

## RESPONSE BY J CHANNAY

### RESPONSE TO CONSULTATION QUESTIONS: Consultation on an updated Waste Transfer Pricing Methodology for the disposal of higher activity waste from new nuclear power stations (DECC, URN 10D/994, December 2010)

**Question 1:** Do you agree or disagree that the level of the Waste Transfer Price should be subject to a Cap and that in return for setting a Cap the Government should charge a Risk Fee? What are your reasons?

- 1.1 The use of nuclear power for generating electricity demands costly long term commitment on ensuring the safe isolation of radioactive wastes from the biosphere (for up to 240,000 years). The incumbent Government needs to do the intelligent thing and decouple nuclear waste producing low-carbon electricity from climate change mitigation strategies. In particular, the incumbent Government lacks the express public mandate necessary (in a modern democracy) to continue, or authorise, the production of and amassing of nuclear waste, in the absence of a proven demonstrably safe permanent method for waste disposal.
- 1.2 In the context of nuclear waste, promotion of nuclear power as a low-carbon source of energy is akin to promotion of the mushroom *Amanita phalloides*<sup>1</sup> (or, even *Boletus satanoides*<sup>2</sup>) as a low-fat food source<sup>3</sup>. Both varieties of mushroom are poisonous and easily confused with the edible variety of the same family. In the case of nuclear power, there currently exists no environmentally demonstrably safe permanent disposal route for nuclear wastes in the UK (or, elsewhere in the world). There exist other low-carbon sources of energy that do not produce higher activity nuclear waste.
- 1.3 Resorting to nuclear power for generating electricity is a recipe for locking the country in to continuing the production of new additional highly radioactive wastes and transferring a negative externality, in the form of risk, uncertainty and responsibility for geological disposal of the waste, to future taxpaying generations (manifestly a societal disbenefit).
- 1.4 Is the Government trying to lift sophistry to new heights, repeatedly asserting it does not amount to a subsidy for new build nuclear power stations when the state takes title to all nuclear new build radioactive waste (including spent fuel) from private sector producers and installs a fixed Final Price ceiling for crucial end-of-life back-end state provided services on geological disposal of nuclear waste?
  - a. In support of what other private sector business activity does the Government operate as a Waste Disposal and Repository PLC, providing similar back end services for permanent safe disposal of other hazardous waste?

<sup>1</sup> Jordan Michael (1995). The Encyclopaedia of Fungi of Britain and Europe. David & Charles.  
*Amanita phalloides*, a large fleshy agaric with ring, is lethally poisonous even in very small quantities (p198).  
On the other hand, *Amanita strobiliformis*, a large fleshy agaric with ring, is edible but can be confused with *A. phalloides* (p199).

<sup>2</sup> Jordan Michael (1995). The Encyclopaedia of Fungi of Britain and Europe. David & Charles.  
*Boletus satanoides* is a large or massive poisonous bolete (p340), not to be confused with the large or massive edible *Boletus reticulatus* (p339).

<sup>3</sup> mushrooms are approved low fat food stuffs by the Food Standards Agency and the NHS  
<http://www.eatwell.gov.uk/asksam/healthydiet/fruitandvegq/#A218472>

- b. It is spurious for the Government to argue that,
- (i) there can be a high level of reliability in any computation of a fixed price for geological disposal<sup>4</sup> of new build nuclear waste, which admittedly could only occur at some future as yet indeterminate date: perhaps in 2078 (60 years after the production of the first gramme of new build nuclear waste) or in 2153 (135 years' time) or even later; and,
  - (ii) that, such a fixed price "properly reflects any financial risks or liabilities assumed by the state" (para.1.5).
- c. An attempt at basing such computation on a risk premium (para.1.12), combined with putative actual costs of disposal of legacy high level nuclear wastes in 2040 (as the Government fervently hopes: para.2.2.11), fails to vitiate the spurious reliability. At best, a Deferral Period serves only to give succour to a spurious calculation. Self evidently, the "current best estimate of waste disposal costs" (para.1.26) is only guesswork. What if the actual costs turned out to be higher by an order of magnitude, or more? Is that so improbable as to salvage computation reliability?
- d. How can there be such thing as a reliable level of conservatism, given the right of challenge under a dispute resolution procedure (as proposed: paras 3.3.59, 3.3.80 and 3.3.120, respectively)? The assertion that the proposed Transfer Price Methodology is capable of "ensuring the taxpayer is protected" (para.1.5), is highly questionable. The history of the Government's track record to date on nuclear waste management<sup>5</sup>, let alone common sense, pours doubt on putative reliability of costs of risk and uncertainty: whether in respect of the immediate future (consider, for example, the perceived rock solid foundations of the UK financial banking sector in August 2007, compared with systemic unravelling in August/September 2008 and thereafter), the medium term (2078) or the long term (2153). In essence, para.2.2.8 belongs in the realm of fantasy economics. In reality, the long term costs are inevitably and inexorably liable to fall on taxpayers.
- e. Under what authority does the incumbent Government arrogate the state an obligation to take possession of, look after and permanently safely dispose (including post-disposal monitoring commitments) the hazardous wastes created by investor-led private sector profit-maximising entities? How can it be in the best interest of future generations of taxpayers, for the incumbent Government to selectively nationalise geological disposal of higher activity radioactive wastes (a negative externality) produced by all private sector owned and operated future new nuclear power stations, from 2017 onward?
- f. Caving in to industry lobby, the Government has ruled that its express priorities lie with providing prospective new build nuclear operators "certainty over the maximum Final Price they will be expected to pay the Government for the provision of a waste disposal service" (para.1.12) and "to specify a maximum Final Price the operator would be expected to pay (the "Cap")" (para.1.15). These objectives arguably,

<sup>4</sup> <http://mrws.decc.gov.uk/> : According to the UK Government's White Paper on Managing Radioactive Waste Safely (June 2008),

"Geological disposal involves isolating radioactive waste deep inside a suitable rock formation to ensure that no harmful quantities of radioactivity ever reach the surface environment. It is a multi-barrier approach, based on placing wastes deep underground, protected from disruption by man-made or natural events. Geological disposal is internationally recognised as the preferred approach for the long-term management of higher activity radioactive waste."

<sup>5</sup> consider footnote 11, hereof.

- (i) erode the state's democratic accountability and authority, intra- and inter-generationally. The state no longer stands as an entity independent of the hazardous waste producer. The incumbent Government is intimately engaged in aiding and abetting the creation of new additional higher activity nuclear waste. The efficacy of a safe permanent disposal solution for these wastes will only become known to unknown Governments in the fullness of time in the far distant future (a negative externality); and,
  - (ii) enshrine perverse incentives for operators of new electricity generating power stations to maximise, not eliminate, the continuing production of additional higher activity nuclear wastes. The incentives encourage companies to build or expand their electricity generation business by utilising nuclear power technology. Each operating nuclear power station inexorably locks the business operator into seeking the most convenient least cost route for the disposal of the resulting nuclear wastes. However, it is contended neither by the Government nor industry that guaranteeing safe geological containment of nuclear wastes for the indefinite future is demonstrably commercially viable for any nuclear operator. Accordingly, the incumbent Government is resorting to brainwashing the public and taxpayers alike:
    - that, for the state to provide private sector nuclear operators certainty on the costs (negative externality) of geological disposal in the distant future, is not a subsidy for new nuclear power stations;
    - that, getting the state to take direct ownership of and responsibility (negative externality) for all higher activity nuclear wastes produced by all new private sector nuclear power stations in future, is not a subsidy for new nuclear operators; and,
    - that, imposing on generations of taxpayers far into the distant future (negative externality), the full responsibility for constructing, operating, sealing and post-closure monitoring of geological repositories for safe permanent containment of nuclear wastes, is not a subsidy for new nuclear operators.
  - g. Inexplicably, the incumbent Government is not proffering similar graveyard largesse for carbon laden gaseous wastes produced by fossil fuel power stations, for the permanent geological burial of captured carbon.
- 1.5 In that regard, the Government has conducted the entire range of recent consultations on nuclear new build (since December 2010), deliberately back to front. The incumbent Government has not endeavoured to seek from the electorate express requisite political mandate:
- a. for the state to take title to new nuclear wastes created by private sector operators of nuclear new build, from 2017 onward;
  - b. to impose on current, the next and subsequent generation of taxpayers the responsibility for managing interim storage environmentally safely after the Transfer Date, for as long as it takes for a suitable GDF to become available to accept the waste. The transfer and severance of such monumentally negative social externality is designed to conveniently permit the private sector creators of new radioactive wastes to walk away from their environmental and ethical responsibilities on ensuring the safe disposal of nuclear wastes for the indefinite

future, while protecting and pocketing the lucrative profits (positive private externality) from their nuclear waste generating practices;

- c. to forcibly lock future generations of taxpayers into discharging in full the responsibility for eventual burial of all private sector created nuclear wastes in a geological repository, and to ensure the isolation of those wastes from the biosphere for perpetuity;
  - d. to lock irreversibly all future generations into monitoring the closed/sealed geological repository/repositories for the indefinite future; and,
  - e. establish a precedent for cyclically locking each subsequent generation of taxpayers into responsibility for ensuring the safe geological disposal of higher activity nuclear waste created under the encouragement of preceding Government(s), in turn.
- 1.6 Given the momentous nature of the incumbent Government's lock-in for future generations, every Government ought to be obliged to seek afresh express and proper political mandate, at the start of its term of office, on the question of nuclear waste production and permanent disposal.
- 1.7 A cap is necessary, not on the transfer price of nuclear waste, but on the continuing production of new additional intermediate level and high level radioactive wastes (including spent nuclear fuel). Contemporary Governments need to honour recommendation 27 of the UK Royal Commission on Environmental Pollution<sup>6</sup>, issued in 1976. Namely, demonstrate "beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future", before permitting nuclear new build. Disgracefully, and in abuse of democratic process, the incumbent Government is engendering a large programme of nuclear waste production under the subterfuge of policy creep, having failed to demonstrate to date a safe working, established permanent solution to the problem of nuclear waste disposal. Such policy creep amounts to flagrant breach of the precautionary principle<sup>7</sup>, to which the United Kingdom signed up under the Rio Declaration on Environment and Development, at the First Earth Summit held in Rio de Janeiro in 1992.
- 1.8 In order sensibly to give effect to the Royal Commission's Recommendation 27,
- a. the incumbent Government first needs to cap the inventory of intermediate level and high level radioactive wastes at the existing (2010 committed lifetime inventory levels), from existing nuclear power stations still in operation at the time of the instant Updated Consultation;
  - b. second, before permitting the construction of new nuclear power stations, contemporary Governments next need to demonstrate *apriori*, beyond reasonable doubt, that a method exists to ensure the safe containment of all higher activity

<sup>6</sup> Cmnd 6618 (1976). Royal Commission on Environmental Pollution, Chairman Sir Brian Flowers, Sixth Report: Nuclear Power and the Environment, HMSO 1976. Recommendation 27 stated:

"There should be no commitment to a large programme of nuclear fission power until it has been demonstrated beyond reasonable doubt that a method exists to ensure the safe containment of long-lived highly radioactive waste for the indefinite future."

<sup>7</sup> Johnson Stanley P (1993). The Earth Summit — The United Nations Conference on Environment and Development (UNCED), Graham & Trotman/Martinus Nijhoff, 1993. Principle 15 of the 1992 Rio Declaration, states:

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

nuclear waste (that has been accumulating since the 1950s), for the indefinite future; and,

- c. beyond that, the responsibility for the safe permanent disposal of all future higher activity nuclear waste should rest firmly and solely on the producers of new nuclear waste, under strict application of the polluter pays principle<sup>8</sup>. Any different arrangement serves not only to violate the polluter pays principle, it also acts as a perverse disincentive on nuclear businesses to eliminate, if not minimise, the production of higher activity nuclear waste in accordance with the internationally recognised waste management practice hierarchy<sup>9</sup>.

- 1.9 It cannot be the business of the Government to nationalise risk and uncertainty (negative externality) attending safe final permanent disposal of higher activity nuclear waste. The incumbent Government has neither a political mandate to exceptionally nationalise waste disposal from private sector operated new nuclear power stations nor an ability to ascertain the best interest of distant future generations of taxpayers who will be saddled with the responsibility for constructing, operating, sealing and post-closure monitoring of a suitable nuclear waste geological repository. Inexplicably, the incumbent Government's new found enthusiasm for underpinning market capitalism in the production of nuclear waste with socialisation of the risks and uncertainties intrinsic to the safe permanent geological disposal of nuclear waste would not appear to extend to other categories of industrial wastes also requiring geological disposal. Curiously, while keen to fly a proverbial "red flag" for nuclear GDF, the incumbent Government is resolutely shy of doing the same for Carbon Capture and Storage GDF. It would appear to be a case of market capitalism for captured carbon geological disposal facility and socialism for nuclear waste geological disposal facility (GDF).
- 1.10 The contagion of nationalised nuclear waste disposal will by no means be limited to the term of the incumbent Government. The spread of contagion beyond the demise of the incumbent Government is deliberate, inexorably contaminating the prerogative of all future generations of taxpayers, potentially for the indefinite future<sup>10</sup>. The contagion effectively enshrines permanent bail out for private sector new nuclear operators. The contagion further promulgates perverse incentives for maximising spent nuclear fuel production and maximisation of operator profitability, at the same time as maximising risk containment and limiting full liability. In other words, a quadruple win for private sector new nuclear operators.
- 1.11 An audacious claim that "in contrast [to a private sector operator], the Government does have capacity to manage risks around waste disposal costs, as these costs will be heavily influenced by the manner in which the Government implements geological disposal" (para.1.14) is belied by the state's historical record on nuclear waste management cost containment in the UK<sup>11</sup>.

<sup>8</sup> Park, Chris (2009). Oxford Dictionary of Environment and Development, 3<sup>rd</sup> edition: defines the polluter pays principle as,

"The principle that the polluter should pay the costs of controlling the pollution they generate, and of cleaning up any environmental damage that is caused by that pollution."

<sup>9</sup> ICE (1995). Hierarchy of waste management practices in: *Waste Minimisation – A Practical Guide*, Institution of Chemical Engineers.

The hierarchy runs as follows, in order of priority: Elimination; Reduction at source; Recycling; Treatment ; and, Disposal.

<sup>10</sup> Farnan, Cho & Weber, Quantification of actinide alpha-radiation damage in minerals and ceramics. *Nature* 445, 11.01.2007, pp190-193. According to Farnan et al, alpha particles from the decaying radionuclides can cause such severe damage to the crystalline structure of the zircon ceramic that plutonium starts leaching out after only 210 years and the entire plutonium-zircon ceramic:

"would be amorphous after only 1,400 years in a geological repository (desired immobilization timescales are of the order of 250,000 years)."

<sup>11</sup> The cost to the taxpayer had already mushroomed to £40 billion in 2001 (see: Managing radioactive waste safely, Consultation Paper, DEFRA/DOE/ National Assembly for Wales/Scottish Executive, September 2001) and then to £56 billion in 2004 (see: Nuclear Decommissioning Authority Strategy, Draft for Consultation, August

- 1.12 As for the proposed Risk Fee (para.1.22), it is highly doubtful whether such fee is capable of ever addressing meaningfully,
- a. the inherently unknowable cost of GDF closure and post-closure monitoring for the indefinite future;
  - b. erroneous or unrealistically high expectations on the benefits of a Deferral Period. For example, the assumption that deferral could help reduce actual emplacement cost uncertainties (paras 3.1.7 and 3.2.16, respectively);
  - c. the cost of GDF abandonment due to site contamination, flooding, seismic disturbance, sabotage, acts of terrorism and collateral damage or direct targeting during international conflict<sup>12,13</sup>. Weapons technology for high energy projectiles and deep earth penetration capability is highly likely to have proliferated widely by the time the UK GDF is anticipated to come on stream, around 2040.
- 1.13 The Government's *belief* that "it will be possible to ensure that costs are apportioned correctly in the event of any sharing of facilities between legacy and new build and does not consider that such arrangements would constitute a subsidy to new build" (para.2.2.23) is neither sufficient nor proper basis for policy formulation and implementation. A "belief" carries little, if any, weight. To that extent, the Government's belief serves to confirm the preferred co-disposal arrangements do indeed constitute a subsidy for nuclear new build. That, in turn, brings into question the veracity of the Updated Consultation.
- 1.14 At para 2.2.30, the Government has arguably misframed the entire issue. Although conceding "there is substantial uncertainty over waste disposal costs", the Government attempts to gloss it over by claiming it does not mean "that a price setting methodology is not possible". However, a salient test the Government seeks to avoid goes begging: how adequate is the methodology; how reliable can it ever be?
- 1.15 The incumbent Government has failed to advance convincing justification for establishing the state as a "monopoly supplier of GDF" (para.2.2.31). The Government claims to be uniquely gifted in its ability to control costs and contain uncertainty. Curiously, the privileged powers seemingly come to fore exclusively in connection with a concept GDF (nothing of the sort exists as yet in the ground, so to speak!).
- a. On what evidence has the Government decided that a state monopoly GDF is the most efficient means of allocating scarce resources, over the course of geological timescales?

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2005). The next review by the Nuclear Decommissioning Authority in 2006 uplifted that figure to £70 billion (*The Times*, 31.03.2006). By 2006, the cost had risen a further 12% over the previous estimate, to £72.7 billion (NDA Annual Report & Accounts 2006/7, p102). These costs are many times what it cost originally to build to completion the Government's first two major nuclear power programmes. Furthermore, this is the bill for the decommissioning and clean up of only those nuclear facilities constructed between 1950 and 1968. That is, *the bill does not include all the existing nuclear facilities*. Nor does the bill include *the cost of final disposal of highly radioactive and radiotoxic nuclear wastes*, which remains inherently unknown. Moreover, the nuclear wastes created by the military and the private sector industry are expected to cost another £44 billion (*ENDS Report*, December 2001).

<sup>12</sup> Demetri Sevastopulo, *The Financial Times*, 20.05.2005: "The White House wraps star wars weapons in cloak of darkness". A report on hypersonic "... Rods from Gods, tungsten metal rods dropped from satellites in space" capable of striking ground targets anywhere in the world.

<sup>13</sup> Giles Whittell, *The Times*, 19.04.2010: "Pentagon chief raises threat of attack as Iran taunts US with missile display". A report on a bunker busting weapon, the Massive Ordnance Penetrator, allegedly "capable of burrowing through 200 ft of reinforced concrete before exploding."

- b. On what convincing basis has the Government comprehensively faulted the fabled and highly vaunted powers of free market competition (namely, the most efficient allocation of scarce resources), when it comes to designing, siting, constructing, operating, sealing and post-closure monitoring of a GDF for nuclear waste, over geological timescales?
  - c. On the basis of what evidence on GDF geobiology, geochemistry and geophysics has the Government determined:
    - (i) its ability to control GDF costs and contain uncertainty to such an extent as to clearly disincentivise non-nuclear waste generating options for meeting the projected need for electricity generation capacity in the UK; or,
    - (ii) that eliminating the creation of new higher activity nuclear wastes (thereby obviating need for legacy GDF enlargement or a second GDF), is environmentally and socially of little significance and effectively inconsequential in terms of both intra- and inter-generational equity?
- 1.16 The Updated Consultation stands wholly deficient in failing to address the opportunity costs of geological disposal of nuclear wastes generated by nuclear new build power stations, compared with the opportunity costs of disposal of wastes generated by equivalent non-nuclear new build electricity generation capacity.
- 1.17 The Updated Consultation stands further deficient in failing to propose remedy against a defaulting nuclear operator, including the following circumstances:
- a. the operator ceases to trade by reason of insolvency;
  - b. the operator refuses to cooperate in making good any deficit in relevant Independent Fund;
  - c. embezzlement of the Independent Fund, whether or not involving the operator;
  - d. the operator's inability to maintain the Independent Fund by reason of scale of volatility in the electricity and/or input materials market, notwithstanding any carbon floor price support?
- 1.18 At para.2.2.39, the Government singularly fails to secure full cost recovery from new nuclear operators for their proportional use of co-disposal GDF. It is simply not good enough that the nuclear operator should pay only a contribution to the fixed costs of a GDF. As defined by the Government (para.2.2.42), fixed costs exclude a plethora of state expenditure. The Government's failure to impose full cost recovery under a legal charge on all successors in time of new nuclear operators, how so ever remote in time or remotely tenuous the linkage, belies a hidden agenda on subsidy for nuclear new build. The Government's preference for putative "best proxy" based on poorly defined "share of total variable costs", is as incomprehensible as it is an artifice. It behoves the Government to set out fully and clearly the difference between full cost recovery and a full share of total variable costs. Further, how testable is the Government's notional relationship between the use an operator makes of the GDF, and the operator's share of total variable costs (as per the definition in para.2.2.42)? Is that relationship backed by robust evidence? In any case, if the Government expects nuclear "operators to produce their own estimates" (para.2.2.61), why are private sector operators not racing to break the state's nuclear GDF monopoly?

- 1.19 There is a failure to disclose the putative “finding of fact” proving that “unit costs fall gradually as the size of the new build fleet increases” (para.2.2.40). Notably, neither the Government nor nuclear operators possess any experience what ever of complex underground construction projects at the proposed depth, handling and storing the proposed category of heat generating higher activity radioactive wastes!
- 1.20 No explanation has been advanced at para.2.2.41 on what might constitute significant risk as to warrant a second GDF. To the extent significant risk exists, why is it not sound insurance for the state to set the Mark-up under Risk Fee (para.3.3.108) at 100%?
- 1.21 The calculation of the Fixed Cost at para.2.2.43 appears seemingly arbitrary in so far as bearing on research and development expenditure, and unconvincing in relation to post-closure monitoring.
- a. On what rational basis is it argued that the exclusion of all design and other costs incurred before the point at which a prospective new nuclear operator requests the First Price, does not amount to a subsidy to the customer (namely, the nuclear operator)? By analogy, does the pharmaceuticals industry exclude all research and development expenditure from the product’s cost to the customer?
  - b. On what basis can the Government calculate the costs of maintaining institutional control for the facility post closure and post closure monitoring for the indefinite future, for inclusion in the chargeable Fixed Cost to the customer perhaps a century or more in advance of the date of GDF closure?



**Question 2:** Do you agree or disagree that the Deferral Period should be 30 years after start of electricity generation, in order to enable uncertainty over waste disposal costs to be reduced? What are your reasons?

- 2.1 Whatever the seductive appeal of a Deferral Period of whatever length, a material question arises: how large a reduction in uncertainty is objectively achievable under a Deferral Period?
- a. In the case of a Deferral Period concluding just after the GDF commenced operations (as in the Government's anticipated reference scenario at para.3.3.9: First Waste Emplacement in a GDF around 2040, with a Deferral Period ending around 2048), arguably there could be little meaningful reliable reduction in waste disposal cost uncertainty.
  - b. In the case of a Deferral Period concluding at the operating mid-life of the GDF, arguably the level of reduction in waste disposal cost uncertainty would still remain elusive as none of the post-closure costs are known.
  - c. In fact, even in the case of a Deferral Period coinciding with the GDF closure date, the level of reduction in waste disposal cost uncertainty would continue to remain elusive.
  - d. Arguably, waste disposal cost uncertainty could only reduce to meaningfully low levels perhaps a couple of generations (say, a passage of 30 or 50 years) after the GDF closure date.
- 2.2 In other words, the salient point glossed over under the device of a Deferral Period is that post-closure monitoring cost uncertainty, for the indefinite future, inherently defies characterisation. This is on account of a number of interacting factors, including:
- a. uncertain environmental (climatological, biological, chemical or physical) and geological (seismic, volcanic, tectonic or glaciation and deglaciation) risks evolving interactively over geological timescale. Consider, for example, uncertainty regarding the long-term physical, chemical and biochemical impact of one or more ice-ages on a geologic repository during the next 100,000 years<sup>14</sup>. Glaciation could result in variations in the chemical and biological environment capable of affecting the engineered parametric barriers. Ice age glaciation and deglaciation may also physically affect a repository, through lateral movement, overburden profile gouge, thinning or removal, major earthquakes and permafrost effects; and,
  - b. uncertainty surrounding impedance and enhancement of corrosion rates of the copper emplacement canister, within a dynamic evolving interactive multi-dimensional environment of an intrinsically unconstrainable waste emplacement envelope. For example, according to prevailing research findings,
    - (i) accelerated corrosion of copper canisters (in which spent fuel rods are expected to be held in a geological repository: para.2.2.52) has been observed, under pressure, at higher than room temperatures, in repository oxygen-free groundwater<sup>15,16</sup>; copper canister breach acceleration through

<sup>14</sup> see footnote 17, hereof.

<sup>15</sup> Swahn Johan (2009), The Swedish NGO Office for Nuclear Waste Review (MKG). In, Greenpeace Nuclear Waste Seminar, Helsinki 2009 - Presentation Transcript. <http://www.slideshare.net/greenpeacenordic/presentation-of-johan-swahn-in-greenpeace-nuclear-waste-seminar-helsinki-2009> .

brittleness induced in hydrogen mediated reaction conditions; persisting uncertainties on the long term threat to artificial barriers of copper and bentonite clay under repository environment<sup>17,18</sup>; and,

- (ii) accelerated loss of integrity of durable crystalline materials<sup>19</sup> widely expected to immobilise radionuclides; prevalence of microbial forms of life in geological rock formations and strata<sup>20,21,22</sup>, reaching deeper than the location depth of a potential UK geological repository.

2.3 Nevertheless, an apparent seductive appeal of the Government's Deferral proposition carries real risk of successful whitewash in confusing "some" uncertainty reduction for "all". In that regard, practitioners should stand reminded of the law of unforeseeable consequences.

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- <sup>16</sup> Apted MJ, Bennett DG and Saario T (2009): 3. A Review of Evidence for Corrosion of Copper by Water. Research Report (number: 2009:30 ISSN: 2000-0456), for Strålsäkerhetsmyndigheten/ Swedish Radiation Safety Authority. September 2009. [www.stralsakerhetsmyndigheten.se](http://www.stralsakerhetsmyndigheten.se).
- <sup>17</sup> Swahn Johan (2008). Nuclear Waste: the Unresolved Environmental Issue. The Swedish NGO Office for Nuclear Waste Review (MKG) <http://www.greenpeace.org/raw/content/finland/fi/dokumentit/johan-swahn-the-finnish-swedi.ppt>
- <sup>18</sup> Apted MJ, Bennett DG and Saario T (2009): 3. A Review of Evidence for Corrosion of Copper by Water. Research Report (number: 2009:30 ISSN: 2000-0456), for Strålsäkerhetsmyndigheten/ Swedish Radiation Safety Authority. September 2009. [www.stralsakerhetsmyndigheten.se](http://www.stralsakerhetsmyndigheten.se), p33. The review by Apted et al concluded that under current understanding, the possibility that copper may corrode slowly by extracting oxygen from water molecules, with the production of hydrogen under near-neutral conditions in pure water at atmospheric (1 bar) pressure, could not be completely ruled out. The reviewing authors have consequently recommended a truly *independent* experimental investigation of the postulated copper corrosion process, to be overseen by a suitably qualified and independent review panel.
- <sup>19</sup> Ceramic Zircon (a class of mineral based ceramics) has long been considered the most robust crystalline structure developed to date for immobilising plutonium and other actinides (such as americium and curium) present in nuclear wastes. However, the structural durability of zircon ceramics has turned out to be extremely short lived as compared with the hazardous half-life of the radionuclides. Under constant bombardment of alpha-particles, even zircon crystals turn leaky and are prone to disintegration. According to Farnan, Cho & Weber (in *Nature* 445, 11.01.2007, pp190-193: Quantification of actinide alpha-radiation damage in minerals and ceramics), alpha particles from the decaying radionuclides can cause such severe damage to the crystalline structure of the zircon ceramic that plutonium starts leaching out after only 210 years and the entire plutonium-zircon ceramic:  
 "would be amorphous after only 1,400 years in a geological repository (desired immobilization timescales are of the order of 250,000 years)."
- <sup>20</sup> There apparently exists considerable uncertainty about the geological depth of the biosphere, even at depths deeper than 1km below ground. For example, according to Head, Jones and Larter (in *Nature* 426, 20.11.2003, pp344-352: Biological activity in the deep subsurface and the origin of heavy oil),  
 "Evidence suggests that a deep crustal biosphere beneath both land and sea has reached approximately 3 km below the Earth's surface, with oil biodegradation suggesting that this can be extended to at least 4 km."
- <sup>21</sup> Richard A Kerr in *Science* 312, 14.04.2006, p179: Life Slow Enough to Live on Radioactivity.  
 "... a new measurement suggests that a substantial number of subsurface microbes might be surviving solely by consuming a product of feeble radioactive decay lingering from before the earth's formation."  
 Analysis of 400 meters of cored ocean mud sediment from beneath kilometres of the sea floor of the eastern equatorial Pacific has revealed:  
 "Microbes there make a living by oxidizing organic matter – which was buried up to 12 million years ago – while chemically reducing sulphate, iron, and manganese."  
 "... marine sediment in another core has enough natural radioactivity to "feed" 10% of the microbes there. In mid-ocean sediments, which have much less organic matter, radiolysis may be the dominant energy source ..."
- <sup>22</sup> There apparently exist uncertainties as well about novel forms of life deep below the earth's surface. For example, at the Witwatersrand Basin gold mine in South Africa, microbiologists have stumbled upon a previously unknown pathway for microbial life deep in crustal rock. Microbes have been discovered at a depth of 3.5 km below the Earth's surface, living in pockets of water trapped in cracks in the rocks. The microbes are thought to thrive on hydrogen gas, hydrogen peroxide and oxygen produced as a result of alpha particles breaking up water molecules. The alpha particles arise from the radioactive decay of natural uranium atoms in the earth's crust (see: Fields, in *Science* 299, 28.02.2003, p1307: Nuclear-Powered bugs).

**Question 3:** Do you have any comments on the updated Waste Transfer Pricing Methodology? Comments are sought in particular on the proposed approach to setting an Expected Price and a Risk Fee

- 3.1 The Risk Fee as proposed fails to encapsulate evolving risk and uncertainty for future generations, in ensuring safe permanent disposal of very long lived radioisotopes. The notion of a Risk Fee is riddled with high degree of uncertainty regarding the nature and consequence of intrinsically unpredictable risk involving geobiological, geochemical, geophysical and socio-political interacting parameters, over extremely long timescales.
- 3.2 Neither the uncertainties nor the risk or time scales are insignificant. The issues involved range wider than stable geology and hydrology of the GDF site.
- a. Intrinsic environmental and socio-political uncertainties of safe permanent disposal of higher activity nuclear waste extend far beyond the GDF's immediate physical boundary, potentially ranging extensively geospatially as well as across the continuum of time.
  - b. In addition to induced radioactivity, a number of hazardous actinide fission products are created during the operation of atomic reactors. Plutonium-239 is one of a number of very long-lived actinides that make up the content of higher activity nuclear waste. Plutonium-239 in the environment is considered to remain biologically hazardous for up to 240,000 years<sup>23</sup> (nearly a quarter of a million years!).
  - c. The containment timescales for safe permanent nuclear waste disposal supersede the lifetime of the incumbent Government and, indeed, the lifetime of all three (or even four) generations alive today in any household anywhere in the United Kingdom (not to mention the rest of the planet). The need to ensure biological isolation of nuclear wastes over the course of the next 240,000 years, straddles the serial lifetimes of up to 50,000 future governments!
  - d. It is simply not possible to predict the future likelihood, type and consequence of risk events impinging the integrity of the GDF and its nuclear waste content, over the course of the next 240,000 years. A headline review of a handful of historical key events, over similar past timescale, underscores the enormous range and scale of risk and uncertainty. Such historical events suffice to render manifestly deficient the incumbent Government's proposed Risk Fee, chargeable to private sector producers of nuclear waste, for a geological waste disposal service to be provided by the state, ostensibly for the indefinite future.

240,000 years ago      evidence of the world's oldest blade tools (near Lake Baringo, Kenya), cut from stone cores with precision and consistency suggestive of an intellectual advance by hominids<sup>24</sup> (modern humanity's ancient ancestors).

100,000 years ago      earliest evidence of emergence of anatomically modern humans<sup>25</sup> (southern Africa).

<sup>23</sup> The physical half-life defines the passage of time after which the number of atoms of an element still radioactive would have decreased ("decayed") to one half of the starting number. As a rule of thumb, the potential biological significance of a radioisotope is presumed generally to persist for ten successive physical half-lives. Plutonium-239 has a physical half-life of 24,000 years.

<sup>24</sup> Do Kenya tools root birth of modern thought in Africa? J Gutin, *Science* 270, 1995, pp 1118: as cited in footnote 25, hereof.

<sup>25</sup> Human Antiquity, K L Feder and M A Park, Mayfield, 3rd edition, 1997, p311.

10,000 years ago	separation of the British Isles from mainland Europe, following the formation of the North Sea as a result of sea level rise from the melting of glaciers, at the end of the last Ice Age.
5,000 years ago	earliest evidence of writing, in Mesopotamia <sup>26</sup> .
195 years ago	1815: the Tambora volcano eruption in Indonesia, blowing away 30 cubic kilometres of the cone and depositing a thick layer of ash up to 60 centimetres deep at a distance of 70 kilometres from the volcano <sup>27</sup> .
149 years ago	1861-1865: The American Civil War; 1864: Prussia defeats Denmark; 1863: France colonises Cambodia, Laos and Vietnam <sup>28</sup> ,
96 years ago	1914-1918: The First World War.
72 years ago	1938-1945: The Second World War.
26 years ago	19 July 1984: The strongest earthquake in historical times in Britain, magnitude 5.4 on the Richter Scale. With its epicentre at Llanaelhaearn in Gwynedd (North Wales), the event occurred along a completely unsuspected intra-plate fault 20 Km deep underground <sup>29</sup> . It was stronger than the Carlisle earthquake (26 December 1979, Magnitude 4.6) and the Colchester earthquake (22 April 1884, estimated Magnitude 4.4).
76 days ago	two temporally proximal earthquakes, each strong enough to be felt throughout Cumbria (the local authority area most minded to volunteer hosting a geological repository for Britain's nuclear waste). 21 December 2010 <sup>30</sup> : Coniston, Cumbria, magnitude 3.5ML earthquake, focal depth 14.3 km. 3 January 2011 <sup>31</sup> : Ripon, North Yorkshire, magnitude 3.6ML earthquake, focal depth 6.2 km.

- 3.4 Does a full share of waste management costs (the Government's preferred approach) mean full cost recovery of all disposal related costs from private sector producers of new additional nuclear waste? The Government's silence would suggest not. If so, the incumbent Government appears opportunistic in taking advantage of an intrinsic temporal constraint on the ability of future generations to hold this Government to account.
- 3.5 The incumbent Government could rectify a fundamental deficiency in its proposals, by restoring a modicum of inter-generational equity, through imposition of a legal charge for full cost recovery liability on all successors in time of new nuclear operators, how so ever remote in time or with how so ever tenuous a link in time, for the indefinite future.
- 3.6 The Government also needs to act with intelligent courage and ditch the entire edifice of Waste Transfer Pricing Mechanism as an irrelevancy, involving high transaction costs (therefore economically inefficient to operate), cumbersome to administer, and an unnecessary and unfair bureaucratic burden on taxpayers. The interest of taxpayers (current as well in the near and distant future) could be better served and protected through,

<sup>26</sup> The Times Atlas of Ancient Worlds, 1988.

<sup>27</sup> The Cambridge Encyclopaedia of Earth Sciences, Cambridge University Press, 1982, p220.

<sup>28</sup> The Times Atlas of World History, revised edition, 1984.

<sup>29</sup> Lleyn earthquake of 19 July 1984: aftershock sequence and focal mechanism, P C Marrow and A B Walker, Global Seismology Unit Report No: 288, British Geological Survey, 1986.

<sup>30</sup> British Geological Survey. [www.bgs.ac.uk/research/highlights/cumbriaEarthquakeDec2010.html](http://www.bgs.ac.uk/research/highlights/cumbriaEarthquakeDec2010.html):

<sup>31</sup> British Geological Survey. [www.bgs.ac.uk/research/highlights/riponEarthquakeJan2011.html](http://www.bgs.ac.uk/research/highlights/riponEarthquakeJan2011.html):

- a. a cap on the total UK inventory of higher activity nuclear waste, set conveniently at the existing 2010 committed lifetime inventory levels, relating to the existing fleet of nuclear power stations still in operation at the time of the instant Update Consultation;
- b. implementation of Recommendation 27 of the 1976 Royal Commission on Environmental Pollution<sup>32</sup>; and,
- c. examination and consultation on the opportunity costs of geological disposal of nuclear wastes generated by nuclear new build power stations, compared with the opportunity costs of disposal of wastes generated by equivalent non-nuclear new build electricity generating capacity.

3.7 Nevertheless, to the extent the incumbent Government is autocratically minded to push ahead with its messy Waste Transfer Pricing Mechanism, the Government needs to take the following action in fairness to taxpayers (current and future alike), who are forcibly destined to become the recipients of all manner of negative externalities indissolubly inherent to the Government's infatuation with maintaining higher activity nuclear waste electricity generating capacity (in contrast to non-nuclear-waste low-carbon electricity capacity: the Government might do well to recall an analogy, that although all mushrooms are equally low-fat foodstuffs, some mushrooms produce lethal poison):

- a. ditch the proposal for a dispute resolution procedure (para.3.3.11). The taxpayers' anticipated burden of externalities is onerous enough, as it is. There exists no ethical justification for creating new financial rights for new nuclear operators. New nuclear operators should be required to pay the Final Price as given, on take it or leave it basis. In that regard, there already exist appropriate nuclear regulatory authorities to police properly approved alternative waste management practices of new nuclear operators;
- b. ditch the proposed Cap on the Final Price. Instead, convert the Cap into a Floor for the Final Price. That is, the Final Price is never allowed to fall below the level of the Floor;
- c. employ an improved Cost Estimating Methodology, expressly favourable to taxpayers, in order to set a high level of the Floor. If, in the final analysis, taxpayers should end up making a profit (of whatever size), what is wrong with that? Any profit is likely to be a welcome positive externality for taxpayers, to the wider benefit of all of society;
- d. set the level of Optimum Bias adjustment at a factor of at least 2 (that is, 200%). The Treasury's Green Book recommended adjustment range for a "non-standard civil engineering project" (para.3.3.75) is not at all appropriate for a GDF type deep underground ultra-engineered robust environment facility (incorporating decay radioactivity parameters). A GDF plainly comprises an exceptionally non-standard civil engineering project. The evolution of geologic and waste content intrinsic parametric risks and uncertainties are virtually impossible to predict over geological timescales. Again, whatever it profits future taxpayers, this further positive externality would accrue to the wider benefit of all of society and not for creaming off by some bonus-snatching high-flyer clique or inflating the portfolios of elite shareholders;
- e. finally, for simplicity, set the Mark-up under Risk Fee (para.3.3.108) at 100%; and,

<sup>32</sup> see footnote 6, hereof.

- f. once the Floor, Risk Fee, Expected Price and the Final Price have been set, they should be indexed for inflation, based on which ever index is higher at the time: the Retail Price Index or the Consumer Price Index.

In the round, reasons for these measures can be found in the totality of this submission.

- 3.8 Lastly, a seeming illogicality at the heart of the incumbent Government's policy approach on the central role of the private sector in a push for expansion of nuclear power generation from 2017 onward, merits reiteration. Namely, build and operate as many new nuclear waste producing power stations as the sector can sustain but do not build and operate a geological disposal facility for nuclear wastes produced by the sector's nuclear power stations. A question goes begging: why should the Government and new nuclear operators seemingly conspire to ditch the free market on the question of ensuring safe permanent disposal of higher activity nuclear waste? Mindful of its ideological complexion, what fundamental flaw has the incumbent Government discovered, such as to countenance jettisoning a cardinal market principle? Namely, the private sector does things better consistently and more cost effectively than the state ever can.