual average discharge to sea from an AP1000 reactor is expected to be 80,000Bqs per year, with an expected annual maximum of 108,000Bqs per year.

(For a triple AP1000 reactor NPS this will be average discharges of 240,000 Bqs per year of Pu 241, with a predicted maximum of 324,000 Bqs per year)

10.9 No such detail is provided for the UK EPR reactors in relation to Pu 241 discharges.

However, given that both Westinghouse and NNB Genco documentation make "guideline" reference to operational experience and data from other existing PWRs when discussing reactor radioactive waste arisings and discharges of liquid radioactive wastes to sea, this submission assumes that it may be the case that arisings and discharges are likely to be (loosely) similar in volume/quantity when plant capacities are similar.

10.10 On that basis, in the context that three AP1000 reactors are (broadly or loosely) comparable in terms of energy production to 2 UK EPR reactors, and in the complete absence of any relevant data from the manufacturers and developers of the UK EPR, this Submission postulates that proposed 2 UK EPR reactor stations MAY have similar alpha/actinide outputs to those of the 3 AP1000 reactor stations:

ie yearly average of 240,000 Bqs of Pu 241, yearly maximum of 324,000 Bqs

10.11 If this should be the case, this Submission does not concur with any suggestion that UK EPR station Pu 241 discharges are negligible and, on the contrary, argues that both NNB Genco and the Regulating Agencies and the GDA process should have clarified and quantified the issue of Pu 241 discharges from the UK EPR reactors.

10.12 This Submission further wishes to draw attention to the fact that the principal reason given by Westinghouse for the identification of Pu 241 as an isotope of "significance" (because it has a long half life and may persist or accumulate in the environment) applies equally well (if not more so) to the other alpha/actinide fission products in the proposed discharge streams from both UKEPR and AP1000 reactors.

10:12 In fact, Pu 241 has a relatively short half life of 14.4 years and is thus relatively non persistent compared to other isotopes listed (above) in the alpha/actinide discharges. For instance, the decay/daughter product of Pu 241, Americium 241, has a half life of 432.2 years which of course makes it far more persistent in the environment than Pu 241.

The majority of the other "listed" alpha/actinides similarly have half lives ranging from hundreds through to thousands to millions of years (in the case of Neptunium).

10.13 This Submission draws attention to the fact that the Regulating Agencies, through the GDA process, appear to concur with the proposal that alpha/actinide discharges are not important, because the GDA process does not appear to have demanded clarification of the issues raised above, nor has it demanded any limits on alpha/actinide discharges other than those of Pu 241.

10.14 The issue of the listed alpha/actinides is one of considerable significance because alpha activity is generally considered to be of major (potential) radiological health significance, because if ingested or inhaled such material may cause more significant and lasting damage to human health than other forms of radioactivity.

10:15 In this context further urgency is given to the understanding and control of alpha active radioactive wastes by the fact that, in UK marine environments there appear to be a range of mechanisms of increasing concentration in addition to those discussed in Section 4 above.

10.15 Thus, although the annual RIFE monitoring reports (any year) do not bother to record concentrations of Pu 241 in the marine environment around (for example) Hinkley Point, they do undertake monitoring for 3 other Pu isotopes as well as Americium 241 and 3 isotopes of Curium.

NB This Submission draws attention to the apparent dichotomy between

(a) *the developers/manufacturers characterisation of these isotopes as of "negligible" significance and the regulating Agency's apparent decision to concur with this position;*

compared to

(b) *the developers/manufacturers characterisation of PU 241 as "significant" and the Regulating Agency's and monitoring body's decision to NOT MONITOR for this isotope.*

10.16 The RIFE Reports (nos 6, 13 & 15 etc) record positive (but rising!) low concentration results for several isotopes of Plutonium and one isotope of Americium in Hinkley Point C samples (shrimps only):

Hinkley 2000

Sample	Pu238	Pu239/240	Am241	Cm242	Cm243/244
Shrimp	0.000073	0.00034	0.00067	NA	NA

Hinkley 2007

Sample	Pu238	Pu239/240	Am241	Cm242	Cm243/244
Shrimp	0.000063	0.00048	0.0016	NA	NA

Hinkley 2009

Sample	Pu238	Pu239/204	Am241	Cm242	Cm243/244
Shrimp	0.00021	0.00091	0.00076	0.00011	NA

(Similar monitoring at the Sizewell B site also reports a positive presence for 2 isotopes of Plutonium, Americium 241, and isotopes of Curium.)

10.17 Neither the manufacturers of the UK EPR and the AP1000 reactors, nor the developers of proposed nuclear new build, nor the regulating agencies (during the GDA process) have addressed the issue of the established presence and rising concentrations of Pu, Am and Cm in the context of the proposals to discharge further unquantified volumes of these products. Apart from commenting that the concentrations of these isotopes in seafoods is of "negligible significance" the RIFE reports have not addressed the issue of rising concentrations or offered an explanation for the observed phenomenon.

10.18 This Submission concludes that, in the context of the information set out in the preceding paragraphs, there are significant issues relating to the discharge to sea of alpha/actinide wastes from proposed nuclear new build which have not been examined during the GDA process.

Thus the potential environmental and public health impacts of the discharges of Pu, Am and Cm are unknown and unquantified and therefore any conclusions reached by the GDA process must lack scientific rigour in relation to those issues.

11. Issues Arising From the Decay Production of Americium 241

11.1 During the late 1980s it was realised that there was an issue of rising marine environmental concentrations of alpha emitting Americium 241 derived from the decay of historically discharged (in virtually unlimited quantities till relatively recently) Plutonium 241.

It has been projected that by the end of this century, that the marine Americium 241 production from the decay of previously discharged Pu 241 will be delivering approximately 1,300 curies (48 Tbq) per year into Irish Sea (and associated marine area) environments.

(Ref 19)

NB RIFE 16 (2011) reports that in 2010 the Sellafield recorded discharges of Americium 241(+ Curium) was 1.66E+07 Bq

11.2 The annual RIFE reports confirm, and make regular reference to, this issue (in relation to marine sediments).

However, neither the reactor manufacturers, new build developers nor the regulating agencies (via GDA) discuss the phenomenon in relation to the proposed ongoing discharge of Pu 241 (which generates decay production of Am 241), nor have they discussed the issue in relation to the direct discharge of unquantified volumes of Am 241 (see section 10 above).

11.3 This Submission draws attention to the wide consensus that

(a) Americium 241 is a known alpha emitter and potentially at least as radio toxic as the Plutoniums (if not more so);

and that the fact that

(b) like the other alpha/actinides, decay product Americium 241 will eventually appear in coastal and estuarine fine sediment deposits.

11.4 This Submission concludes that, in the context of the information set out in the preceding paragraphs, there are significant issues relating to the discharge to sea of both Pu 241 and Am 241 from proposed nuclear new build which have not been examined during the GDA process.

Thus the potential environmental and public health impacts of the discharges of Pu 241 and Am 241 (in conjunction with the decay product Am 241 arisings) are unknown and unquantified and therefore any conclusions reached by the GDA process must lack scientific rigour in relation to the environmental and public health significance of Pu 241 and Am 241.

12. Studies of Sea to land Transfer of Marine Radioactivity (Sea Spray and Marine Aerosol Pathway

12.1.1 Since the early 1980s a small number of studies have been carried out on the sea to land transfer of radioactivity via sea spray and marine aerosols. The initial work was carried forward by the research division of the UK AERE, who chose the Irish Sea as their field of work (because of the presence of Sellafield and its major programme of discharge to sea of liquid radioactive wastes) and various nuclides of Plutonium (Pu) and Americium (Am) which became the radio nuclides of interest.

12.2 The AERE studies reported that:

(a) several nuclides of Pu and one of Am were found to be airborne in any coastal area where the field work was carried out in onshore wind conditions and that the magnitude of the effect generally increased with wind speed;

(b) the magnitude of the effect was also very closely linked to the volume of fine sediment particles ejected into the air in spray or aerosol formations and subsequently captured on muslin screens; but

(c) that the work was unable to provide accurate data on the true extent of the sea to land transfer of actinides, because the attempts to quantify the phenomenon were based on the use of flawed technology and methodology, which was itself derived from the absolute non-availability of appropriate equipment.

12.3 Muslin screens were deployed for the capture of airborne particles at surf line and near coastal (terrestrial) environments, while high volume air samplers (which draw air through an opening 1 metre above ground level) were sited inland of the muslin screens.

Muslin screens were originally deployed as a back up to the use of high volume air samplers, which were noted to be "not particularly suited" to sea to land transfer studies because they are "believed to be not very efficient for the relatively large particles". (Ref 20)

12.4 However it was reported that muslin screens provided inherently inaccurate data because as wind speeds increase (especially beyond Force 5) the muslin stretches and its porosity increases allowing more and more (and larger and larger) particles to pass through the material.

Attempts to estimate collection efficiency of the screens were unable to provide a definitive efficiency level for low winds but concluded that, at wind speeds of 12 metres per second (28 to 30 mph), the transmission/porosity of the screen was noted to be as high as 50% (efficiency had decreased by 50% of whatever it would be at minimum wind speeds).

It was accordingly noted that muslin screens should be used "only as a qualitative tool to compare relative concentrations of actinides in sea spray" (Ref 21)

12.5 It was also reported that the muslin screens (5 m long, 1 metre deep) were mounted vertically with their lower edges 1 metre off the ground level, but that the "enriched spray front" detected by the UKAEA at the shoreline in force five winds was probably about 10 metres high.

N.B. At greater wind speeds it seems highly likely that an "enriched spray front" will be higher and that the transmission/porosity failure of the screens will become even greater than that observed at 12 metres per second wind speeds

12.6 Despite the inability to provide usefully quantitative data on the concentrations of the actinides Pu and Am transferring from the marine to the terrestrial environments, such studies have conclusively demonstrated that the phenomenon does occur.

12.7 Subsequently further studies attempted to investigate and confirm the impacts of the phenomenon on terrestrial environments. In order to ascertain the significance of sea to land transfer of radioactivity along the Cumbrian coast, soil samples along two transects extending up to 20km inland were analysed for the insoluble nuclides Plutonium and Americium in 1982

It was reported that: "Pu and Am deposits decrease with distance inland and correlate with deposits of marine-derived sodium. An enrichment of actinides in sea spray relative to seawater is required to account for the observed deposit." (Ref 22)

12.8 As mentioned above, the study of the sea to land transfer of anthropogenic marine radioactivity commissioned by the nuclear industry and/or government agencies has been focussed:

(a) on the coastal areas of the northern basin of the Irish Sea in the vicinity of the Sellafield sea discharge point sources; and

(b) on the insoluble alpha actinides/transuranics.

However there is a body of independently commissioned and conducted work, which has reported on the phenomenon in other coastal areas and in respect of "soluble" radionuclides, some examples follow:

12.9 In south west Wales, Dyfed County Council commissioned a study of radioactivity in the county in the late 1980s, which, among other issues, was asked to confirm or deny the presence of indications of sea to land transfer of Sellafield derived sea discharged material in inland terrestrial environments.

This study confirmed the presence of Caesium 137 (proved to have been derived from Sellafield sea discharges) in pasture grass at 10 km inland of the Cardigan Bay coast of south west Wales, thus confirming:

(a) an unexpectedly deep inland penetration of this isotope;

(b) the fact that it must therefore be entering into the regional terrestrial dairy and meat food chain; and

(c) and strongly implying it's entry into other local produce food chains (potatoes, vegetables and fruit etc) (Ref 23).

12.10 In a study of patients from North Uist (Western Isles of Scotland) an independent medical team found excess Caesium body burdens compared to those in patients from the Scottish mainland and investigated the source of Cs in the N.Uist patients.

The immediate dose source was shown to be excess dietary intake of Cs, which was identified in all types of island grown food produce and environmental samples. Island dairy produce, meat and fish all had higher Cs concentrations than their mainland counterparts, however it was noted that fish was not a significant part of average islander diet.. High concentrations of Cs were also reported for N.Uist seaweed, beach sand, inland peat and both coastal and inland pasture grass.

Highest body burdens of Cs (and highest concentrations in urine samples) were found in those patients shown to be consuming the greatest dietary percentage of island produce. The average islander dietary dose, from Cs 137 alone, was calculated at 13.7 micro Sv.

NB: In the context of this section of the Submission, it is highly relevant to compare

*(a) the average Uist, single nuclide, local terrestrial dietary dose **(13.7 micro Sv)**, to*

*(b) the 7 nuclide dietary dose received by residents of Hinkley Point eating locally produced terrestrial foods **(14.2 micro Sv)***

[Addendum 1 MAFF 5. Topic 2. Hinkley C PWR Inquiry Documents 1989. Duplicate Diet Studies. 3 pages]

The "fingerprint" of the analysed Cs indicated a clear Sellafield sea discharge component in the majority of samples. The study concluded that it was "important to note that an isotope discharged into the sea as waste may return to land at considerable distance from the site of discharge and enter the human food chain".

(Ref 24)

12.11 Since North Uist is shown to be saturated with Sellafield sea discharged Cs, it is not unreasonable to assume that other nuclides known to transfer from the sea to the land are also present in the islanders diet. Islander doses for total nuclides will plainly be significantly greater than the calculated dose for CS only.

NB:North Uist is approximately 200 kms by sea from the Sellafield discharge pipe.

12.12 In addition to the sea to land transfer by pathways of sea spray and marine aerosols, inundation during storm surges and tsunami type phenomena is also a recognised, though poorly studied pathway. (see section 4 above which discusses Enrichment Factors)

Section 4 above also referenced the fact that Plutonium Enrichment Factors of 26,000 (relative to those in ambient sea water) have been recorded in marine algal blooms.

The transfer of marine fine particles, re-suspended from the drying surfaces of exposed inter-tidal sediments, during periods of onshore wind has also been alluded to in some studies but is very poorly researched.

12.13 There may be also be possibility that other pathways such as fog formation and evaporation from enriched sea surfaces and the drying out of inter tidal sediments may also make a contribution to sea to land transfer, such processes may be particularly relevant in the case of soluble nuclides such as Caesium and Tritium but such pathways remain hypothetical at the present as no studies appear to have investigated such a possibility.

13. Flaws and Failures of Sea to Land Transfer Reporting

13.1 In the case of the UK Nuclear industry, reactor manufacturers, nuclear new build developers and the regulating authorities, there does not appear to be

(a) a coherent policy towards,

(b) a coherent understanding of, or

(c) a coherent reporting of the real facts of the issue of sea to land transfer of anthropogenic radioactive wastes derived from the sea discharges of nuclear sites.

13.2 The AERE study (published in 1982) and referenced above, concluded that the inhalation (lung) dose to the public from Pu 239 and Pu 240 (2 nuclides only) was about 1% of the ICRP 5mSv annual effective dose equivalent then in operation.

However it is important to note that the study had measured the presence of a total of only 5 sea to land transferring nuclides on the measuring devices (Caesium 137, Plutonium 238, Pu 239, Plutonium 240 and Americium 241) and that there are has never been any evidence to suggest that ONLY THOSE 5 are actively transferring from the sea to the land via atmospheric pathways.

Thus the reported dose to the public was based on only a partial record (2 out of the 5 nuclides measured for: and possibly many more which were not measured for) of the full potential range of nuclides which would have contributed to dose.

13.3 This Submission draws attention to the fact that many other nuclides are present in the proposed radioactive waste discharges to sea from proposed new build AP1000 and UK EPR reactors. One table issued by Westinghouse, the manufacturers of the AP1000 reactor lists a total of 65 nuclides described as "expected annual release of radioactive effluent discharges"(Ref 18) consisting of either insoluble or soluble radionuclides.

No evidence has been presented to prove that ONLY the 5 radionuclides measured for in the AERE studies are available for suspension in marine aerosols and seasprays.

Therefore this Submission concludes that it is inevitable that inhalation of such aerosols and seasprays MUST be delivering doses from many more radionuclides than those 2 factored into the already flawed dose estimates.

13.4 In 1990, page 29 of the MAFF (annual) Aquatic Environment Monitoring Report (Number 23) under the heading of "External Exposure": stated that "the levels of radio nuclides in (marine) sediments give rise to only very minor radiation exposures to the public following inhalation of resuspended particulates including those from the surf line".

In justification of the statement, the MAFF AEMR referenced an even earlier 1981 study (Ref 26) in which the dose is reported to be 0.2% of the derived air concentration (DAC) modified for members of the public.

13.5 It is highly relevant to note that both of the above mentioned research studies were carried out at a very early stage in the investigations of sea to land transfer and were using data gathered by the use of the inefficient and inaccurate tools which had been specifically described as NOT SUITABLE FOR QUANTIFICATION WORK.

13.6 It is also of the utmost relevance to note that

(a) The dose calculations undertaken for the 1981 and 1982 studies were based on 1979 ICRP values when the annual effective dose equivalent limit was 5mSv.

(b) In 1986 the ICRP limit was reduced to 1mSv.

(c) 1987 the UK NRPB had given "interim guidance" that limit should be reduced to 0.5 mSv per year

13.7 This Submission draws attention to the fact that the MAFF AEMR No 23 had uncritically and mistakenly carried forward a series of errors and lapses in information to the public in that the calculated doses were

(a) based on the effect of only two (of potentially many) nuclides;

(b) based on calculations derived from the use of inefficient and inappropriate equipment specifically described as NOT SUITABLE FOR QUANTIFICATION WORK; and

(c) based on historical dose rate limits which were both outdated and a factor of 10 times higher than the contemporary "guidance" dose rate limit (NRPB 1987) and five times higher than the eventual agreed level of 1mSv.

This catalogue of specific inaccuracies about dose rates by inhalation via the marine seaspray/aerosol pathway were repeated in subsequent MAFF AEMR reports through to 1993 and have subsequently been promulgated by nuclear industry and regulatory agencies alike as "fact" thus enabling those bodies to jettison and disregard any further concern in that specific pathway..

13.8 By 2000, the issue of resuspended particulates in **sea spray from the surf zone** had been dropped from Reports and replaced by a discussion of "resuspended beach sediments" which are a radically different issue.

13.9 From a Marine Science perspective, resuspended particulates in sea spray and marine aerosols must, by definition, be relatively small and "fine" enough to be suspended in the water column. The opposite may be true of "beach sediments" because

(a) "beach" is not equivalent to mud flat or salt marsh environment where fine sediments deposit out;

(b) "beach sediments" are those found deposited out on beaches and may well be of larger particle size range than "suspended sediments" in water columns;

(c) beach sediments are not necessarily involved in sea spray/marine aerosol transport from sea to air to land; and

(d) resuspended beach sediments may well be those involved in dune building processes (transported by wind across a dry/or drying intertidal: and by virtue of their weight not generally reaching a great height above ground).

13.10 Thus Radioactivity in Food and the Environment (RIFE-5:pub' 2000) page 40, under the heading "External exposure", makes no mention of inhalation of resuspended particulates including those from the surf line but does report that "inhalation of resuspended beach sediments and inadvertent ingestion of the same material give rise to only minor radiation exposures to the public" and references an NRPB study published in 1994 as the source for the statement.

(Ref 34)

13.11 However a review of the 1994 NRPB study reveals the following

(a) the study began in 1987 and finished prior to the publication date

(b) the study is a desk review of field and modelling work completed before the commencement date

(c) all dose calculations were based on the dosimetry set out in ICRP Publication 26 (published in 1977)

(d) the study did not investigate the impacts of marine aerosol/seaspray as this had previously been concluded insignificant.

(e) the NRPB study was flawed because it carried forward, repeated and compounded all of the errors set out in paras 13:1 to 13:7 above with regard to investigating a very limited group of nuclides and making use of outmoded and redundant ICRP dosimetry.

13.12 Subsequently (and still with a close focus on the Sellafield coast), there have been ongoing investigations of aspects of sea to land transfer in and around the Ravenglass Estuary. These have latterly focussed on the analysis of terrestrial foodstuffs to investigate the extent of transfer of radio nuclides from sea to land. Analysis of samples of milk, crops, fruit, livestock and other environmental indicators are collected annually and analysed for radio nuclides released in liquid effluent discharges from the Sellafield pipelines. The general drift of this work is to attribute the transfer to inundation from the sea, deposition from seaspray and aerosols and the use of seaweeds as a fertiliser.

13.13 Thus the annual RIFE reports regularly report the detection of low levels of Technetium 99 and other artificial nuclides and also identification of (probably Sellafield derived) transuranic nuclides such as Pu 238, Pu 239 and Pu 240 in samples + technetium: thus confirming the occurrence of sea to land transfer and the entry of sea-discharged radioactivity into both wild and cultivated human terrestrial food chains. (Ref 35)

13.14 From the evidence set out above this Submission concludes that the understanding of the mechanisms of sea to land transfer are poorly understood and measured, because, as of yet there is no indication that technologies suitable for the QUANTIFICATION of sea to land transfer of radionuclides in marine aerosols and seaspray are available or have been deployed.

13.15 From the evidence set out above, this Submission concludes that attempts to calculate potential doses to the public via inhalation of marine aerosols and seaspray containing

(a) suspended particles and their adsorbed non soluble radionuclides; and

(b) seaspray/aerosol marine water containing dissolved soluble radionuclides (Caesium/Tritium etc).

Remain deeply flawed and highly inaccurate and lacking in scientific rigour and thus do not provide any accurate or useful data.

This Submission concludes that the converse is true and that the data that has been promulgated is deeply flawed and provides a false and misleading representation of the doses to the public via these pathways.

14. Unavailable Information on the issue of Sea to Land Transfer of radioactive wastes

14.1 There has been, and continues to be, a major problem due to the lack of accessible historical data. One of the major problems has

(a) the relative paucity of relevant work; coupled with

(b) the almost single minded focus on researching sea to land transfer issues in the north eastern basis of the Irish Sea (ie that area to the east of the Isle of Man).

Other than the body of work in that sea area, very little has been conducted elsewhere. Despite a data search I have only found reference to 1 other study in UK waters at Carlingford Lough (Ireland).

The fact that research is focussed on the N.E. basin of the Irish Sea presumably relates to the presence there of the Sellafield site and the fact that its sea discharges represent by far the largest volume of radioactive waste inputs to a UK sea area.

14.2 However, this Submission draws attention to the fact that the sea is not a single uniform entity and that even within one sea area there will be wide range of variations in the environmental parameters (sediment loading, current speeds, freshwater inputs, water temperatures, wind exposure and fetch etc).

Across several discrete sea areas these variations are likely to be even greater. Thus Bristol Channel environmental parameters will differ widely from those found in the southern North Seas and neither may be similar to those found in the north east basin of the Irish Sea.

In the context of the evidence sited above, this Submission warns that the Nuclear Industry/Government Agency focus on N.E Irish Sea research on sea to land transfer means that there exists a body of unknown "data gaps" about both the behaviour and fate of radioactive wastes discharged to sea and sea to land transfer mechanisms and impacts in sea areas other than the N.E. basin of the Irish Sea.

14.3 In the case of the UK work, while some information is available from peer reviewed journals, some data produced by government agencies and nuclear industry bodies can rapidly disappear from public access.

14.4 The most recent example encountered by this consultant has been the attempt to access a copy of one of the most recent UK Government/Regulating Agency reviews of Sea to Land Transfer issues:

"Sea to land transfer of radio nuclides. How much do we know?" Ould-Dada, Z. 2000. (Proceedings 2nd Radrem-Tesc Workshop. London: Jan 21.1999. DETR/RADREM/00.001 DETR London) which has been much referenced in recent annual RIFE reports and other documents, in support of the arguement that sea to land transfer is of low radiological and public health significance.

14.5 Surprisingly however, applications for a copy of this paper, made to the libraries of DETR, CEFAS, DEFRA, DECC and even to the author himself (now working for the DECC) have been met with the reply that it is no longer available. No other explanation has been offered for the inability to produce a copy of this paper.

Thus it is not possible to carry out an analytical review of this, or similar, papers. Given the title of the Ould-Dada paper it is proposed that it would have some close relevance to issues under discussion here.

This Submission draws attention to the fact that during the research work carried out during production of Previous Consultation Responses, none of the documents (originating from developers or regulatory agencies) studied by this consultant made any reference to the Ould-Dad paper and thus it is concluded that they too are not aware of its contents or its implications.

15. Fate and Behaviour of Tritium in Marine Environments.

15.1 Historical understanding of the significance of fate and behaviour of tritium

Historically there has been a wide consensus between the nuclear industry and the regulatory agencies that Tritium was of little radio biological significance, largely based on the assumption that discharged tritium (as tritiated water) would naturally dissolve to infinity once in the marine environment and thus present no radio biological hazard. This attitude was typified by the following example:

15.2 In 1985, liquid Tritium discharges from the Hinkley A Station were increased following work to clean the coolant circuit. The 1985 discharge was 23 TBq, compared to previous years when the annual liquid discharge of Tritium from this station was less than 1 TBq per year. (Ref 27)

15.3 Despite the observed 23 fold increase in tritium discharges in 1985, the regulatory authority stated that: "the increased discharges were of negligible radiological significance" (Ref 28)

15.4 However by 1999 this approach appears to have been under review, when a more precautionary position began to appear when reference was made to the "relatively high levels of organically bound tritium (OBT) in local fish and shellfish" from the Cardiff area of the Bristol Channel/Severn Estuary (max of 33,000 Bq/Kg in cod and 26,000Bq/Kg in mussel). (Ref 29)

15.5 It was also reported that additional sampling of tide washed pasture and wildfowl (Curlew, Pintail, Shelduck and "duck") that feed in the Bristol Channel/Severn Estuary intertidal zone had found elevated levels of tritium in most samples with:

(a) lowest wildfowl concentrations at 2,400 Bq/Kg;

(b) "the highest values found were in Shelduck at about 61,000Bq/Kg total tritium";

(c) grass concentrations ranging from less than 3 Bq/kg to 2,000Bq/Kg; and

(d) intertidal sediment concentrations ranging from 18Bq/Kg to 2,500Bq/Kg.

While the ambient sea water concentrations of total tritium were reported to range from 9.2 Bq/Kg to 10Bq/Kg: thus representing an extremely high rate/level of biological accumulation of total tritium (assumed to be OBT + tritiated water)

15.6 In the context of these findings it was reported that research and further sampling were underway "to examine the mechanisms by which tritium becomes incorporated into biota in the marine environment" (Ref 29)

15.7 A follow on study of the behaviour of Tritium (3H) in the Severn Estuary and Bristol Channel (published in 2001) found that:

(a) Tritium concentrations in sea water from the Atlantic approaches to the Bristol Channel is estimated to be less than 0.4 Bq/Kg.

(b) Measured Tritium concentrations in sea surface water samples at the mouth of the Bristol Channel were lower than the detection level of 2 Bq/Kg.

(c) Measured Tritium concentrations in seawater inside the Bristol Channel were at their highest (between 2 and 10 Bq/Kg) on the English side of the Bristol Channel in the vicinity of the Hinkley Nuclear Power Station outfalls.

(d) Measured Tritium concentrations reached their Bristol Channel second highest concentrations (between 2 and 7Bq/Kg) in the vicinity of the Cardiff outfalls.

(e) In general, measured concentrations were at their most elevated (2 to 5Bq/Kg) in the eastern end of the sea area and at their least elevated to the west of the Hinkley discharge points. (Ref 30)

15.8 The 2001 study also reported that marine organisms incorporate Tritium, via exposure to tritiated water, very rapidly and, within a range of a few minutes to a few hours and reach concentrations close to that of the tritiated sea water in which they are immersed or from which they are acquiring their food.

15.9 These are highly significant findings in the context of the information discussed in 14:7 above. If there were to be discrete pulses or peaks (individually consisting of as much as 21% of annual discharge limit) of liquid tritium discharge, it follows that tritium concentrations in marine organisms, with their very rapid incorporation rates, will be subject to similar time related peaks of concentrations of tritium.

15.10 From the information currently available it remains unclear whether the various assumptions for delivered doses of tritium have been based on steady state delivery of liquid tritium discharges to the Hinkley marine environment or whether they are based on the peaks and troughs of tritium discharges implied by NNB Genco's statements.

15.11 The 2001 study also found that:

(a) tritium becomes incorporated into the organic matter of cells and becomes Organically Bound Tritium (OBT), but at a slower rate than above and typically reaches a concentration of about half that of the ambient tritiated seawater;

(b) Organisms which consume tritiated food accumulate OBT at a faster rate than those exposed only to tritiated water and may reach higher concentrations by bio-accumulation;

(c) environmental monitoring through out UK waters demonstrates that concentrations of 3H in seafood in the Bristol Channel/Severn Estuary sea area are significantly greater than in other UK marine areas;

(d) there was an observed disparity in the rate and degree of Tritium bioaccumulation between sediment, seaweed, benthic (seabed) organisms and fish; however this was provisionally attributed to different processes of Tritium uptake by different species; and

(e) that bioaccumulation of tritium by benthic organisms and demersal fish occurs primarily via transfer up through a web of sediment dwelling microbes and meiofauna, which had been feeding on organic bound tritium. In this context it was observed that herbivorous species and pelagic fish had lower concentrations of tritium than carnivores and demersal (dwelling near the sea bed) fish. (Ref 30)

16. More Recent Research on the Fate and Behaviour of Tritium Diischarged to Sea

16.1 A more recent study (published in 2009) has built upon the emerging understanding of the behaviour and fate of tritium in the marine environment illustrated above and reports that:

(a) tritium's reactivity with organic materials and solids in the marine environment had previously been "assumed to be limited"; and that

(b) previously, the accumulation of tritium in organic rich sediment and the food chain of the Severn Estuary "including concentration factors in excess of 100,000 for demersal fish and shellfish, were ascribed to the existence of organically bound tritium (OBT) in local nuclear waste in the form of specific bio-chemicals, including carbohydrates, vitamins and amino-acids".

16.2 However, the 2009 research demonstrated that, contrary to this assumption, the research "found that its distribution appears to be influenced by its affinity for organic matter" and that "Significantly, a measurable fraction of sorbed tritium associates with proteinaceous material that is potentially available to sediment-feeding organisms."

16.3 It was also noted that the discharge of tritiated water from a nuclear establishment on the Tamar estuary resulted in the immediate dilution to activities of less than 10 Bq per Kg in ambient water, "whereas corresponding activities of about 300Bq/Kg (dry weight) in sediment" where observed.

16.4 In the context of the above effect (which has been noted in this and other, estuarine waters) it was reported that the research absorption and adsorption (sorption) experiments had demonstrated that "sediment organic matter is critical to the removal of tritium from the aqueous phase" and that the effect "was greater in seawater than in river water"

16.5 The 2009 study noted that "the most remarkable aspect of our investigation is the extent of associated tritium, with both dissolved HOM (hydrophobic organic matter) and fine estuarine particles".

16.6 "Experimental results, suggest that the presence and nature of organic matter is critical to the fate of tritium in the aquatic environment, and that there is also potential for its interaction with and uptake by inorganic phases. Association of tritium with sediment organic matter was corroborated in our studies by its near complete (greater than 95%) digestion in untreated estuarine particles"

16.7 Noting that "these characteristics have not been reported previously", the 2009 study concluded that:

"Clearly the view that tritium occurs exclusively as tritiated water and therefore dissolves to infinity should be considered cautiously. Further research into the concept and nature of tritium partitioning in natural waters is required, and the adoption of unit value (or sub-unit value) distribution coefficients and concentration factors that are currently recommended by the IAEA, but not supported by clearly defined measurements, may require reconsideration."

(Ref 31)

N.B. It is relevant to note that, as late as this 2009 study, academics were still commenting on the fact that there was a perception that radioactive wastes discharged to sea would dissolve "to infinity".

17. Summary conclusions on Tritium:

17.1 Aqueous tritium discharged to sea rapidly mixes with surface water and behaves like any other water. Thus there are good technical grounds for assuming that it will transfer easily from the sea to the land in marine sea sprays and aerosol droplets.

A search of "Science Direct" has been unable to find any publications/references for the subject "Tritium in sea spray and marine aerosols", this Submission therefore concludes that there is little, or no, published research on this subject.

17.2 NNB Genco states that there are no available techniques to remove tritium from reactor coolant and thus, to avoid the build up of tritium in the coolant, a portion of the coolant must be discharged to sea and replaced. (ie reactors cannot be safely operated without the discharge of tritium)

NNB Genco say that discharge strategies are normally decided by the site operator and that they will identify the preferred management strategy regime before the start of operational management of the plant.

17.3 The chosen management strategy for proposed new liquid tritium discharges at Hinkley appears likely to be based on that employed at EDF reactors in France, where discharges are pulsed rather than continuous. NNB Genco statements imply that this may be the chosen strategy at Hinkley.

17.4 If such a strategy is employed at Hinkley this could lead to as much as 21% of annual discharge being discharged in 1 month, leading to major peaks and troughs of discharge across a 12 month period. It follows that tritium concentrations in marine organisms, with their very rapid tritium incorporation rates, will be subject to similar time related peaks of concentrations of tritium.

17.5 From the information currently available it remains unclear whether the various assumptions for delivered doses of tritium (via seafoods) have been based on steady state delivery of liquid tritium discharges to the Hinkley marine environment or whether they are based on the peaks and troughs of tritium discharges implied by NNB Genco's statements.

17.6 The previous hypothesis was that tritium would disperse and dilute to infinity after discharge into the Bristol Channel marine environment and hence that tritium discharges were of negligible significance.

NB This hypothesis is a re-iteration of the original hypothesis for the behaviour and fate of all radioactive wastes discharged to sea.

17.7 However, the evolving (post 2000) empirical research now demonstrates that, contrary to the previous view:

- (a) tritium does not disperse and dilute to infinity;
- (b) tritium rapidly bonds with suspended organic/sedimentary particles in the receiving waters;
- (c) tritium concentrations in fine sediment deposits are significantly elevated over those found in ambient seawater;
- (d) tritium bio-availability is much greater than expected; and
- (e) uptake through organic/sedimentary particles to marine and estuarine food webs is demonstrated to be much higher than was expected, (tritium concentration factors in demersal fish and shellfish of up to 100,000).

17.8 As a result of these and other findings independent researchers have stated that:

- (a) existing IAEA recommendations are not supported by clearly defined measurements;
- (b) the adoption of unit value (or sub-unit value) distribution coefficients and concentration factors currently recommended by the IAEA may require reconsideration; and
- (c) further research is required.

17.9 It is highly relevant to note that the actual annual discharges, and annual limits for discharges, of Tritium from the Bristol Channel nuclear power stations, had been markedly reduced, over the decade prior to nuclear new build applications, in response to the evolution of the understanding of tritium.

Thus, in 1999, the combined Hinkley A and B station Tritium actual discharge was 355.8TBq (RIFE 5).

But by 2009 the combined Hinkley Point A&B station Tritium discharge was reduced to 105.232TBq (RIFE 15)

17.10 However the Regulating Agency has now concurred with the demand for a reversal of that recent policy and thus

- (a) If the proposed new Hinkley and Oldbury reactors come on line, tritium discharge limits (for combined existing and new Bristol Channel NPSs) will rise by 50% from 653 TBq to 983 Tbq per annum and
- (b) If the proposed new Hinkley and Oldbury reactors come on line the actual annual discharge of tritium (for combined existing and new Bristol Channel NPSs) will rise from 105.4 TBq to 314.6 TBq per annum (3 fold rise)

17.11 A Subchapter of NNB Genco's Radioactive Substances Regulation Submission Hinkley Point C: Chapter 12.2 says that

(a) Initial Radiological Assessments (IRA) provided by the Environment Agency have been used to determine environmental concentrations and doses to the public.

(b) the general methods used in IRA are described in the EC Guidance Document Radiation Protection 72 published in 1995. (Ref 32)

(c) In 1998, UK Agencies (NRPB, E.A etc) initiated use of the modelling system PC CREAM 98 as a tool for carrying out radiobiological impact assessments according to the methodology detailed in "Radiation Protection 72" and this is referenced as the modelling system for the hypothetical calculation of environmental concentrations and doses to the public arising from the proposed Hinkley C liquid discharges. (Ref 33)

17.12 To date it remains unclear whether the calculations/modelling of the behaviour and fate of tritium in the Bristol Channel environment and subsequent doses of tritium of tritium to Bristol Channel populations are based on:

(a) the use of models, methodologies and empirical data based on the most recent (2009) reported field and laboratory research and defined measurements;

(b) the use of models, methodologies based on the pre 2000 false hypotheses;

(c) the use of models, methodologies and hypothetical data "not supported by clearly defined measurements"; and

(d) the recommendation that further research is required.

17.13 N.B. To date, the available empirical monitoring/sampling data (as presented in RIFE reports) on the concentrations of Tritium in seawater, sediments and biota appears to be restricted to relatively small areas adjacent to points of discharge.

Thus there remain huge data gaps concerning the mid and far field behaviour and fate of tritium in marine environments.

18. Flawed Modelling

18.1 It is a well understood principle that the accuracy and reliability of hypotheses and hypothetical models is strictly dependant upon both the amount and the accuracy of input data.

18.2 Earlier sections of this Submission have drawn attention to the following issues.

(a) the demonstrable weaknesses in the original hypothesis about the behaviour and fate of radioactive wastes discharged to sea (sections 1 to 4);

(b) the failure/inability of monitoring programmes (based on the failed hypothesis) to generate appropriate accurate data on the behaviour and fate of radioactive wastes discharged to sea. (sections 5 to 8); and

(c) the absence of data (data gaps), and/or issues not taken account of during GDA and other assessments of the marine implications of proposed sea discharges from proposed NPS. (sections 9 to 17)

18.3 In the context of these flaws, failures and omissions this Submission concludes that any hypothetical modelling programmes which repeat and encapsulate those flaws, failure and omissions must be of questionable value and can not represent an appropriate degree of scientific rigour.

18.4 The NNB Genco Submission for the Hinkley C proposed discharges (NNB-OSL-REP-000147 Sub Chapter 12:2) explains that the general methodology used to calculate environmental concentrations of radioactivity and the doses derived from those concentrations is described in the EC guidance document Radiation Protection: 72 RP72.

It is explained that RP72 describes what is defined as a "comprehensive model" called the Consequences of Releases to the Environment Assessment Methodology otherwise know as CREAM. This model was developed as a tool for carrying out radiological impact assessments.

18.5 This Submission draws attention to the fact that RP 72 was first published in 1995 and that the edition of the CREAM model, used by the Environment Agency and the HPA's Radiation Protection Division and referenced by NNB Genco for use during the assessments of outcomes for the proposed Hinkley C UK EPR station liquid discharges, is PC CREAM 98

18.6 However, the website address:

Introduces PC-CREAM 08 which is stated to be "a significant improvement to the PC-CREAM 98 version of the software because it takes into account feedback from users and recent model developments".

NNB-OSL-REP-000147 (page 8: sub chapter 12.2) specifically states "The PC CREAM 08 model was not available when the assessment process was undertaken".

Furthermore the HPA's Radiation Protection division is on record as stating that, as of February 28th 2010 it will no longer be committed to providing support for PC CREAM 98.

18.7 This Report therefore concludes that, in the context of the evidence above, it is evident that the PC CREAM 98 modelling software should be considered redundant This Report also concludes that since the assessment process was evidently undertaken some time ago it may therefore not be fully informed about the latest consensually agreed advances in radiological science regarding a range of issues discussed by this Submission (Tritium for instance).

18.8 NNB-OSL-REP-000147 (page 8: sub chapter 12.2: fifth paragraph) states "All discharges are assumed to be continuous, uniform, routine releases". This, as is explained above, applies to the modelling conducted under PC CREAM 98.

However, as shown in earlier sections of this Report, discharges of some nuclides from the proposed Hinkley C rectors are expected to be pulsed or intermittent and thus the work carried out under PC CREAM 98 will not be relevant to any such pulsed or intermittent discharges.

18.9 The Environment Agency's GDA Assessment report UK EPR-05 (page 25: para 119) states that

"For GDA, EDF and AREVA selected Irish Sea/Cumbrian Waters for predicting dispersion of liquid radioactive discharges using the model PC CREAM. They said this would give pessimistic results for the dose impact calculations". The Environment Agency GDA Report does not question the assumption.

18.10 This Submission draws attention to the fact that neither NNB Genco, EDF/AREVA, nor the Environment Agency have offered any review, discussion or examination of the statement.

This Submission has already introduced evidence to demonstrate that there are major differences between Irish Sea and Bristol Channel fine particle sediment loadings of the water column (with Bristol Channel fine sediment loadings vastly exceeding those reported for the Irish Sea and Bristol Channel fine sediments reported as being more likely to be organic in origin)

N.B. mechanisms of re-concentration of radionuclides (alpha/actinides) by adsorbtion to fine sediment particles and attachment of some radionuclides (eg tritium) to organic particles are shown (see earlier sections) to be a major factor in the behaviour and fate of sea discharged radioactive wastes.

18.11 In the context of the above, this Submission thus concludes that there is no scientific evidence to support the assumption that the choice of Irish Sea/Cumbrian Waters is appropriate to assessments for the Bristol Channel or for claims that model outcomes will be pessimistic; in fact the available evidence tends to suggest that they may well be optimistic.

This Submission thus concludes that the use of Irish Sea data in a Bristol Channel context lacks both evidential justification and scientific rigour on the part of both NPS developers and the Regulating bodies.

18.12 This Submission draws attention to the fact that the DORIS marine dispersion component of the CREAM model has been revised since the 2003 publication of the EC MARINA ll study into the behaviour of radioactivity in the marine environment, and thus assumes that these revisions are not encapsulated in PC CREAM 98.

18.13 This Submission also notes that a research study with the working title "Identifying Key Parameters which Control Coastal Dispersion Modelling" has been under way for some time, was originally supposed to be published in 2010 but had not yet been published.

Although this study has been variously attributed to the Environment Agency, the HPA and the National Dose Assessment Working group and is referenced as ongoing in several websites, inquiries to each body, while confirming that such a research project is underway, have been unable to clarify either the authors, the proposed date of completion of the study or a confirmed future date of publication.

18.14 This Submission therefore concludes that the outcomes of what must be highly important research input to the modelling processes and software discussed above are still not available and thus that the modelling processes and software in question are therefore not informed by the latest subject specific research.

18.15 This Submission re-iterates the fact that, in order to generate the most reliable and accurate hypothetical models of the behaviour and fate of radioactive wastes discharged to sea, models of potential pathways of dose delivery to the public and models of potential actual doses received by the public, it is imperative to input the most recently identified, accurate, reliable and up-to-date data and understanding of all relevant parameters.

18.16 This Submission draws attention to the fact that, in the context of the issues set out in preceding paragraphs of this section, the various modelling programmes concerning the environmental behaviour and fate of marine discharges radioactive wastes, pathways of exposure and the subsequent doses of radioactivity to the public are **not** informed by the most recently identified, accurate, reliable and up-to-date data and understanding of all relevant parameters.

18.17 This Submission draws attention to the fact that although hypothetical models are generally calibrated against observed data, in this case much of the existing observed data is deeply flawed because it is based on the catalogue of errors set out in preceding sections of this Submission and summarised in 18:2 above.

18.18 This Submission therefore concludes that the entire suite of hypothetical models upon which the proposed "safety" of the proposals to discharge radioactive wastes to sea are based are significantly flawed for the reasons set out above and that their use by NPS developers and the Regulating agencies has little or no evidential justification and has demonstrated a lack of scientific rigour.

19. Potential Marine Environments Outcomes of Fukushima Type LOCA/Emergency Coolant Water Use at New Build NPS.

19.1 In the aftermath of the Fukushima incident the UK and Northern Ireland Nuclear Free Local Authorities submitted a large body of evidence to the Weightman Inquiry into the lessons to be learned from that incident.

19.2 One of the issues covered by the NFLA's submission to Weightman was that of the major radioactive pollution of the adjacent marine environment as a result of

(a) the initial series of Loss of Coolant water Accidents (LOCA) at the plant;

(b) followed by the use of enormous volumes of Emergency Cooling Water (ECW) in order to prevent reactor and cooling pond meltdowns;

(c) the lack of systems for the management, control, capture and storage of the huge volumes of radioactive liquid which arose; and

(d) leading to the runoff (to adjacent watercourses, the sea and adjacent land surfaces) of the contaminated liquids.

19.3 This Submission draws attention to the fact that the occurrence of LOCA events are not restricted to the 2011 Fukushima incident where multiple Reactors and Spent Fuel Cooling Ponds (SFCP) suffered catastrophic loss of their coolant.

Other examples of LOCAs are the Windscale fire of 1957, the Mayak Reprocessor SFCP (USSR) 1957, the Lucens reactor (Switzerland) 1969, Three Mile Island (USA) 1979 and Chernobyl (USSR) 1986.

A majority response to such events (in order to avoid a melt down and subsequent major release of radioactivity to the atmosphere) is to use ECW as a preventative measure and to keep on applying ECW until the situation is fully under control.

19.4 Despite the past history of LOCA occurrence and the consensual conclusion that they are caused by human fallibility (designer or operator error) in the face of unforeseen events, neither the Proposals submitted by the developers of proposed new NPS nor Regulating Agency's GDA Aqueous Radioactive Assessment Reports have bothered to address Loss of Coolant Accidents (LOCA) in the context of the behaviour, fate and management of primary and secondary cooling waters in the event of a LOCA event.

Additionally, neither have addressed the response necessary for the management of potentially massive Emergency Cooling Water (ECW) arisings, and neither have carried out an analysis of the potential damage impact to site infrastructure, storage tanks or drainage systems due to unforeseen circumstances responsible for LOCA events.

19.5 The GDA Aqueous Radioactive Assessment Reports also fail to address the issues surrounding the necessity for the provision of capture/retention/treatment capacity for hundreds of thousands of cubic metres of ECW generated over prolonged time scales.

19.6 It is evident that the information given in the GDA's Aqueous Radioactive Assessment Reports is relevant to only "normal operations" and contains no discussion of specific issues arising in the event of reactor or cooling pond LOCA events requiring the use of Fukushima type volumes of Emergency Cooling Water (or severe flooding of sites as a result of such phenomena as tidal bore, storm surge, tsunami, excessive rainfall).

19.7 The following extracts from the GDA for the proposed Hinkley C UK EPR are relevant:

"We have not considered at GDA other site liquid discharges such as surface water. The design of such systems will be site specific and there should be no contamination in normal operation. We will review site drainage at site specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling."

(Ref 39)

19.8 Annex 1 (Fig 1) of Ref 39: shows collection and management of three liquid effluent streams:

(a) Primary Liquid Effluent.

(b) Spent Liquid Effluent.

(c) Drainage Water from Turbine Hall.

19.9 In their GDA for the Oldbury type AP 1000 reactor, the EA list five sources of aqueous radioactive waste (Paras 35–46)

(a) Reactor Coolant System Effluents.

(b) Building floor drains and sumps.

(c) Detergent wastes (sinks, showers etc).

(d) Aqueous chemical wastes (laboratory and other small volume sources).

(e) Steam Generator blowdown wastes.

(Ref 40)

19.10 And at Page 15: Para 49 of Ref 40 EA says "We consider that all sources of aqueous radioactive waste have been identified".

And at Para 57 (page 16) EA say "AP1000 has five types of tanks for collecting aqueous radioactive waste":

(a)	Reactor Coolant drain tank	volume= 3.4 cubic metres
(b)	Effluent Hold up tanks	volume= 2 x 106 cubic metres
(c)	Waste hold up tanks	volume= 2 x 57 cubic metres
(d)	Chemical waste tank	volume= 34 cubic metres
(e)	Monitor tanks (42 days storage)	volume=6 x 57 cubic metre
TOTAL VOLUME		**=705'4 cubic metres**

19.11 It is evident that the information given in the GDA's Aqueous Radioactive Assessment Reports is relevant to only "normal operations".

Thus the GDA Aqueous Radioactive Assessment Reports fail to address LOCA response and the potential for massive Emergency Cooling Water (ECW) arisings, and do not conduct an analysis of the potential damage to site infrastructure, storage tanks or drainage systems due to unforeseen circumstances.

19.12 The GDA Aqueous Radioactive Assessment Reports fail to address the issues surrounding the necessity for the provision of capture/retention/treatment capacity for hundreds of thousands of cubic metres of ECW generated through the post LOCA period and, in the case of the Fukushima site, still underway over a year after the initial event.

(See Annex 1 for a detailed breakdown of the Fukushima post tsunami events and issues relating to production and management of post event highly radioactive waters)

Similarly the various submissions by the developers of both UK EPR and Westinghouse/Toshiba AP1000 also fail to consider the control and management of any ECW arisings in the event of a LOCA response

19.13 The Nuclear Free Local Authorities (NFLA) have already submitted information to the ONR Weightman Inquiry on these issues and made the following recommendations:

(a) Site drainage (with specific relevance to emergency situations including LOCA response and inundation) should be made a GDA and major planning issue and NOT be determined by site operators, on a site specific basis.

(b) The GDA should review reactor basement design and construction in order to confirm that, if they are to be used for collection and storage of spilled reactor and/or cooling pond coolant and ECW, they will prevent leaching, facilitate the monitoring of the Highly Radioactive Water (HRW) and escaped coolant and be provided with appropriate equipment such as pumps, gauges etc.

(c) HRW capture/retention, storage and treatment capacity should be made a GDA issue and NOT be determined on a reactor specific or site specific basis. It should be thoroughly reviewed for all proposed Nuclear New Build (and also existing sites) in the context of both:

1. the Fukushima event; and
2. the potential LOCA events and the potential for tsunami/flood events.

(d) The storage capacity for highly concentrated wastes generated by the filtration treatment of HRW should be reviewed by the GDA with a view to ensuring that, in the event of the need to filter treat high volumes of escaped coolant and contaminated ECW, there is sufficient storage capacity for the ensuing highly concentrated radioactive waste

19.14 This Submission draws attention to the fact that prior to the (listed above) LOCA events, the occurrence of LOCA was generally reported and assumed to be unthinkable and therefore programmes for the management and control of lost primary and secondary coolants and subsequent emergency cooling waters were not put in place

In a similar vein, as can be seen from the paucity/lack of available relevant and appropriate data about the marine/aquatic impacts of the Fukushima events, no provision was made for pre-planned programmes of emergency environmental monitoring.

19.15 This Submission concludes that a similar industry and regulator mind set is now in place with regard to the current proposed UKEPR and AP1000 PWRs but warns that there is no evidence to justify such an assumption,

This Submission further concludes that, on the contrary, the available evidence from the previous events demonstrates the very real need for the precautionary installation of

(a) appropriate site infrastructure;

(b) strategies and procedures for the containment and management of lost coolants and emergency cooling waters; and

(c) pre-planned programmes for emergency monitoring of all aspects of aquatic and marine environments.

References

1. "Disposal of Radioactive Wastes: a review of IAEA efforts to assure safety". IAEA Bulletin Vol 03: Issue 3. 1961. (page 3).

2. Statement by John Dunster (UKAEA) to the United Nations Conference "Peaceful Uses of the Atom" 1958

3. Cooperative Research Report 155, ICES, Copenhagen, 1989: International Council for the Exploration of the Seas

4. "Atlas of the Seas around the British Isles". Lee & Ramster. (Editors). Directorate of Fisheries Research. Ministry of Agriculture and Fisheries.1981. (pps 2.10 and 2.21)

5. "Marine Pollution". R.B. Clark. 3rd Edition. Clarendon Press. Oxford 1992. Chap'7. page 106

6. "Radioactivity in Food and the Environment" 2009 (RIFE 15)Environment Agency, Food Standards Agency, Northern Ireland Environment Agency, Scottish Environment Agency. October 2010. (Table 2.8. page 80)

7. Walker, M.I et al' "Actinide Enrichment in Marine Aerosols". Nature 323, 6084, 11 September 1986 (pages 141–143)

8. Eakins et al' "Studies of Environmental Radioactivity in Cumbria: Part 5. The Magnitude and Mechanism of Enrichment of Sea Spray with Actinides in West Cumbria". Report no R10127. AERE. Harwell. 1982.

9. "An Introduction to Coastal Geomorphology" John Pethick. Edward Arnold (Hodder Headline Group). Pps 150–155 &178.

10. IBID ref 5:

11. IBID ref 7 (page 24)

12. Radioactivity in Food and the Environment 2009 (RIFE-15.) Table 4.7(a) page 137.

13. "Atlas of the Seas around the British Isles". Lee & Ramster (Editors) Directorate of Fisheries Research. Ministry of Agriculture Fisheries and Food. 1981 (p2:16)

14. "A review of Sediment dynamics in the Severn Estuary : Influence of Flocculation" Marine Pollution Bulletin 2010: Vol 61, Issues 1–3: pps 37–51 (para3.2)

15. IBID Ref 14 (para 5, page 13)

16: IBID Ref 14 (para5, page 14)

17. NNB Genco: Radioactive Substances Regulation Submission Hinkley Point C. Chapter 4. Liquid Discharges (NNB-OSL-REP-000105) page 15 of 64

18. "AP1000 European Design Control Document and the Environment Report" Westinghouse. Table 3.4–6. available via **www.ukap1000application.com**

19. First report of the House of Commons Environment Committee. HMSO. LONDON. 1986

20. Eakins et al' "Studies of Environmental Radioactivity in Cumbria: Part 5: The Magnitude and Mechanism of Enrichment of Sea Spray with Actinides in West Cumbria". Report No R10127. AERE Harwell. 1982 (page 7)

21. IBID Ref 20 (page 14)

22. Cambray RS et al' "Pu, Am241 and Cs137 in soil in West Cumbria and a maritime effect" Letters to Nature. Nature 300. pps 46–48 (04 November 1982)

23. RADMID First Report: 1987 and 1988. Dyfed County Council. Carmarthen. Dyfed. South Wales. (page 12)

24. Isles. CG et al' "Body concentrations of Caesium 137 in patients from Western Isles of Scotland". British Medical Journal. Vol 302. 29th June 1991.

25. IBID Ref 7

26. Pattenden, N.J et al': "Atmospheric measurements on radionuclides previously discharged to sea" pps 201–221. in "Proc' Int. Symp. IAEA on the Impacts of Radionuclide releases into the Marine Environment" IAEA. Vienna. IAEA-SM-248/138

27. MAFF Aquatic Environment Monitoring Reports (Nos 12,13 &14) Table 1

28. MAFF Aquatic Environment Monitoring Report (no 14) section 6:6: page 36

29. Radioactivity in Food and the Environment 1999 (RIFE-5) 2000. Section 8:2 and 112 and Tables 8:2 (a) and 8:2 (c) page 111

30. McCubbin D et al' "Incorporation of Organic Tritium (3H) by Marine Organisms and Sediment in the Severn Estuary/Bristol Channel (UK)" marine Pollution Bulletin. Vol 42. Issue 10. October 2001.pps 852–863

31. Turner.A et al' "Distribution of tritium in estuarine waters: the role of organic matter" Journal of Environmental Radioactivity. Vol 100. Issue 10. October 2009. pps 890–895

32. Simmonds et al' "methodology for Assessing the radiological consequences of routine releases of radio nuclides to the environment" EUR 15760 EN . Radiation Protection. 72. 1995

33. Mayall et al' "PC CREAM: installing and using the PC system for assessing the radiological impact of routine releases " EUR 17791 EN. NRPB-Sr-296. 1997

34. "An Assessment of the Present and Future Implications of Radioactive Contamination of the Irish Sea Coastal Region of Cumbria". Wilkins BT et al': National Radiological Protection Board. NRPB-R267. 1994

35. Radioactivity in Food and the Environment (RIFE-15) 2010. pps 49 and 51 and Table 2.14

36. "A Process Based model for the partitioning of soluble suspended particulate and seabed sediment fractions of Plutonium and Caesium in the Eastern Irish Sea" Vives I., Battle et al'. Journal of Environmental Radioactivity. Vol 99. Issue 1. January 2008. pps 62–80. para 2.6

37. "Remote Sensing of temporal and spatial patterns of suspended particle size in the Irish Sea in relation to the Kolmogorov scale". Van der Lee EM et al'. Continental Shelf Research. Vol 29. Issue 9. May 2009. pps 1213 to 1225.

38. A Review of Sediment Dynamics in the Severn Estuary: Influence of Flocculation." Marine Pollution Bulletin. Issues 1–3. pps 37–051 (para 3:2 and para 5) page 13.

39. Environment Agency. GDA ASSESSMENT Report UK EPR-05. Assessment Report: Aqueous Radioactive Waste Disposal and Limits. Page 25: para 118.

40. Environment Agency. GDA ASSESSMENT Report AP1000 Assessment report: Aqueous Radioactive Waste Disposal and Limits.

Annex 1

RECOMMENDATIONS ARISING FROM LESSONS LEARNED FROM THE FUKUSHIMA DAIICHI EVENT

A Report to the Nuclear Free Local Authorities for submission to the Weightman Inquiry

September 2011

Tim Deere-Jones: Marine Radioactivity Consultant: August 2011.

Introduction

The foci of this submission are

1. The events preceding and giving rise to the discharge of LOCA derived radioactive material to the marine environment adjacent to the outfalls of the Fukushima

2. Attempts to control and manage both the coolant water which escaped from reactors and spend fuel cooling ponds (Scups) and the emergency cooling water (ECW) used to respond to the loss of that coolant

3. Attempts to identify and quantify the radioactivity discharged to the environment (in liquid/aqueous form) during the event

4. Attempts to monitor the marine environmental impacts of the radioactivity discharged during the events.

I have placed the Recommendations first.

A brief review of the chronological and factual aspects of the Fukushima Daiichi follows the Recommendations.

That brief review tries to

(a) clarify a mass of poorly reported and often contradictory facts;

(b) to develop a time line of events as they relate to discharges to sea; and

(c) to identify weaknesses/failures in procedures, management and response to the event.

Recommendations in Light of FUKUSHIMA Experience:

1.1 Despite assessments of the full range of potential threats the Fukushima event was not foreseen and safety measures designed and built in to the plant during it's initial construction and during subsequent years were not adequate to the task of preventing the event**.**

1.2 Thus the event demonstrates that no matter how much statistical analysis is applied to such issues in order to attempt to forecast potential threats, human fallibility will never be able to guarantee identification of all possibilities.

The only guarantee is that totally unexpected events will occur. This is the most important lesson to be learned from the Fukushima event.

Site Drainage Infrastructure and Management

2. *Responding to initial loss of coolants*

2.1 The Fukushima accident demonstrated that in the event of catastrophic LOCAs at either Reactor units and/or Scups (Spent Fuel Cooling Ponds), large volumes (up to the total volume contained within the units) of highly radioactive Primary and Secondary coolant can be lost from both Reactors and pond containment systems as a result of single (earthquake) and multiple events (earthquake+ tsunami), and presumably any other similar magnitude "shock" or "flood" incidents, causing disabling damage and loss of function to infrastructure and operating systems.

2.2 Having escaped from the engineered containment systems, liquid (as opposed to vaporised) coolant was then able to enter non "contained" areas of the site.

2.3 The available evidence indicates that this coolant initially entered and was retained in various "basement" and "trench" sections adjacent too and/or beneath the Reactors and turbine halls. No evidence has been offered to demonstrate that such basement areas were specifically designed and engineered to be "fit" for this purpose. The available evidence suggests that this then gave rise to uncontrolled losses of such liquid, from "trenches" and into the marine environment.

3. *Recommendations for management of initial coolant losses*

3.1 In the event of a Reactor or SFCP LOCA it is evidently necessary to have in place a system of Emergency Catchments/Containment systems to prevent the total escape, and loss of control, of leaking Primary and Secondary coolant.

3.2 Thus each unit or facility (Reactor, SFCP, high level liquid waste storage) should be equipped with sufficient emergency catchments space to capture and hold the entirety of coolant from the relevant source.

3.3 This emergency catchments should be sited as low as possible in order to collect escaping coolant on a gravity flow basis (with engineered flow assisting channels) and thus maximise the amount of escaping coolant which can be collected in the event of site-wide mechanical and electrical failures.

3.4 Such emergency catchments should be sealed from "outside" non-LOCA parameter sources such as heavy rainfall, flood or tsunami.

Such emergency catchment should be engineered to the highest standards of accident survivability.

3.5 Such emergency catchment should be equipped with it's own integral pumping system to facilitate removal of this material to safe long term storage. Additionally it should be provided with the facility to easily and simply attach "emergency" pumping equipment if so required

3.6 Such emergency catchment should be equipped with it's own integral radiation level readers and also with sampling equipment enabling thorough radiological analysis of the contents of the emergency containment to be carried out. Additionally it should be provided with the facility to easily and simply attach "emergency" sampling equipment if so required.

4. *Responding to outcomes of Emergency Cooling Water Use*

4.1 The Fukushima event has demonstrated that, in the event of catastrophic LOCAs at Reactor and SFCP units, a primary and very long term response is the application of high volumes of Emergency Cooling Water (ECW).

4.2 It is evident that the scale of use of ECW gave rise to an additional series of problems surrounding the management and control of ECW

4.3 The available evidence suggests that, having been passed through/over fully or partially melted fuels in Reactor cores and SFCPs, the ECW initially entered the various "basement" and "trench" sections beneath the Reactors and turbine halls where it must be assumed to have mixed with the initial lost coolant.

4.4 There is a wide discrepancy between the combined volume of liquid radioactivity reported to have escaped from "trenches" and that deliberately discharged from pre-event liquid waste tanks in order to store more highly active liquid wastes generated by coolant loss and ECW use, when compared to the total volumes of ECW used as discussed in the main body of this submission.

4.5 Continuous application of ECW plainly led to the eventual spread of liquid radioactivity into other sectors of the site and hence into the marine environment.

5. *Recommendations re control and management of ECW*

5.1 In the event of a catastrophic LOCA requiring the application of massive volumes of ECW, measures are required to prevent the ECW from reaching the marine environment.

5.2 Where ECW is being applied to ruptured/breached reactors and SFCPs, the Emergency Secondary Catchment systems proposed above might be used if they were of sufficient volume to hold that coolant lost during the initial LOCA + the additional ECW.

5.3 However, in the case of an incident such as the Fukushima event, it is evident that the huge volume of ECW (reportedly 1,000's of tonnes) would likely quickly overwhelm any basic LOCA emergency catchment systems unless they were specifically engineered to hold such high volumes.

5.4 Controlling flow and end fate of ECW poses additional problems in the context of the "exterior use" of ECW which was applied to reactor roofs (and possibly SFCPs) by helicopter drop, riot control water cannon and fie trucks in scenarios which might exclude the collection of excess ECW etc in the proposed emergency catchment systems while generating free flowing (uncontrolled) run off of ECW.

5.5 Such difficulties could be circumvented if the initial site design and build process were to ensure that all areas in the vicinity of potential sources of radioactive material (including potential internal and external applications of ECW) were to be fully bunded and provided with gravity driven run off/drainage control systems including extensive and very high volume holding tanks such that NO site liquid run offs would be uncontrolled (ie ALL surface liquids generated within the site: including LOCAs, ECW, all rainfall and any other spills, would be controlled).

5.6 In order to combat a scenario like the Fukushima event such holding tanks would have to be numerous and large with the capacity to hold many 1,000s of tonnes of radioactive liquid.

5.7 Such high volume holding tanks should be engineered to withstand as best as possible, all flood and shock events, provided with inbuilt pumping systems enabling the transfer of liquids from one to the other and provided with the facility to easily and simply attach "emergency" pumping equipment if so required

5.8 In addition to providing management options for the control of ECW etc, the use of such tanks would have the additional benefit of catching and containing long term (late discovered) leaks of radioactive liquids via site drains, such as has been recorded at UK reactors under normal operational conditions.

(see Appendix 1: "Incomplete discharge Data": para 4)

5.9 All such high volume tanks should be fitted with their own integral radiation level readers and also with sampling equipment enabling thorough radiological analysis of the contents of the tanks to be carried out. Additionally they should be provided with the facility to easily and simply attach "emergency" sampling equipment if so required.

5.10 Use of such tanks to prevent direct run off of LOCA, ECW and other radioactive (or potentially radioactive) liquids in to marine and other environments would thus permit control of the initial event and an appropriate level of management of the liquid wastes thus generated (including: thorough investigation of the radioactivity content of retained liquid, controlled discharge of low level liquids, appropriate control and manipulation of liquids in the process of decaying to acceptable levels, retention and treatment of high level liquids and settlement of particulate matter)

5.11 Additional issues thrown up by the Fukushima event include that of the application of sea water as ECW with subsequent damage and the reduction of efficiency of reactor and SFCP pipe work due to salt clogging of pipe work etc, which led to a reduced flow of water through Reactor and SFCP systems. Such impacts can be avoided by the use of freshwater instead of salt water.

5.12 The reporting of the Fukushima event makes it plain that freshwater sources were depleted very soon after the event began. Plainly, any future reactor site design must include provision for unbroken supplies of freshwater, best achieved by having both on site and regional reservoirs of freshwater dedicated to the task of coolant replenishment.

5.13 Ready access to regional supplies is necessary in order to avoid the total loss of supply in the event that on site supplies are overwhelmed.

Replacement emergency delivery systems (pumps and pipe work) must be installed or immediately available in order to avoid the catalogue of delays and interruptions to supplies reported during the Fukushima event.

6. *Post event monitoring of marine environments*

6.1 The purpose of post event radiological monitoring and analysis of the environment is to assess the public health impact and the behaviour and possible fate of all of the radioactivity discharged during the event

6.2 Post Fukushima type event scenarios require the rapid deployment of thorough and coherent monitoring and analytical programmes designed to investigate the concentrations and behaviour and fate of the full inventory of radioactive materials likely to have been discharged during the event.

6.3 The post Fukushima event monitoring and analysis of the marine environment was characterised by late inception, restricted frequency and limited investigation of limited parameters. It appears to be representative of a rushed, panicky and incoherent response to unforeseen circumstances.

6.4 The Fukushima monitoring/analytical programmes have failed to ct to comprehensively (or even adequately) investigate the full inventory of potential radioactive pollutants in that they have focussed almost exclusively on Iodine and Caesium isotopes, while ignoring many others especially the alpha emitting actinides known to be present in BWR reactor cores and SFCP (several isotopes of Plutonium, uranium, curium, americium).

7. *Recommendations for post event marine monitoring programmes*

7.1 Any future monitoring and analysis, following a Fukushima type event must fully take into account the full inventory of radioactivity available for release given the nature of the accident and the actions taken.

7.2 At Fukushima the monitoring authorities chose to focus on those isotopes (iodine and Caesium) which are highly soluble in water, while at the same time ignoring those which are insoluble and prefer to attach by Adsorbtion to sedimentary particles suspended in the water column.

7.3 They also failed to investigate the presence, concentration and radiological significance of "hot" particles of reactor fuel, used fuel from cooling ponds and/or pieces of reactor of cooling pond structure released into coolant and ECW flows as a result of explosion, meltdown, containment breach, washout of coolant and through flow of ECW.

7.4 In order to adequately fulfil the purpose of future post (reactor and Cooling Pond) LOCA marine monitoring and analytical programmes those operators and agencies responsible for drawing up such programmes should prepare A CLEAR AND DETAILED POST EVENT MONITORING AND ANALYTICAL PROGRAMME, subject to wide scrutiny and peer review and available for immediate deployment in the event of such an event

7.5 Such a programme should take account of the following parameters

(a) the full inventory of radioactive materials contained within both Reactor cores and spent fuel ponds;

(b) any monitoring and analytical work should include coverage of both beta emitters and alpha emitters, activation products and fission products; and

(c) accident derived "hot" particles (pieces of fuel from reactors and/or cooling ponds subject to explosion or meltdown, materials likely to have escaped from reactors of SFCP as a result of coolant escape and the use of ECW).

7.6 Such a programme should take account of the known environmental behaviour of both highly soluble radioactive materials and non-soluble radioactive materials with regard to both their immediate behaviour and long term behaviour and fates.

Such a programme should investigate the behaviour of radioactivity by filtering seawater samples and identifying the concentrations of the inventory radioactivity found in filtered seawater and that found in any sedimentary particles previously suspended in the seawater.

7.7 Such a programme should identify near, mid and far field end fate deposition environments (seabed and inter tidal fine sediment deposits) where very long lived, non-soluble isotopes of Plutonium, Americium, Uranium and Curium might be expected to deposit out and re-concentrate relative to ambient water column concentrations.

7.8 Such a programme should have regard to the scientifically attested work which has demonstrated the ability of several isotopes (both highly soluble and in-soluble and in particulate form) to re-concentrate in marine micro layers, marine sea sprays and marine aerosols and hence to transfer from the sea to the land. Analytical work to assess the post event Public Health significance of these mechanisms must be undertaken, leading as they do to potential human exposure via inhalation, contact etc.

7.9 Such a programme should also have regard to the attested fact that such isotopes (including Caesiums and actinides and particulates) have been shown to transfer from the sea to the land (via sea spray, aerosols, flooding) and to contaminate terrestrial foodstuffs and thus enter terrestrial dietary chains. Analytical work to assess the Public Health significance of these mechanisms must be undertaken in the context of potential exposure of humans via pathways of ingestion, inhalation and contact.

7.10 Such a programme should also have regard to the fact that radioactivity deposited in inter tidal sedimentary environments has been shown to be susceptible to re-suspension (in drying conditions) and blowing ashore adsorbed to fine sediment particles to contaminate house dust and perhaps terrestrial foodstuffs

8. *Recommendations arising from EAs GDA statements that site drainage issues should be determined on a site specific basis*

8.1 Site drainage (with specific relevance to emergency situations including LOCA response and inundation) should be made a GDA issue and NOT be determined on a site specific basis.

8.2 The GDA should review reactor basement design and construction in order to confirm that, if they are to be used for collection and storage of spilled reactor and/or cooling pond coolant and ECW, they will prevent leaching, facilitate the monitoring of the HRW and escaped coolant and be provided with appropriate equipment such as pumps, gauges etc.

8.3 Highly Radioactive Water (HRW) capture/retention, storage and treatment capacity should be made a GDA issue and NOT be determined on a reactor specific or site specific basis. It should be thoroughly reviewed in the context of the Fukushima event

8.4 The storage capacity for highly concentrated wastes generated by the filtration treatment of HRW should be reviewed by the GDA with a view to ensuring that, in the event of the need to filter/treat high volumes of escaped coolant and contaminated ECW, there is sufficient storage capacity for the ensuing highly concentrated radioactive waste

Description/Chronology of events at Fukushima Daiichi

1.1 There is now a maturing and ongoing consensus among industry commentators that the Fukushima events have been characterised by

(a) low standard of accuracy and transparency of reporting;

(b) confusion of chronology;

(c) confusion of factual detail (mistakes); and

(d) inadequate number of parameters reported.

1.2 This has led to both an inadequate understanding of the event itself and an equally inadequate management of many issues, not least those leading to the ongoing mis-management of issues concerning the marine environmental impacts of post-incident remedial actions.

1.3 As of yet there is a dearth of in-depth and peer reviewed analyses of the factual and chronological evolution of events. Additionally of course, it is undoubtedly the fact that events continue to unfold as the Inquiry hears evidence thus many of the outcomes of the Fukushima event are still unknown.

1.4 Evidently it is premature to conduct any reviews of the implications of the event (in respect of the UK's ongoing nuclear power developments) until such time as the Fukushima events and their aftermath are universally agreed to have concluded and a wide ranging, peer reviewed analysis of what actually happened at Fukushima, and it's full range of environmental, public health and economic impacts had been conducted and made public.

1.5 Thus, in the current context, the UK Government has acted precipitously in setting up the Inquiry and insisting on a limited time scale for conclusion and presentation of recommendations in the absence of a factually and chronologically complete, wide ranging and peer reviewed analysis of all of the available facts.

1.6 Consequently this submission relies upon the relatively "immediate" responses of various experts and commentators, which have been reported as events continue to unfold.

The following paragraphs are based on information provided by TEPCO and Japanese Government Press Releases, and a very well referenced summary of the event provided by WIKIPEDIA.

2. *Loss of Reactor 1 coolant water*

For brevity's sake this submission will focus on events surrounding the 3 partial meltdown incidents at Fukushima Reactors 1, 2 and 3 all of which have required remedial injection of high volumes of emergency cooling water (ECW) supplies due to leaks following breach of containment

2.1 Reactor 1: chronology of emergency coolant water injection

(a) Within 16 hours of initial major quake: containment/cooling systems completely failed and fuel rods exposed. The reactor core had melted, fallen to bottom of pressure vessel and burned through it.

(b) 12 March: (20.20 Japan Time) (JT): seawater injection to reactor core initiated using fire trucks (flow rate of 2 cubic metres per hour)

(c) 23 March: Seawater injection by site feed water systems (flow rate increases to 18 cubic metres per hour)

(d) 24 March: high rate of seawater injection increases pressure in reactor….steam vented and (water flow rate reduced to 11 cubic metres per hour)

(e) 25 March: 1,890 cubic metres freshwater brought to site by barge and fresh water injection replaces seawater injection.

(f) 12 May: TEPCO confirms that due holes in pressure vessel, coolant water continues to leak.

(g) June: Japanese Government confirms that reactor containment had been breached and that pumped cooling water continued to leak

(h) 23 August: TEPCO press release confirms that water continues to be injected at flow rate of 3.7 cubic metres per hour.

No details have been provided regarding the starting date of this reduced flow rate programme, thus militating against any calculation of the volumes of water used during this period.

2.2 I have been unable to find any comprehensive assessment of volumes of emergency cooling water use re Reactor 1. Such data appears to have not been calculated.

However the following may give some impression of the volumes of ECW used at Unit 1 (cubic metre == approx I tonne of water)

Dates	*Given Flow rates*	*Total Volumes for period*
12 to 23 March	2 cubic metres per hour	528 tonnes per 11 days
23/24 March	18 cubic metres per hour	432 tonnes per 1 day
25 March	11 cubic metres per hour	264 tonnes per 1 day
23 August report	3.7 cubic metres per hour	88.8 tonnes per day (but date of flow change not available)

2.3 Thus, after 13 days of ECW pumping (12 to 25 March) an estimated 1,224 tonnes of water had pumped into the reactor core of Unit 1 at an average rate of 81.6 tonnes per day.

2.4 During the subsequent 151 days (March 25 to Aug 23) the ECW flow rate cannot be precisely calculated due to the very poor reporting.

However, using the data presented in 2:1 (above) the range of potential values would spread from

Max Value a: 150 days at 264 + 1 day (Aug 23) at 88.8 = approx' 39,688 tonnes

Min Value b: 151 days at 88.8 = approx' 13,408 tonnes

2.5 Total estimated pumped ECW values for period 12 March to 23 Aug (164 days) thus range between

Value a: 39,688 tonnes +1,224 tonnes = 40,912 tonnes

(average daily rate = 250 tonnes)

Value b: 13,408tonnes +1,224 tonnes = 14,632 tonnes

(average daily rate=90 tonnes)

2:6 As of Aug 23, there has been 164 days of continuous pumping of ECW through the reactor core.

In the context of the

(a) official confirmation of meltdown beginning within five hours of the first earthquake because of cooling failure;

(b) constant application of ECW to reactor core; and

(c) confirmation of leaks in the reactor pressure vessel and containment systems.

It cannot be denied that ECW has been continuously passing over/through the reactor core (and subsequently the molten mass of fuel arising as a result of the meltdown) for 5..5 months and flushing a range of particulate and dissolved radioactive fission and activation products from the reactor core and into non-core, non pressure vessel and non-containment system environments : ie transporting those various radioactive materials from within a supposedly safe and shielded environment to the outside environment.

2.7 When reactor core cooling fails in such a scenario the zirconium alloy fuel cladding fails and fission products are released. There can be no doubt that the ECW flows will have collected a highly significant quantity of the full range of fission products and transported them in the ECW flow through the reactor core, the pressure vessel and the containment buildings to whatever their end deposition site will have been.

2.8 No comprehensive calculation, assessment or estimate of the total volume/quantity of core derived fission products entrained in the ECW through flow has yet been made public.

2.9 In the absence of any other data it may be assumed that the full range of fission products derived from uranium oxide based fuels undergoing a meltdown were available for entrainment into the ECW deployed at Unit 1.

These fission products will have included approximately 17 actinides composed of:

Several isotopes of Uranium;

Several isotopes of Plutonium;

Several isotopes of Americium; and

Several isotopes of Curium.

2.10 In addition the BWR cores will have contained isotopes of Caesium, Iodine, Tritium, and Rubidium and a cocktail of approximately 55 other radioactive isotopes (including corrosion products derived from the irradiation of reactor and pipe work structural materials as well as from the fuel and it's cladding.)

3. *Loss of Reactor 2 Cooling water*

3.1 Reactor 2: chronology of emergency coolant water injection

(a) 14 March : fuel rods exposed and water levels falling to minimum values.
Injection of sea water into reactor vessel initiated and reactor vessel half filled

(b) 14 March : pumping stopped due to four of five pumps failed and 5th ran out of fuel. Also gauge accidentally turned off and blocked flow of water into reactor vessel

(c) 15 March: pumping resumed

(d) 26 March: switch to freshwater injection

(e) 28 March : Nuclear Safety Commission suspects rad' mats leaked from reactor into water in trenches……volumes of pumped water reduced because of concern about leaks to sea

(f) 15 May: TEPCO reports that Unit 2 leaking and that 1,000s of tonnes of pumped ECW had leaked

(g) 23 May: TEPCO reports Reactor 2 achieved meltdown about 100 hours after initial quake

(h) August: ECW still being pumped

3.2 As of yet I have not been able to access details of the flow rates of ECW pumping flow rates. Nor have I have been unable to find any comprehensive assessment of volumes of emergency cooling water use re Reactor 2. Such data appears to have not been calculated.

However the scant available details of the progress of events at Reactor 2 imply that pumping flow rates for ECW were probably broadly similar to those at Reactor 1.

3.3 Therefore, and subject to the release of additional information, I propose that the range of Total Pumped Volume of ECW for reactor 2, be taken as similar to that of Reactor 1.

3.4 Total estimated pumped ECW values for period 14 March to 23 Aug (164 days) thus range between

value a: 39,688 tonnes +1,224 tonnes = 40,912 tonnes

(average daily rate = 250 tonnes)

value b: 13,408tonnes +1,224 tonnes = 14,632 tonnes

(average daily rate=90 tonnes)

3.5 There has now been at least 162 days of continuous pumping of ECW through the reactor 2 core.

In the context of the

(a) official confirmation of meltdown beginning due to the first earthquake because of cooling failure; and

(b) confirmation of leaks in the reactor pressure vessel and containment systems

3.6 This can only mean that water has been passing over the fuel rods and subsequently the molten mass of fuel arising as a result of the meltdown.

3.7 It cannot be denied that ECW has been continuously passing over/through the reactor core (and subsequently the molten mass of fuel arising as a result of the meltdown) for 5.5 months and flushing a range of particulate and dissolved radioactive fission and activation products from the reactor core and into non-core, non pressure vessel and non-containment system environments : ie transporting those various radioactive materials from within a supposedly safe and shielded environment to the outside environment.

3.8 When reactor core cooling fails in such a situation the zirconium alloy fuel cladding fails and fission products are released. There can be no doubt that the ECW flows will have collected a highly significant quantity of the full range of fission products and transported them in the ECW flow through the reactor core, the pressure vessel, the containment buildings to whatever their end deposition site will have been.

3.9 No comprehensive calculation, assessment or estimate of the total volume/quantity of core derived fission products entrained in the ECW through flow at Reactor 2 has yet been made public.

3.10 In the absence of any other data it may be assumed that the full inventory of fission products derived from uranium oxide based fuels undergoing a meltdown were available for entrainment into the ECW deployed at Unit 2.

These fission products will have included approximately 17 actinides composed of:

Several isotopes of Uranium;

Several isotopes of Plutonium;

Several isotopes of Americium; and

Several isotopes of Curium.

3.11 In addition the BWR cores will have contained isotopes of Caesium, Iodine, Tritium, and Rubidium and a cocktail of approximately 55 other radioactive isotopes (including corrosion products derived from the irradiation of reactor and pipe work structural materials as well as from the fuel and it's cladding.)

4. *Loss of Reactor 3 cooling water*

4.1 TEPCO have announced that meltdown in this reactor occurred approx' 60 hours after the initial quake.

In September 2010 TEPCO had announced the restart of Reactor 3 using Pu MOX fuel and Uranium Dioxide.

(a) 13 March: seawater injection of Reactor core commenced using fire truck pumps
(b) 14 March: pumping stopped due to consumption of water in "reserve pool". Pumping later resumed when alternative supplies connected
(c) 17 March: 4 helicopter drops of seawater on to reactor roof (approx 13.5 tonnes each: 54 tonnes total).
(d) 17 March: riot police water cannon spray water onto Reactor roof
(e) 18 March: six fire engines pumping seawater (flow rate 54 tonnes per hour) but duration of this work not reported
(f) 22 March: estimated that 3,742 tonnes of ECW used to date
(g) 25 March: TEPCO report that reactor vessel probably breached and leaking rad' mat's
(h) 15th May TEPCO report that Reactor 3 likely to be breached and leaking water
(i) August: ECW pumping still continues

4.2 As of yet I have not been able to access details of the flow rates of ECW pumping flow rates for Reactor 3.

Nor have I have been unable to find any comprehensive assessment of total volumes of ECW use re Reactor 3. Such data appears to have not been calculated.

4.3 However, the scant available details of the progress of events at Reactor 3 imply that pumping flow rates for ECW were, at the very least, broadly similar to those at Reactor 1.

But it should not be forgotten that there was an additional ECW strategy employed at Reactor 3, this being the application (by helicopter, water cannon and fire engine) of ECW to the reactor 3 roof at various rates (54 tonnes per hour) and (54 tonnes during 4 helicopter drops)

4.4 Therefore, and subject to the release of additional information, I propose that the range of Total Pumped Volume of ECW for reactor 3, be taken as similar to that of Reactor 1.

4.5 Total pumped ECW values for period 13 March to 23 Aug (163 days) thus range between

value a: 39,688 tonnes +1,224 tonnes = 40,912 tonnes

(average daily rate = 251 tonnes)

value b: 13,408tonnes +1,224 tonnes = 14,632 tonnes

(average daily rate = 90 tonnes)

BUT not forgetting the above mentioned (para 4.3) ECW applications to the Reactor 3 roof.

4.6 There has now been 164 days of continuous pumping of ECW through the reactor core. In the context of the

(a) official confirmation of meltdown beginning within five hours of the first earthquake because of cooling failure;

(b) constant application of ECW to reactor core; and

(c) confirmation of leaks in the reactor pressure vessel and containment systems

It cannot be denied that ECW has been continuously passing over/through the reactor core (and subsequently the molten mass of fuel arising as a result of the meltdown) for 5..5 months and flushing a range of particulate and dissolved radioactive fission and activation products from the reactor core and into non-core, non pressure vessel and non-containment system environments: ie transporting those various radioactive materials from within a supposedly safe and shielded environment to the outside environment.

4.7 When reactor core cooling fails in such a situation the zirconium alloy fuel cladding fails and fission products are released. There can be no doubt that the ECW flows will have collected a highly significant quantity of the full range of fission products and transported them in the ECW flow through the reactor core, the pressure vessel, the containment buildings to whatever their end deposition site will have been.

4.8 No comprehensive calculation, assessment or estimate of the total volume/quantity of core derived fission products entrained in the ECW through flow has yet been made public.

Additionally such assessments for Reactor 3 are complicated by the fact the fuel was PU MOX.

4.9 In the absence of any other data it may be assumed that the full inventory of fission products derived from uranium oxide based fuels undergoing a meltdown were available for entrainment into the ECW deployed at Unit 3.

These fission products will have included approximately 17 actinides composed of:

Several isotopes of Uranium;

Several isotopes of Plutonium;

Several isotopes of Americium; and

Several isotopes of Curium.

4.10 However, there is a wide consensus that the higher Plutonium proportion in MOX fuel increases the amount of fission product and actinide created during combustion: in particular the "activity" of fission product/actinide arisings will be greater than that of normal Uranium based fuels

4.11 In addition the BWR cores will have contained isotopes of Caesium, Iodine, Tritium, and Rubidium and a cocktail of approximately 55 other radioactive isotopes (including corrosion products derived from the irradiation of reactor and pipe work structural materials as well as from the fuel and it's cladding.) Such products will also be created as a result of MOX combustion.

5. *Estimating the total volume of ECW used to date during reactor cooling*

5.1 As a result of chaotic, spontaneous attempts to acquire and apply ECW during the response to unforeseen major events such an estimate cannot currently (and very probably never will) be accurately calculated.

5.2 Various press statements released by TEPCO have thrown a little light on the volumes of contaminated water released from the site.

On 21 April TEPCO estimated that 520 tonnes of radioactive water from Unit 2 had leaked into the sea via leaking "pits" before the leaks were plugged

Somewhat later TEPCO stated that 300,000 tonnes of "less radioactive water" leaked (or were deliberately released) in order to free up room for the storage of even more highly contaminated waters.

TEPCO have also described failed attempts to contain contaminated water in the harbour near the plant, by installing "curtains" to prevent outflow.

5.3 However, for one reactor specific response action (Reactor 1) there appears to have been at least an attempt to maintain an estimate of the flow rate of ECW being applied to the reactor core. This has allowed an estimated "range" of total volumes of ECW applied to Reactor 1 to be drawn up.

5.4 As demonstrated above this allows a range of daily ECW application to be estimated (for the period early March to late August) at between 90 tonnes per day and 250 tonnes per day per reactor.

5.5 Allowing for ECW application to 3 Reactors over a 164 day period (13 March to 23 August) we can calculate that the range of total ECW application for the period was between 44,190 tonnes and 122,750 tonnes.

5.6 However this is strictly dependant on the

(a) reliability of the flow rate figures given by TEPCO for the Reactor 1 ECW;

(b) the reliability of assumptions that the ECW flow rate for the other 2 reactors is broadly similar to that of Reactor 1; and

(c) the reliability of chronological details of ECW application provided by TEPCO.

5.7 However, as discussed earlier at 1:1 above, there is now a maturing and ongoing consensus among industry commentators that the Fukushima events have been characterised by

(a) low standard of accuracy and transparency of reporting;

(b) confusion of chronology; and

(c) confusion of factual detail (mistakes).

6. *Spent Fuel Cooling Ponds: damage and remedial actions*

6.1 Reporting of Spent Fuel Cooling Pond (SFCP) response is at least as confused and lacking in detail as is that for Reactor actions, possibly more so.

There does seem to be a consensus that

(a) the SFCPs, which sit above the reactors within the Unit buildings, are now without any form of containment since explosions have torn away their roofs and exposed the fuels to open air; and

(b) the SFCP at Units 1, 2 and 3 at least, had lost their cooling systems.

6.2 Unit 1 SFCP

31 March onwards: additional sea water added to spent fuel pond using concrete pump

14 May: freshwater replaces sea water use

29 May: freshwater injection via temporary pump and SFCP line

10 Aug: freshwater via circulatory SFCP line with heat exchangers

No flow rate data is provided for the volume of ECW used at Unit 1 SFCP.

6.3 No information is offered to clarify if the additional sea water added from 31 March was to

(a) replace water which had evaporated due to residual heat of spent fuels

(b) replace water which was leaking due to damage of pond structure

(c) replace water lost during an explosion scenario

6.4 The available scant information implies that injection pumping was continuous until August 10 when the circulatory SFCP lines with heat exchanger were finally deployed.

It may therefore be assumed (in the absence of any information to the contrary) that there were either leaks in the ponds or relatively rapid evaporation of pond water, requiring constant application of ECW until Aug 10 because prior to that date there is no mention of any circulatory cooling mechanism such as the heat exchangers.

6.5 Lack of detailed flow rate information means that at this stage absolutely no assessment can be made of the volume of Unit 1 SFCP water lost to the environment as steam or leaked water

6.6 **Unit 2 SFCP**

20 March onward: seawater added to spent fuel pond cooling line

29 March: seawater substituted for seawater

31 May: freshwater via circulatory SFCP line with heat exchanger

6.7 Once again no flow rate data was provided for the volume of ECW used in the Unit 2 SFCP.

No information is offered to clarify if the additional sea water added from 31st March was to

(a) replace water which had evaporated due to residual heat of spent fuels

(b) replace water which was leaking due to damage of pond structure

(c) replace water lost during an explosion scenario

Thus the comments made in para's 6:4 and 6:5 above apply in the case of Unit 2

6.8 Unit 3 SFCP

14 March: Water believed boiling away from SFCP (note this pond holding PU MOX assemblies which are thermally hotter than uranium fuel assemblies)

24 March: 35 tonnes of seawater added to pond via cooling system

25 June: 90 tonnes of "borated water" pumped into SFCP

2 July, water now injected into SFCP via circulatory cooling system with heat exchangers.

6.9 No information is offered to clarify if the additional sea water added from 24 March was to

(a) replace water, which had evaporated due to residual heat of spent fuels

(b) replace water, which was leaking due to damage of pond structure

(c) replace water lost during an explosion scenario

As was the case with the other units, no flow rate data was provided for the volume of ECW used in the Unit 3 SFCP.

Thus the comments made in para's 6:4 and 6:5 above also apply in the case of Unit 3.

6.10 However, in the context of the need to respond to the elevated thermal heat of PU MOX fuel in the Unit 3 SFCP, it can be seen that the addition of 90 tonnes of borated water was required. This was not reported for Units 1 and 2.

6.11 In the context of that elevated thermal output, it appears probable that the basic cooling requirements of Unit 3 SFCP were greater than those of the other two SFCPs and thus a greater volume of ECW was required.

6.12 In summary it can be seen that

(a) there was a consensus that the SFCPs for Units 1,2 and 3 had all lost their cooling water systems

(b) the SFCPs at Units 1,2 and 3 were all in receipt of ECW,

(c) no data has been provided for the loss rate of cooling water in the ponds due leaks or evaporation

(d) no data has been provided for the flow rates of ECW application at any of the three SFCPs

7. *Explosion at SFCP Unit 3?*

7.1 Various sources continue to argue that the SFCP for Unit 3 (where the reactor was burning PU MOX fuels) had suffered some sort of explosion, which had ejected highly radioactive material to the outside environment.

7.2 In early April, the New York Times published details of a Nuclear Regulatory Commission assessment of the status of the Fukushima Daiichi plant. ("US Sees Array of New Threats at Japan's Nuclear Plant": by James Glanz and William J Broad).

It is this NRC assessment which suggests that fragments or particles of nuclear fuel from spent fuel pools above the reactors were blown "up to one mile from the units" and that pieces of highly radioactive material fell between 2 units and had to be bulldozed over to protect workers.

The NYT article also reported that the ejection of this material may indicate more extensive damage to the highly radioactive SFCP than previously disclosed.

7.4 "American nuclear engineer Arnold Gundersen, noting the much greater power and vertical debris ejection compared to the Unit 1 hydrogen blast, has theorized that the Unit 3 explosion involved a prompt criticality in the spent fuel pool material, triggered by the mechanical disruption of an initial, smaller hydrogen gas explosion in the building. Low-dose radiation researcher and anti-nuclear activist Christopher Busby speculated on Russia Today that the explosion that destroyed the Reactor 3 building was a "nuclear explosion" of some kind in the spent fuel pool." (from Wikipedia: The Fukushima Nuclear Disaster)

7.5 Fairewinds Associates reported August 26th that the very high Caesium 137 and 134 levels reported by TEPCO (19 and 20 August) following the analysis of SFCPs (Units 1, 2 and 3) water is evidence of spent fuel damage and confirms that the source of the spent fuel fragments found a mile from the Units was indeed spent fuel. from one or other of the SFCPs.

7.6 Whatever the cause of the explosion and subsequent ejection of highly radioactive material, there is no doubt that there is agreement that the event was of sufficient force to carry the highly radioactive material for "up to a mile" before deposition.

7.7 Evidently this scenario would have permitted the deposition of such material directly into the marine environment.

8. *Marine Environmental outcomes of Fukushima events.*

8.1 The major monitoring/analytical effort has focussed on the detection of radioactive Iodine and Caesium.

Radiological analysis of sea water by TEPCO, Greenpeace International and Japanese Government Agencies has proved the presence of very highly elevated concentrations of radioactive Iodine, 2 isotopes of Caesium, in seawater, seaweed and marine fish within a 30 to 50 mile radius of the Fukushima site.

8.2 A range of less well know and lower profile radioactive materials have also been analysed for (and found) in seawater: they are isotopes of

tellurium, technetium, chlorine, barium and lanthanum (March 29th). Analysis for these items is at a much lower level than that for Iodine and Caesium.

Other nuclides have been identified in contaminated water (derived from reactor/SFCP leaks and ECW) found in basements and trenches attached to various reactor units; Thus in the basement of Unit 1 (25 March) TEPCO recorded the presence of isotopes of chlorine, arsenic, yttrium, iodine, lanthanum and three isotopes of caesium.

8.3 Direct deposition of "explosion ejected" radioactive debris into adjacent marine environment appears to be highly likely in the context of issues discussed in paras 7.1 to 7.7 above.

TEPCO have stated that small traces of Plutonium have been identified in five soil samples near Reactors 1, 2 and 3. TEPCO have agreed that the Plutonium in two of the samples is confirmed as "direct result of the recent incident".

TEPCO have also reported that some of those soil samples also contain Curium 242, which supports the proposal that the Fukushima accident has indeed ejected alpha emitting actinides (from at least one of the reactors or SFCPs) into the site environment.

8.4 I have not found any statement giving details of the pathway of transport by which Plutonium and Curium was ejected from within contained structures.

Thus it remains an open question as to whether the Plutonium and Cm found and analysed by TEPCO was carried out of containment as a result of explosion followed by atmospheric discharge or whether it was carried out of containment in cooling water or ECW flows.

As of yet there is no evidence to support or reject either theoretical pathway and so the aquatic pathway remains a viable potential transport pathway for the Plutonium and Curium.

8.5 It is highly noteworthy that none of the actinides or recognised major alpha emitters, expected to be found inside the reactors and SFCPs, have been reported as analysed for in any marine samples (seawater, marine algae of marine fish) by any industrial or governmental agency.

No explanation has been given for this omission.

8.6 Entry of radioactive water (from within the Fukushima site) into the marine environment has been confirmed by TEPCO and other observers/commentators. Given the admitted earthquake damage to reactor containment and SFCP containment there can be no doubt that a percentage of that radioactivity is derived directly from the cooling waters from both sources PRIOR to the post-accident response injection of ECW to reactors and ponds.

8.7 Further radioactive contamination of the marine environment will inevitably have been caused by the remedial (post accident) inputs of ECW injected into leaking reactors and ponds

8.8 I have found no statement to the effect that radioactive waters from within the site have ceased to enter the marine environment. It must therefore be assumed that, at the time of writing this submission, the site radioactive run off continues to enter the marine environment

8.9 Official monitoring of radioactivity in terrestrial and atmospheric environments confirms that a reportedly large, but unquantified total amount, of radioactivity has been injected into the atmosphere and subsequently deposited via fallout and washout, onto terrestrial surfaces over a wide swathe of Japan.

There has been no indication that atmospheric leaks from within the Fukushima site have ceased, so it remains the case that radioactive fallout from the accident site continues to fallout and wash out onto land surfaces from which they can wash or leach into watercourses and hence to the marine environment.

8.10 The meteorological data demonstrates that winds have blown from many opposing compass directions since the initialisation of the accident. Thus, it is reported that during the first week of the accident winds blew from the west, thus taking (and depositing) most of the atmospheric releases seaward.

At other times since the earthquake/tsunami winds have blown radioactive atmospheric releases inland or seaward.

Plainly there has been ample opportunity for significant percentages of the atmospheric releases to be deposited onto the sea at varying distances from shore.

8.11 A number of media reports confirm that the Japanese authorities are aware that many standing (non-marine) waters have been contaminated by radioactive fallout and washout (eg: public and school swimming pools) and that these cannot be emptied and their contents disposed of as radioactive wastes because of lack of appropriate disposal sites and infrastructure.

8.12 The deposition of Fukushima accident derived radioactivity onto terrestrial surfaces means that under a variety of meteorological conditions (rainfall, snow melt, re-suspension of radioactive small particles in dry weather etc) such material will be remobilised to enter the marine environment by means of a range of mechanisms including

(a) leaching/remobilisation into rivers and streams running down to sea; and

(b) aerial mobilisation leading to "secondary" deposition to sea.

8.13 In the context of the atmospheric discharges and subsequent fallout of radioactive contamination onto land surfaces, it should be noted that, due to the meteorological fluxes described in the preceding paragraph, Fukushima derived radioactivity has now crossed the coastal watershed and fallen onto land and water surfaces from which watercourses are running westward, rather than eastward into the Pacific.

Thus, in the longer time scale, Fukushima derived radioactivity will be transported into the relatively enclosed Sea of Japan and impact upon coastal and estuarine environments there.

9. *Immediate behaviour of ex-containment cooling waters and ECW*

9.1 As described earlier, throughput of ECW through damaged reactor cores and damaged SFCPs must have transported a (so far un-quantified) percentage of that standard Uranium fuelled BWR isotopic inventory + the additional elevated concentrations of fission and actinide arisings from the MOX fuel

(a) out of the reactor core or cooling pond containment systems;

(b) into the immediate *exterior* environment of the Unit sites, (ie outside the containment buildings); and

(c) and then, as a result of continuing and expanding volumetric flow, further away from the Unit sites and out into the wider environment, where as liquid always does it will have gravitated towards the lowest possible physical level such as drainage systems, trenches, pits, canals, streams/rivers and the sea.

9.2 A study of the available, very poor description of the physical events and their chronology strongly implies that the process outlined above must have occurred in two stages.

9.3 Stage 1 must have consisted of the initial surge of very highly contaminated reactor and SFCP coolant, which would have leaked as soon as physical breaches (holes/leaks etc) of reactor containment vessels and SFCPs were created.

The volumes of such coolant remain unknown due to the lack of data about the volumes of steam and explosive hydrogen generated following the failure of reactor and SFCP cooling systems. This phase was relatively short lived by comparison to the second phase

9.4 Phase 2 consisted of the chronologically much longer term flow of ECW applied to reactor cores and SFCPs (still continuing through August as this submission is written) following the leaks/water loss associated with the initial incidents.

Within phase 2 there were evidently a series of "pulses" due to various technical failures and management decisions regarding the use of different pumping/ECW application techniques and equipment as set out in earlier paras above.

9.5 It is inevitable that these various surges and pulses will have exercised some significant modifying influences on the speed/direction, behaviour and end fate/destination of the highly contaminated radioactive waters under discussion.

However, these cannot be quantified as the events in question are over and done and no observations were made.

9.6 What percentage of this "escaped" liquid radioactivity may have reached the marine environment is un-quantified at this time and is almost certainly going to remain precisely un-calculable due to the lack of useful basic data already alluded to in many places above.

9.7 The relative radiological significance (concentration of radioactivity) of the Phase 1 leaked material compared to that of the Phase 2 leaked material can not be assessed in the current absence of relevant data.

However, the fact that Phase 2 leakage from the reactor cores includes ECW which has been poured over and run through the molten mass of the melted fuel in Reactors 1,2 and 3 and the SFCP at Unit 3 offers the possibility that the cumulative radiological impact of the Phase 2 ECW may be higher than that of the Phase 1 initial loss of coolant from reactors and SFCPs.

10. *Fukushima Site Drainage System*

10.1 Although a few, very basic, diagrams of parts of the site drainage system have been made public, these are

(a) universally highly simplistic and lacking in detail

(b) focussed on reactor units and turbine halls and associated basements and trenches

(c) fail to describe standard infrastructure across the rest of the Fukushima sites such as those designed to respond to normal site drainage issues such as rainwater

(d) fail to describe any additional emergency drainage infrastructure across the Fukushima sites such as those designed to deal with "planned for" emergency flooding scenarios such as excess rainfall

(e) fail to describe emergency drainage infrastructure across the rest of the Fukushima sites, specifically designed to deal with leaked reactor and SFCP coolant and/or other radioactive contaminated liquids

(f) fail to provide any detail of the volume of liquid which may be held within such basements or trenches, nor of the potential flow rate of liquid entering, running through or exiting such basements or trenches

(g) do not discuss emergency systems that may have been fitted to the drainage systems either to restrict excess flow or to hold/store excess flow. (All the available evidence strongly implies that no such emergency storage facilities existed.)

However, from the available diagrams and information it would appear that, in general, the Fukushima site drainage system does not differ markedly from that of any other nuclear power station.

10.2 Statements issued by TEPCO and Japanese Government agencies have only referenced 2 routes by which contaminated water from within the site has reached the sea, they are:

(a) as a result of deliberate discharge of pre-incident contaminated waters in order to make space in holding tanks etc for more highly radioactive waters arising as a result of the accident; and

(b) the overflow/escape of some radioactive water from the "trenches" and "pits" associated with Unit buildings.

It is hard to reconcile these confirmed leaks with the enormous quantities of ex-containment radioactive water reported to have been generated as a result of ex-containment cooling waters and the subsequent use of ECW.

10.3 I have been unable to access charts/maps/ground plans of the Fukushima site drainage system, in particular for those areas outside the reactor containment and SFCP buildings.

I have also been unable to access any information on the drainage flow rate of such site infrastructure.

I have been unable to access any data about whether any radiological analytical or monitoring equipment was installed/attached to any of the Fukushima site drainage infrastructure.

10.4 I have not found any reportage or discussion of the effect of either the earthquake, or the tsunami, on the integrity of any such site drainage infrastructure as may have been in existence prior to the events.

10.5 Despite the lack of such detail noted in 10:4 above, it may be concluded that (as is the case with other severe flooding events) the site drainage system was probably overwhelmed by the tsunami.

Thus, blocking of drainage channels and pipelines and their entrances and exits with debris, lifting/removal of man hole covers etc as a result of pressures forces, physical destruction of various infrastructure installation (reservoir walls, bunding, pumping equipment etc) has certainly occurred given the scale of both earthquakes and tsunami.

10.5 I therefore conclude that gravitational flow across the least impeded surface routes will have been the route by which the majority of the radioactive coolant and ECW will have entered the marine environment.

No evidence is offered to prove that this was not the case.

Reportage of the issue of pits and trenches should not be allowed to obscure this fact.

11. *Attempts to assess the radiological significance of marine radioactivity*

11.1 Quantitative clarification of the amount and significance of radioactivity likely to have entered the sea and it's environmental impact has not been completed and cannot be so done until such time as thorough monitoring and analysis of ALL potential isotopes discharged is undertaken.

This work requires both a thorough examination of the melted fuels in Reactors 1,2 and 3 and the damaged fuels in the SFCPs and also a comprehensive analytical monitoring programme of a wide range of environmental media (terrestrial, atmospheric and marine) for a wide range of representative radioactive substances.

At the time of writing this submission no proposal for the above work has been identified

11.2 Focus on Iodine and Caesium isotopes is not sufficient, nor representative of the range of radioactivity discharged into the environment, and will not provide a full suite of data useful for the calculation/assessment of public health, environmental and commercial impacts because it fails to address the impacts of the other radioactive material released during the incident, especially that of the actinides/alpha emitters.

11.3 Various marine environmental sampling programmes have been undertaken by TEPCO, Japanese government agencies and environmental groups but these have all been characterised by

(a) a very narrow range of nuclides/isotopes analysed for

(b) an apparent poor understanding of short, mid and long term behaviour of radioactivity in the marine environment

(c) a very restricted geographical range of sample sites

(d) a very restricted range of environmental parameters subjected to analysis

11.4 Narrow range of nuclides/isotopes:

As explained in section 8 above, the main focus of the analytical work has concentrated on Iodine and Caesium isotopes

As indicated above (paras 2:7 to 2:10) a large number of fission products, actinides and other isotopes will have been present in side the BWR cores of Units 1 to 3 and the used BWR fuel assemblies stored in SFCPs. Additionally high levels of actinides will have been present in the MOX fuel in Reactor 3 and SFCP 3.

11.5 The fuel assemblies of the MOX fuels from reactor 3 and SFCP 3 will contain elevated concentrations of fission product and actinide created during combustion: in particular the "activity" of fission product/actinide arisings will be greater than that of normal Uranium based fuels (see para 4:10 above).

11.6 Despite the "in-site" discovery of both Plutonium and Curium, confirmed as having originated from within the site, and being a "direct result of the recent incident" and well understood to be present in reactor cores and SFCPs, (especially those containing MOX fuels) none of the range of alpha emitters/actinides known to be present in both reactor cores and SFCPs are reported as having been analysed for in any marine samples.

12. *Poor understanding of behaviour of radioactivity in marine environments*

12.1 Some nuclides such as the isotopes of Caesium and Iodine are highly soluble and dissolve relatively easily in NPP cooling water and in seawater

Highly soluble nuclides become well distributed through the water body and concentrations generally appear to dilute with distance from source**.** However, a few minor pathways of re-concentration do exist: thus Cs concentrations can be shown to be enhanced through marine food chains relative to sea water concentrations and indeed through coastal zone foodstuffs (impacted by sea spray and marine aerosols) relative to adjacent ambient sea water concentrations.

(See Appendix 1: relevant headings)

12.2 Irish Sea Caesium isotopes, derived from Sellafield liquid discharges to sea, have been found up to 10 kms inland in (south Wales) in pasture grass (having transferred from the sea to the land) and hence available for entry in to the dairy and meat food chains

Irish Sea caesiums from Sellafield liquid discharges have been found in the entirety of Hebridean island local food production (with highest CS doses received by terrestrial produce eater who did not eat fish). See Appendix 1.

12.3 These two examples provide evidence of both sea to land transfer and dietary doses at DISTANCE from discharge point.

(See Appendix 1)

N.B. In the context of these terrestrial doses it is evident that there's a potential for inhalation doses of Cs and Iodine, both from sea spray, marine aerosols and evaporation from coastal mud flats.

12.4 I have no doubt that populations resident along the Pacific coast of Japan are currently, and will be for some time in the future, exposed to doses of highly soluble isotopes (derived from the Fukushima accident) transferring from the marine to the terrestrial environment by way of the mechanisms described above. Such exposure will give rise to doses of radioactivity via a number of pathways including ingestion of contaminated locally grown/gathered terrestrial foodstuffs, ingestion of locally grown/gathered marine foodstuffs and inhalation.

12.5 In the context of both the very high levels of soluble radioactivity expected to be discharged throughout the incident and the demonstrated ability of soluble radioactivity to travel for long distances from input source, the failure to conduct radiological mid field and far field monitoring and analytical work has been a major failure in both public protection and the gathering of scientific data.

12.6 Other nuclides have a low solubility and tend to be adsorbed onto the surface of particulate matter suspended in the water column. These sediments will in time settle and accumulate in sedimentary deposits such as inter tidal and estuarine mud flats: fine sediment, with their larger surface area, will accumulate more than coarse sediments : thus muds will have far higher concentrations than sands.

12.7 Many actinides and alpha emitters are preferential adsorbers.

Thus, Irish Sea Plutonium and Americium isotopes discharged from Sellafield are shown to become **Ad**sorbed to fine sediment particles suspended in coastal water columns, and (in this form) enriched in marine micro layers relative to bulk seawater by factors of about 4. (Appendix 1)

12.8 Plutonium and Am are shown to become enriched (still in the adsorbed to particulate form) in marine aerosols (generated by bursting bubbles) by factors ranging up to 600 relative to bulk seawater. These aerosols are airborne and readily cross the surf zone and penetrate inland having. Such enrichment mechanisms are found in the context of relatively high sedimentary (fine) particle loadings of the ambient water column. (Appendix 1)

12.9 Such "adsorbing" actinides are also highly susceptible to re concentration in fine sediment deposits, thus, even at distance from input source, they may be found (in mud flats, river estuaries etc) at concentrations several hundred times higher than those observed in ambient sea water samples. (see Appendix 1: relevant headings)

12.10 Such mud flats may provide a source of readily air mobile fine sediments (in drying conditions with high winds) contaminated with adsorbed, and elevated concentrations, of actinides. Such conditions offer the potential for additional sea to land transfer of actinides.

13 *Restricted range of marine sample sites*

13.1 The various descriptions of marine monitoring efforts make it plain that they are focussed on the fate and behaviour of radioactivity within a relatively "near field" range of the Fukushima site liquid discharge point source: ie no further than up to some 30/40 miles radius distant from the discharge point source.

13.2 Results from this work have been fairly widely publicised and some commentators have noted the declining levels of concentrations of (mainly Iodine and Caesium isotopes) within the specific area and claimed that they demonstrate a positive environmental development.

13.3 I can report that satellite imagery of the Pacific coast of Japan (Fukushima Prefecture) shows an area of relatively shallow and turbid (high suspended sediment load) water extending off shore for about 1 to 2 kms/along the relevant stretch of coast

13.4 I note the presence of a number of rivers running down off the high ground inland, across the relatively narrow coastal plain and into the sea. I postulate that (in the wet season) these rivers will make a fairly high fine sediment (clay and organic mineral) contribution to the coastal water sediment budget.

Such sediments are particularly prone to the Adsorbtion of actinides

13.5 I've not yet accessed data about the local/regional inshore currents along that stretch of coast. However I can confirm that the general annual near-surface water body movement along the Pacific coast of Japan (Kuro Shio current) trends northwards

13.6 Satellite imagery of the relevant coast also shows the presence of some significant embayments 50 kms + to the north of the Daiichi plant outfalls.

Both Matsushima Bay and Ishinomaki Bay are extensive and appear (from visual my inspection of satellite imagery) to be characterised by high sediment loadings and extensive inter tidal sediment deposits.

13.7 Such environments have the potential to be long term deposition sites for any long lived actinide/alpha emitter present in the northerly moving water column environment, and hence to act as potential sources of (Fukushima accident derived) alpha emitting isotopes transferring from the sea to the land.

Should this be the case then those coastal zone populations resident adjacent to such environments may be exposed to such material by a number of pathways including ingestion of contaminated locally grown/gathered terrestrial foodstuffs, ingestion of locally grown/gathered marine foodstuffs and inhalation.

13.7 It's my conclusion that the official monitoring regime being carried out by TEPCO and others is inadequate to the task of identifying the potential radiobiological threats to the public because:

(a) they are under-measuring both in terms of nuclides and isotopes because they have chosen to focus on relatively short lived Caesium and Iodine and ignored the issue of the alpha emitting actinides (some of which: including plutonium, americium and curium isotopes have half lives extending into the 1,000s of years) which must also be present in the environment.

(b) they over represent the issue of dilution and dispersion in that they fail to take account of widely attested mechanisms of re-concentration in specific marine environments

(c) they under represent the issues of long distance transport, transfer from one environmental media to another and pathways of delivery to human populations

13.8 It's also relevant to note that a severe storm surge event in Liverpool Bay (UK) caused heavy flooding of coastal town during the course of which large quantities of offshore and near-coastal marine sediments (historically contaminated with Sellafield derived alpha radioactivity) were carried into the town and deposited in the streets, gardens and houses. This material was heavily contaminated with actionable concentrations of man made radioactivity (significant quantities of Americium were recorded). (See Appendix 1: relevant sectionl)

In the current context, it seems not impossible that such a scenario may unfold in the future along this seismic and tsunami susceptible coast, and return a percentage of Fukushima event discharged radioactivity back to the land

13.9 Any attempts to truly quantify the radiological impact of the Fukushima events will of course be restricted by the accuracy and scale of any historical (pre-event) baseline data which may have been gathered on the volume, quantity and isotopic make up of historical discharges from the site: ie

(a) the quantities of man made radioactivity that may have been present in the coastal muds as a result of pre-event discharges from Fukushima NPs? and

(b) just how much of that radioactivity came ashore with the Tsunami inundations?

14: *Restricted range of environmental parameters subjected to analysis*

14.1 As may be deduced from the discussion in the immediately preceding paragraphs, monitoring of radioactivity in non-living environmental parameters should certainly not be restricted to sea water alone.

Fine sedimentary (and indeed organic) particles suspended in the ambient near coastal water column should also be analysed for both soluble and soluble isotopes. Water samples should be filtered in order to better, or more completely, isolate the sedimentary matter. Both filtrate and solids should then be analysed for soluble and less soluble isotopes.

14.2 Such work would greatly assist the plotting of the movement of both soluble and non soluble isotopes and hence diagnosis of the movement and potential deposition sites of alpha/actinides.

14.3 Similarly, those fine sediment inter tidal, near shore and offshore deposition environments regarded as being downstream of the Fukushima marine radioactivity inputs require both identification and subsequent monitoring/analytical work to identify current and ongoing rates of deposition of potentially harmful concentrations of alpha/actinides and enable contingency planning and early warning systems to be put in place should any potential or actual mechanism for the transfer of such material from the marine to the terrestrial environment be identified or occur.

14.4 In the context of those well attested mechanisms of sea to land transfer shown to be contributing to the delivery of doses of marine radioactivity (via ingestion of terrestrial foodstuffs and no doubt inhalation) following sea to land transfer of man made radioactivity, there is a strong case for the monitoring and analysis of

(a) sea surface micro layers where preliminary concentrations of radioactivity build up prior to the production of marine aerosols;

(b) marine aerosols , especially those produced in the surf zone of sediment enriched coastal waters, where very high re-concentration factors have been observed; and

(c) sea spray droplets especially those coming ashore in onshore winds.

14.5 In the context of the list of occurrences at the Fukushima site (explosions, meltdowns, breaching of reactor containment, possible breaching of SFCP containment, massive loss of coolant, massive throughput of ECW) there are no scientific grounds for denying that actual "hot" particles of radioactive fuel, radioactive fuel cladding and possibly) SFCP structure have also entered the non-containment environments both within the site and outside the site.

14.6 There is absolutely no evidence that any of the marine monitoring programmes so far initiated are making any attempt to identify and quantify "hot" particles of radioactive fuel, reactor or SFCP structures.

15. *Position statements from the Environment Agency GDA*

15.1 In the event of

(a) Reactor or cooling pond LOCA event requiring the use of Fukushima type volumes of Emergency Cooling Water; and

(b) Severe flooding of sites (tidal bore, storm surge, tsunami, excessive rainfall (lets not forget the unusual path of Hurricane Katie).

The following extracts from the GDA are relevant:

GDA ASSESSMENT Report UK EPR-05

Assessment Report: Aqueous Radioactive Waste Disposal and Limits

Page 25: Para 118

EA say: We have not considered at GDA other site liquid discharges such as surface water. The design of such systems will be site specific and there should be no contamination in normal operation. We will review site drainage at site specific permitting and, as a minimum, require accessible sampling points at final discharge locations for confirmation spot sampling."

Annex 1 (Fig 1) of the same document shows collection and management of three liquid effluent streams

(a) Primary Liquid Effluent.

(b) Spent Liquid Effluent.

(c) Drainage Water from Turbine Hall.

15.2 In their GDA Assessment Report AP1000 Assessment Report: Aqueous Radioactive Waste Disposal and Limits the Environment Agency list five sources of aqueous radioactive waste (Paras 35—46)

(a) Reactor Coolant System Effluents

(b) Building floor drains and sumps

(c) Detergent wastes (sinks, showers etc)

(d) Aqueous chemical wastes (laboratory and other small volume sources)

(e) Steam Generator blowdown wastes

15.3 And at Page 15: Para 49

EA say " We consider that all sources of aqueous radioactive waste have been identified".

15.4 And at Para 57 (page 16)

EA say "AP1000 has five types of tanks for collecting aqueous radioactive waste"

A:	Reactor Coolant drain tank	volume= 3.4 cubic metres
B:	Effluent Hold up tanks	volume= 2 x 106 cubic metres
C:	Waste hold up tanks	volume= 2 x 57 cubic metres
D:	Chemical waste tank	volume= 34 cubic metres
E:	Monitor tanks (42 days storage)	volume=6 x 57 cubic metre
TOTAL VOLUME		**=705'4 cubic metres**

15.6 It is evident that the information given in the GDA's Aqueous Radioactive Assessment Reports is relevant to only "normal operations" .

The GDA Aqueous Radioactive Assessment Reports fail to address LOCA response and the potential for massive Emergency Cooling Water (ECW) arisings, and do not conduct an analysis of the potential damage to site infrastructure, storage tanks or drainage systems due to unforeseen circumstances.

The GDA Aqueous Radioactive Assessment Reports fail to address the issues surrounding the necessity for the provision of capture/retention/treatment capacity for hundreds of thousands of cubic metres of ECW generated over a six month (and ongoing) period

15.7 Thus, at Fukushima Daiichi, an unknown volume of ECW had already leaked into environment when TEPCO began to provide estimates of the volume of Emergency Cooling Water (ECW):

Sept 6 to 11 TEPCO press statements say that,

(a) since June, when filtering systems were finally installed, they have managed to decontaminate 85,000 tons of highly radioactive water (HRW)

(b) 110,000 tons of HRW remains in basements of the reactor buildings 1,2 and 3.

(c) ECW still being applied daily to Reactors 1, 2 and 3

(d) Growing concern that basement HRW may be leaking into the sea via groundwater flows

(e) Concentrated nuclear waste generated by filtration treatment of 85,000 tons of HRW now occupies 70% of site dedicated, 800 cubic metre, waste storage capacity. (Waste generated so far thus equals 560 tonnes)

(f) TEPCO states need to review cooling efforts in light of the continuing ECW applications and nuclear waste generation

15.8 N.B.:

85,000 tons +110,000 tons= 195,000 tons captured/retained ECW (no calculation has been offered for volume lost to the environment)

85,000 tons HRW treated in 3 months = approx 1000 tons per day = thus it will require approx 110 days to clear the existing backlog (not counting ongoing applications of ECW)

Basements plainly acting as storage tanks

Fear of leaching of HRW

Evident that the nuclear waste produced by filtration treatment of remaining 110,000 tons of HRW (not including ongoing applications of ECW) is going to overwhelm site storage capacity.

15.9 *Recommendations*

Site drainage (with specific relevance to emergency situations including LOCA response and inundation) should be made a GDA issue and NOT be determined on a site specific basis.

The GDA should review reactor basement design and construction in order to confirm that, if they are to be used for collection and storage of spilled reactor and/or cooling pond coolant and ECW, they will prevent leaching, facilitate the monitoring of the HRW and escaped coolant and be provided with appropriate equipment such as pumps, gauges etc.

HRW capture/retention, storage and treatment capacity should be made a GDA issue and NOT be determined on a reactor specific or site specific basis. It should be thoroughly reviewed in the context of the Fukushima event

The storage capacity for highly concentrated wastes generated by the filtration treatment of HRW should be reviewed by the GDA with a view to ensuring that, in the event of the need to filter treat high volumes of escaped coolant and contaminated ECW, there is sufficient storage capacity for the ensuing highly concentrated radioactive waste

Tim Deere-Jones

FREELANCE MARINE POLLUTION CONSULTANT

CV, Client List & Work History

I have been working as a Marine Pollution Consultant since 1983.

EDUCATION

BSc. Hon's (2:1) Maritime Geography, Department of Maritime Studies, Cardiff University, Wales, UK *(Maritime Geography course designed to educate "marine managers")*

Core Studies: Marine Pollution, Marine Environmental Sciences, Ocean/Atmosphere Systems and Marine Anthropology.

Honours Research Dissertation: "The Sea to Land Transfer of Marine Pollutants"

Previous Clients include

Greenpeace International: Greenpeace Australia: Greenpeace UK: Friends of the Earth (England, Wales and Northern Ireland): Friends of the Earth Cymru: World Wide Fund for Nature (WWF UK): The UK Wildlife Trusts: Citizens Campaign Groups in UK, Irish Republic and USA: Local Authorities in England and Wales: UK and Irish Nuclear Free Local Authorities: KIMO: Global Concern.

For whom I have carried out a variety of desk study and fieldwork consultancy contracts relating to:

Anthropogenic marine radioactivity issues including both field and desk work on

Fate and behaviour of anthropogenic radioactivity in marine, coastal and inter-tidal environments: sea to land transfer of anthropogenic radioactivity across Irish Sea coastlines: fate, behaviour and inland penetration of sea to land transferring anthropogenic radioactivity and it's impact on agricultural and horticultural produce

Maritime transport of hazardous and dangerous radioactive cargoes including:

Long term work on the safety of the maritime transport of radioactive wastes (LLW, ILW, HLW and Pu MOX): analysis of accident statistics and design flaws in hazardous and radioactive material carriers: loss of containerised deck cargo consignments of hazardous radioactive materials: detailed desk study reviews of design flaws in double hulled vessels (PNTL Fleet) carrying high level radioactive wastes.

Marine and Coastal oil and chemical spill issues including:

Fate and behaviour of spilled oil and chemicals in marine, coastal and inter-tidal environments: environmental impacts of spill treatment strategies: environmental impacts of transport and disposal of recovered contaminated debris: economic impacts of spills: impacts of spills on coastal zone agriculture: physical, psychological and emotional public health impacts of spills: effects of spills and remedial action on small coastal and island communities.

On behalf of Citizens Campaign Groups and others in the UK, Ireland, France, Australia and the United States I have also carried out work on:

Environmental impacts of ship breaking and decommissioning in an industrial estuary: Environmental and heritage impacts of tourism developments on coastal environments and communities: environmental impacts of port developments: environmental impacts of marine aggregate extractions in UK waters: environmental impacts of marine aggregate extractions in S.East Asia: environmental impacts of capital and maintenance dredging programmes: the impacts of industrial scale fisheries on small scale artisan fisheries: cetacean by catch in pair trawling fisheries: investigation of radioactivity and PCB tissue burdens in coastal cetaceans: investigation of local point sources of PCBs in the marine environment: causes and environmental impacts of localised coastal erosion.

Field Work

I have successfully planned and carried out field work campaigns in coastal environments in the UK, Ireland, France and the Irish Sea on issues including:

surveying and sampling estuarine intertidal sediments to establish the presence and distribution of anthropogenic radioactivity: surveying and sampling coastal and estuarine terrestrial soils and flora (lichens) in order to establish the presence of anthropogenic radioactivity: surveying and mapping the movement of surface floating radioactive "cruds" in the Irish Sea and the Bristol Channel: surveying small island and coastal environments to establish the presence and distribution of toxic heavy metals transferred from the sea to the land: observing and reporting the fate, behaviour and impact of spilled oil on a wide range of coastal environments.

I currently hold the posts of :

Marine Science Syllabus Consultant and **Senior Examiner** to the International Baccalaureate Organisation and

Honory consultant/advisor on marine radioactivity issues to the UK and Irish Nuclear Free Local Authorities

I have held honorary posts as:

(a) **Research Director of the Irish Sea Project** (independent and voluntary funded marine radioactivity research/campaign group) (6 years)

(b) **Founding Co-ordinator of MARINET** (Friends of the Earth: Marine Information Network) (3 years)

I participate (as a group leader and extra mural lecturer) in University undergraduate field visits to coastal environments.

I am an experienced environmental journalist, having written for a wide range of newspapers, magazines and journals including The Ecologist and the BBC Wildlife Magazine

I have made many contributions to TV and Radio news items, current affairs broadcasts and documentaries. I have made many presentations to conferences in the UK and Ireland (in the role of both conference guest speaker and leader of seminars and workshops) and have participated in Public Planning Inquiries in UK and the USA as consultant/expert witness on behalf of clients and as a representative of citizens groups and environmental campaigning organisations.

November 2012

Written evidence submitted by the Weinberg Foundation (NUC 20)

SUMMARY

- This submission presents the case for substantially increased Government funding for research and development into thorium-fuelled nuclear fission.
- Thorium has many advantages over uranium including being more abundant, more energy dense and producing significantly easier to manage waste products.
- New reactor designs, such as the molten salt reactor, can also drastically reduce the generation of waste and offer other significant safety and efficiency advantages over current reactor designs.
- A prominent molten salt reactor design, the Liquid Fluoride Thorium Reactor (LFTR), offers inherent safety features, generates very small quantities of waste and can use legacy waste as fuel. In addition, it is proliferation resistant, more efficient and less costly to construct than current reactor designs.

1. I am writing to the Committee as CEO of The Weinberg Foundation, a not-for-profit organisation set up to promote thorium-fuelled molten salt reactors, a technology pioneered in the 1960s by Alvin Weinberg, Director of the US Oak Ridge National Laboratory.

2. The withdrawal of EON and RWE from the Horizon coalition serves as a reminder that current market conditions do not provide an attractive investment climate even with policy interventions to provide contracts for difference and a supported carbon price. One of the reasons why the expected nuclear new build is proving more difficult to deliver than we might wish, is that currently our use of nuclear power is restricted to a very narrow range of technologies in the uranium fuel cycle. There are many potential new technologies and fuel types that could usher in a genuine nuclear renaissance.