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Higher Level Radioactive Waste: Likely inventory range; the process for altering it; how the community might influence it and understanding the implications of new nuclear build.

Presented to West Cumbria Managing Radioactive Waste Safely Partnership

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2nd Version with reactions to NDA responses

1.0 Introduction

It seems only reasonable that any community expressing a willingness to host a Geological Disposal Facility (GDF) should know exactly what it is letting itself in for. So the first question such a community might be expected to ask would be "*how much waste will we be expected to host*?"

Clearly there are going to be a series of uncertainties about the inventory of waste intended to go for disposal, but, if there can be no certainty over certain aspects of the inventory, then it would seem fair that a community should seek a veto over parts of the potential inventory.

The Committee on Radioactive Waste Management's (CoRWM's) view, in its July 2006 report, was that a community would be unlikely to offer an open-ended commitment to take an unknown quantity and type of waste:-

> "*It is CoRWM's view that communities are unlikely to express a willingness to participate in a siting process unless they have a clear understanding of the waste inventory they may be asked to accept*." (1).

Amongst its recommendations to the Government, CoRWM said:-

> *"**At the time of inviting host communities to participate** in the implementation process, **the inventory** of material destined for disposal **must be clearly defined**. Any substantive increase to this inventory (for example, creation of waste from a new programme of nuclear power stations, or receipt of waste from overseas) would require an additional step in the negotiation process with host communities to allow them to take a decision to accept or reject any additional waste."* (emphasis added) (2)

In relation to existing and committed wastes, there are obviously uncertainties, as CoRWM pointed out, over materials "*currently regarded as having potential future uses rather than as wastes, namely spent nuclear fuel, uranium and plutonium*". (3)

There are also changes to the inventory of committed wastes, as the NDA points out, "*which might occur through application of the waste hierarchy* [and] *alternative management options could alter the inventory of waste destined for geological disposal*." (4)

For example, there is a possibility some reactor decommissioning waste may be 'disposed of' in near-surface facilities thus avoiding the need for emplacement of some "short-lived" and "less radiotoxic longer-lived" ILW in a GDF. (5) And there are uncertainties over what will happen with redundant nuclear submarine compartments.

2.0 New Build Waste

Obviously the NDA's document takes as read Government policy which is set out in the recent draft Nuclear National Policy Statement (NPS). The Government's "*preliminary view that it is satisfied that effective arrangements will exist to manage and dispose of the waste that will be produced from new nuclear power stations*". (6)

It is worth remembering that CoRWM's recommendations did not apply to new build waste.

"It must be emphasised that CoRWM's recommendations are directed to existing and committed waste arisings ... New build wastes would extend the timescales for implementation, possibly for very long but essentially unknowable, future periods. Further, the political and ethical issues raised by the

creation of more wastes are quite different from those relating to committed – and therefore unavoidable – wastes." (7)

After a legal challenge by Greenpeace in the High Court to the Government's consultation on plans for new reactors, Mr Justice Sullivan said in February 2007, the consultation was "*seriously flawed*" and the process "*manifestly inadequate and unfair*." He said the Government's Energy Review consultation document was "*seriously misleading as to CoRWM's position on waste from nuclear new build"*. (8)

CoRWM then re-stated its position. In no sense, CoRWM said, should its position be read as providing any solution to the long-term management of any wastes arising from a new build programme. *"CoRWM's proposals apply only to committed wastes …a new process will be required to examine and justify any proposals for the management of wastes arising from new build"*. (9)

CoRWM was making two very important points. The first point was an ethical point, and the second related to the increased uncertainties about the size of the inventory and the length of time the GDF would need to remain in operation if a new reactor programme goes ahead.

2.1 Ethical Considerations

CoRMW mentions the fact that the political and ethical issues raised by the creation of more waste are quite different to those relating to committed – and therefore unavoidable – waste. One of the points stressed in CoRWM's recommendations, but often ignored, was the uncertainties surrounding the implementation of geological disposal, and the need for continued work on storage in case the GDF was delayed or the programme failed. (10) Deep Geological Disposal was very much recommended as a 'least-worst option'.

CoRWM's paper on ethics says: "*...a solution that is ethically acceptable for dealing with existing spent fuel is not necessarily a solution that would be ethically acceptable for dealing with new or changed materials ... To justify creating new spent fuel from an ethical point of view, there must be a management solution that is ethically sound, not just least bad. Moreover, even a least bad option acceptable for the existing problem might cease to be acceptable if there were changes in the nature of the spent fuel, such as adding enriched fuel*." (11)

Because there are so many uncertainties involved in waste management in general and deep geological disposal in particular, we should not be planning to create more waste. These uncertainties are illustrated by, for example, the 101 outstanding technical considerations listed in the Nuclear Waste Advisory Associates Issues Register. (12)

2.2 Waste Quantities

At the very least any community invited to participate in a siting process should know what the inventory of waste it is being asked to accept includes. The process of participation could be put at risk if there is any uncertainty about the terms of the commitment being entered into. [The process might also be put at risk by vague threats from the Government that if the voluntarist approach does not work, in the context of new build waste, it "*reserves the right to explore other approaches*". (13)]

CoRWM suggested: "*Finland appears to have provided a precedent whereby any substantive changes to the inventory for disposal, for example through creation of new spent fuel from a new reactor, would be subjected to an additional and separate policy decision on the final disposal of the spent fuel, involving the host community*." (14)

David Bonser (at the time of British Nuclear Group) suggested that dialogue should be based on the maximum possible inventory. (15)

The NDA's document already points out that the repository footprint would double with 10GW of new nuclear power. (16)

	Baseline Inventory	**Upper Inventory**
High strength rock	5.6km^2	9.8km^2
Lower strength rock	10.3km^2	19.5km^2
Evaportite	8.8km^2	18.4km^2

Table 1: Repository Footprints.

But it also points out that this only allows for a new build programme at the lower end of current proposals (two reactors at each of Hinkley, Sizewell, Oldbury and Wylfa for example). If the programme is increased with reactors also built at several sites in Cumbria, it could reach 16GW. It would have been helpful if the NDA had provided the West Cumbria Managing Radioactive Waste Safely Partnership with a Maximum Inventory which covered a possible 16GW programme. Such a maximum inventory might look like this:-

Materials (Maximum Inventory)	**Packaged Volume (cubic metres)**
HLW	23,000
ILW	599,000
LLW (not for LLWR)	156,000
Spent Fuel	34,480
Plutonium	10,400
Uranium	208,840
Total	1,031,720

Table 2: Inventory which includes a 16GW New Build Programme

Probably more important than waste volumes would be the repository footprint. It is not clear from the NDA's paper whether this can be increased by a simple proportional increase to allow for a 16GW programme. If it can be then the footprint might look like this:-

	Baseline Inventory	**Maximum Inventory**
High strength rock	5.6km^2	12.3km^2
Lower strength rock	10.3km^2	25.0km^2
Evaportite	8.8km^2	24.1km^2

Table 3: Repository Footprint for Maximum Inventory which includes a 16GW New Build programme.

The NDA could be asked to confirm these number or provide an alternative. Some questions need to be answered about the differences between the baseline inventory and the upper inventory to fully understand the NDA's numbers. Why, for example, does the HLW jump from 1,400m^3 to 23,000m^3 if new reactor spent fuel is presumed not to be reprocessed? And in the Upper Inventory spent fuel from existing reactors is presumed to be only 2,000 m^3 whereas in the baseline inventory it is 11,200m^3? Does this mean the Upper Inventory is assuming the reprocessing of un-contracted spent fuel?

2.3 Quality not Quantity

We can see from the NDA's slides 7 & 8 that a 10GW programme increases the volume of waste by around 10% as is often claimed by the industry. But this is misleading because the majority of existing waste is made up of bulky, intermediate-level waste. The volume is not the whole story – we also need to know the type of waste. CoRWM's Radioactive Waste Inventory estimated a programme

of ten new AP1000 reactors would increase the amount of radioactivity held in all nuclear wastes by an additional 265% - by almost three times. (17)

Spent nuclear fuel from new reactors currently looks unlikely to be reprocessed. The Environment Agency (EA) has set a limit on the risk that may be caused by the burial of radioactive wastes of 10^{-6} (i.e. one in a million). (18) However, the NDA Disposability Assessment Report for waste arising from new EPR reactors states:

"…a risk of 5.3 x 10^{-7} per year for the lifetime arisings of a fleet of six EPR reactors each generating a lifetime total of 900 canisters is calculated" (19)

This is more than half the total risk of 10^{-6} allowable for a GDF. The Draft National Policy Statement is currently proposing to designate 10 reactors sites, each with up to two reactors, which means we may need to consider the impact of spent fuel from 20 new reactors along with legacy waste. Clearly a GDF with spent fuel from more than 12 new reactors, as well as legacy waste, would exceed the risk targets set by the EA.

Co-disposal of legacy and new build wastes was neither examined by CoRWM nor considered within the extensive public consultation organised by CoRWM. It is noteworthy that the Government's Fixed Unit Price consultation accepted that a second GDF for new build waste might be necessary for whatever reason. (20) And, of course, there has been no limit set to the size of a new build programme, so the consultation also recognises that a second GDF might be required "*as a result of the new build programme becoming very large*". (21)

The NDA should be asked what is the maximum size of a new reactor programme which can be accommodated in a single GDF.

2.4 Timing

One of the problems highlighted by CoRWM, which the NDA paper has not dealt with, concerns the length of time the GDF would remain operational for. CoRWM said:

"New build wastes would extend the timescales for implementation, possibly for very long but essentially unknowable, future periods." (22)

The Government says all legacy wastes may not be emplaced until 2130 – 90 years after the GDF is expected to be available. (23) CoRWM recorded the Nirex view that it would take around 65 years after a repository opened to emplace the legacy backlog. (24) So, firstly this quarter decade discrepancy has to be sorted out.

New reactors are likely to use high-burn up fuel which could require up to 100 years of cooling before it can *start* to be disposed of. (25) So assuming new reactors start to come on stream around 2020, disposal could not start until 2120 in any case. But with an expected reactor life of 60 years, this means the GDF will be required to remain open until almost 2200.

3.0 Materials not yet declared a waste

There are three types of materials which may be disposed of which have not yet been declared waste. These are spent fuel from existing reactors (both AGR and PWR un-contracted for reprocessing); plutonium and uranium.

3.1 Spent Fuel

The fixed unit price (FUP) consultation document gives a figure of 1,200 tonnes for PWR spent fuel and 7,000 tonnes of AGR spent fuel, but these figures are for unpackaged waste, so it is difficult to

compare them with the 11,200m^3 of spent fuel packaged volume given in the NDA's baseline inventory. It is also not clear what assumptions have been made about AGR and PWR lifetimes

This is, however, clearly a significant inventory of waste. It represents 70% of the canisters included in the HLW/spent fuel legacy waste inventory. (26)

3.2 Plutonium and uranium

The FUP consultation points out that Plutonium, Highly Enriched Uranium and Depleted Uranium might require disposal in a GDF. If these materials were included in the inventory for disposal they "*would significantly increase volumes and the total cost of disposing of legacy wastes*". (27)

The UK nuclear industry has built up a stockpile of 100 tonnes of separated plutonium which is not currently incorporated into the repository risk estimate. (28) The NDA admits there may be technical, financial and public acceptability risks in disposing of plutonium in the GDF. However the issue obviously requires special consideration especially given the fact that the stockpile is sufficient to make around 7,500 nuclear bombs. (29)

The nature of plutonium, its lethal nature if ingested or inhaled and its long half-life (24,000 years) means that it requires special consideration and it is necessary to isolate it from the biosphere.

Long term management of this plutonium will need to be decided at some stage. If plutonium is not disposed of in a suitable form, and is instead used as MoX then 'spent MOX' would presumably require disposal. This could have significant implications with, for example, a need for long cooling periods prior to disposal. The NDA highlights the disposability of spent MOX as an important factor in deciding whether to use plutonium in this way. (30)

4.0 Reprocessing

The NDA's paper does not mention reprocessing at all, but rather obliquely comments that alternative management options will alter the inventory available for the GDF.

5.0 Questions for the NDA

1. Can the NDA confirm the numbers given in Tables 2 & 3 for a "Maximum Inventory" or provide an alternative set of figures and an explanation about why these are incorrect.
2. Why does the HLW jump from 1,400m^3 to 23,000m^3 from the Baseline Inventory to the Upper Inventory; and why does spent fuel from existing reactors fall from 11,200m^3 in the baseline inventory to 2,000 m^3 in the Upper Inventory? Does this mean the Upper Inventory is assuming the reprocessing of un-contracted spent fuel?
3. It is not clear why the plutonium in Baseline Inventory jumps from 3,300m^3 to 10,400m^3 in the Upper Inventory.
4. What assumptions have been made about AGR lifetimes and the lifetime of Sizewell B to calculate the inventory of spent fuel in the baseline inventory?
5. Can the NDA say what the implications are for the spent fuel inventory of a likely scenario of AGR and PWR life extensions?

6.0 Summary and Conclusions.

(1) Any community considering participating in the GDF implementation process should do so only on the basis of an agreed waste inventory.
(2) CoRWM's recommendations did not apply to new build waste. The ethics of planning to generate more nuclear waste when we only have a "least-worst" option for dealing with waste we have already created is highly questionable.

(3) The community should demand a veto on any substantive changes to the inventory for disposal, and it should insist that the Government makes clear that its vague threat to "*explore other approaches*" would preclude using any sort of compulsion on volunteer communities.
(4) The NDA should be asked to establish a 'maximum' inventory and state where the cut off point would be for the quantity of waste which could be emplaced in a single repository.
(5) A new build programme of the scale currently being considered could almost triple the repository footprint.
(6) Just 6 new EPR reactors could 'use up' more than half of the Environment Agency's risk target.
(7) New build could also require the GDF to remain in operation up to around 2200.
(8) More work needs to be done on the impact on achieving risk targets of the disposal of plutonium and uranium.

7.0 How can the community influence the inventory?

(1) The community should demand a right to an influence on the inventory as a condition of moving the process of volunteerism forward.
(2) The community could demand that only agreed volumes and types of legacy waste are considered for the GDF it is willing to consider hosting and a veto on any substantive changes.
(3) It could, for example refuse any new build waste, or make clear it is only willing to accept one GDF and that the constraints of only having one potential GDF site places on the extent of a new build programme are made clear.
(4) It could demand prompt closure once the agreed inventory is emplaced.

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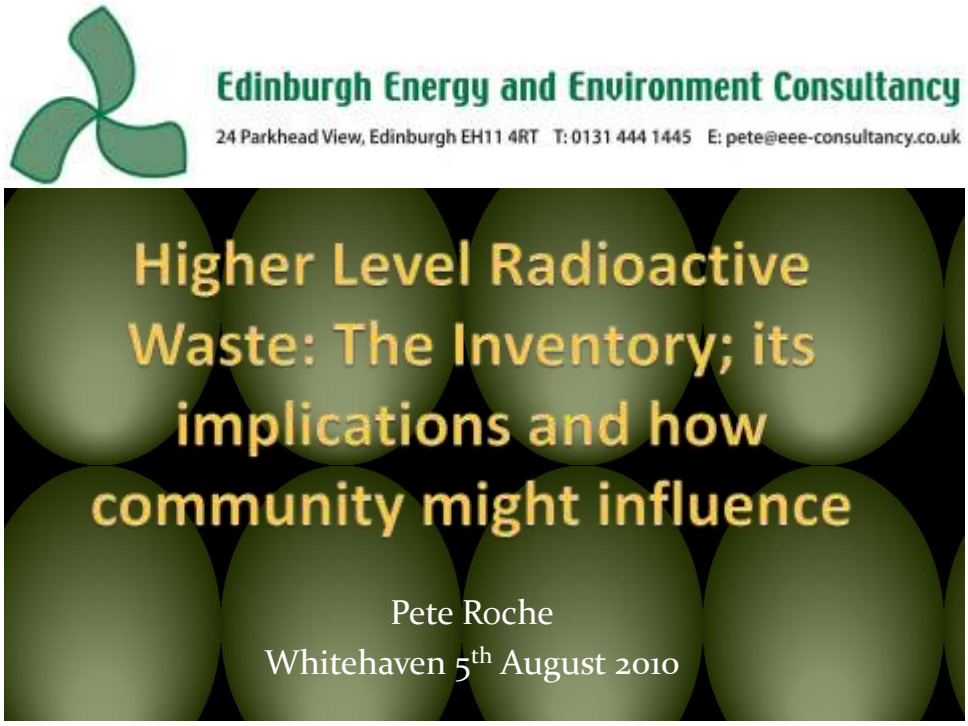
8.0 Presentation given to Partnership Meeting 5th August 2010

Slide 1



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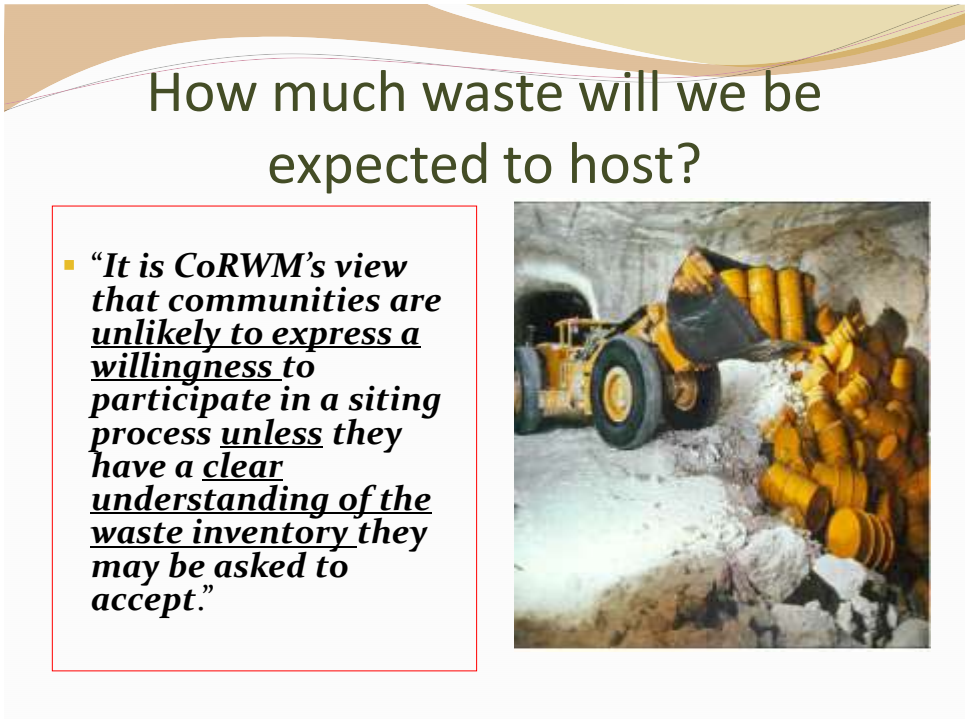


Slide 3

Exploring Uncertainties

- New build waste – the size of any new build programme.
- Spent Fuel from AGRs and PWRs & uncertainties about lifetime of existing reactors.
- Plutonium & uranium.

- NDA - changes through "*application of waste hierarchy*"
- "*alternative management options could alter the inventory of waste destined for geological disposal*."
- Uncertainty over redundant submarines.

Slide 4

New Build Waste

- CoRWM' recommendations did not apply to new waste.

- "*... the political and ethical issues raised by the creation of more wastes are quite different from those relating to committed – and therefore unavoidable – wastes.*"

- Two main reasons: (1) concerning ethics ; (2) increased uncertainty about size of inventory and length of time GDF would remain open.

Slide 5

Ethical Considerations

- CoRWM said: *"...a solution that is ethically acceptable for dealing with existing spent fuel is not necessarily ... ethically acceptable for ... new or changed materials ... To justify creating new spent fuel ... there must be a management solution that is ethically sound, not just least bad."*
- Many uncertainties with GDF – e.g. 101 outstanding technical considerations listed in the Nuclear Waste Advisory Associates Issues Register – so we should not be planning to create more waste.

Slide 6

New Build Waste Inventory

- NDA points out a 10GW programme would double repository footprint. (Only Sizewell, Hinkley, Oldbury, Wylfa)
- 16GW still being discussed which could almost triple the footprint.
- Industry says new reactors would only increase waste by 10%, but its clear from NDA numbers it is quality of waste not quantity which is important.

Slide 7

One dump or two?

- NDA disposability assessment says more than half the 1 in a million risk allowable for GDF could be accounted for by 6 x EPRs.
- Clearly a 16GW (10 EPRs) programme would need a second repository.
- What is maximum size of new build programme before we need to consider a second repository?

Slide 8

Timing for Repository

- Legacy waste may not be completely emplaced until 2130.
- High burn-up fuel may need 100 years cooling, so couldn't start disposal until 2120 anyway.
- Reactors starting to operate 2020 – 2030; 60 year life, so repository may be required to stay open until almost 2200.

Slide 9

Towards a Maximum Possible Inventory

Materials (Maximum Inventory)	Packaged Volume (cubic metres)
HLW	23,000
ILW	599,000
LLW (not for LLWR)	156,000
Spent Fuel	34,480
Plutonium	10,400
Uranium	208,840
Total	1,031,720

Slide 10

Towards a Maximum Possible Inventory

REPOSITORY FOOTPRINT	Baseline Inventory	Maximum Inventory
High Strength Rock	5.6km²	12.3km²
Lower Strength Rock	10.3km²	25.0km²
Evaporite	8.8km²	24.1km²

Slide 11

Spent Fuel from Existing Reactors

- Important part of inventory - represents 70% of the canisters included in the HLW/spent fuel legacy waste inventory (FUP Consultation).
- FUP says 1,200 tonnes of PWR spent fuel and 7,000 tonnes of AGR spent fuel (unpackaged).
- NDA Baseline says 11,200m^3 of spent fuel (packaged).
- Figures need to be comparable.
- Assumptions (e.g. about reactor lifetimes) need to be transparent.

Slide 12

Plutonium.

- FUP says: If these materials were included in the inventory for disposal they "*would significantly increase volumes and the total cost of disposing of legacy wastes*".
- NDA admits there may be technical, financial and public acceptability risks in disposing of plutonium in the GDF.
- 100 tonnes of separated plutonium not currently incorporated into the repository risk estimate.

Slide 13

Plutonium – special considerations

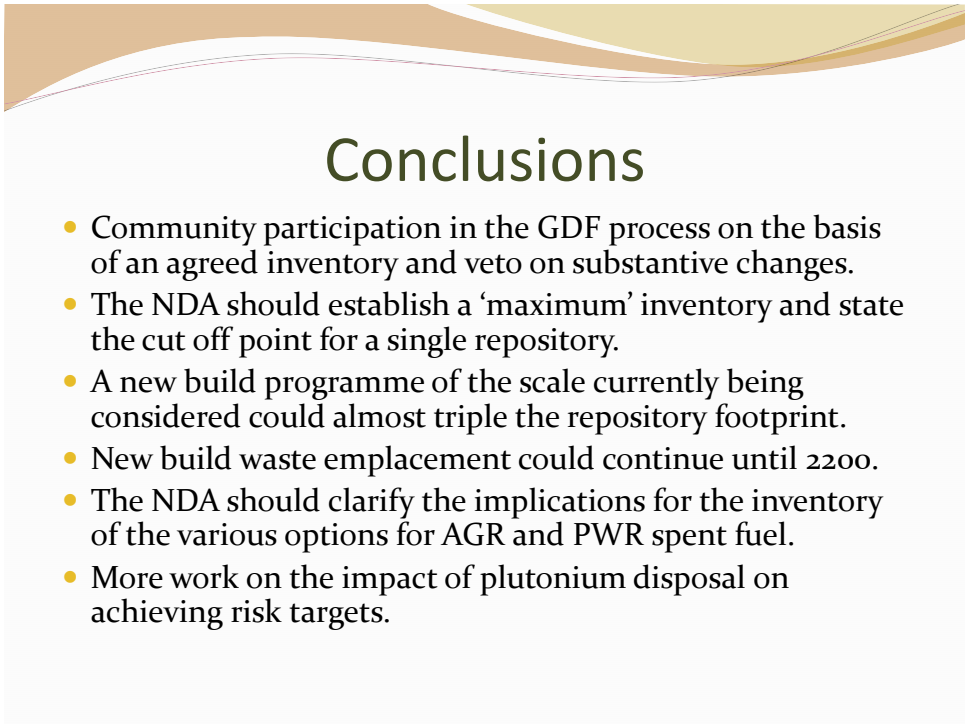
- 7,500 nuclear bombs worth.
- Lethal nature if inhaled or ingested.
- 24,000yrs half-life.
- Requires isolation from biosphere.
- Use as MoX brings other problems.
- Disposability? Long periods of cooling required.
- Why does plutonium inventory jump from 3,300m^3 to 10,400m^3 (Baseline to Upper Inventory).

Slide 14

Community Influence?

- The community could demand a right to an influence on the inventory as a condition of moving the process of volunteerism forward.
- It could demand only agreed volumes and types of legacy waste are considered for the GDF & a veto on substantive changes.
- It could, for example refuse any new build waste.
- It could make clear it is only willing to accept one GDF.
- It could demand prompt closure once the agreed inventory is emplaced.

Slide 15



9.0 Response to the NDA's Inventory Paper Issue 2.

The NDA says "it is not possible to derive a "maximum acceptable inventory" for a single geological disposal facility until a site for such a facility has been identified and characterised and its capacity established".

However, the EA has set a limit on the risk that may be caused by the burial of radioactive wastes of 10^{-6} yr^{-1} (i.e. one person in a million per year contracting a fatal cancer, a non-fatal cancer or inherited genetic defect as a result of radiation exposure). (31) As is pointed out in 2.3 above the spent fuel arising from 6 new EPR reactors (almost 10GW) would be more than half this total risk. The Agency themselves point out:

"*...this does not leave a large margin to the regulatory risk guidance level*". (32)

Clearly the maximum amount of spent fuel which could be accommodated in a single GDF would be that produced by less than 12 reactors, but more than six, depending on the risks associated with legacy waste. Consequently a 16GW programme (which could be 10 EPRs) would appear to be very likely to produce sufficient spent fuel to require the construction of a second GDF. It is, therefore, important that the Partnership discusses the possibility that it may be asked to host two facilities.

9.1 NDA response to questions

The NDAs response to my questions 1, 2 & 3 appear to be clear enough. This is exactly the sort of information which I believe the Partnership should be aware of so that it can build up a picture of the maximum inventory West Cumbria might be asked to host. An Upper Inventory which assumes un-contracted spent fuel from existing reactors is not reprocessed would be a useful addition to the information available to the Partnership.

9.3 AGR Lifetimes

Obviously the assumptions used for AGR lifetimes in the baseline inventory are not very realistic and far from those you would need to use to derive a maximum possible inventory. The assumed lifetime for Hunterston B and Hinkley Point B of 2011, has already been superseded by a recent Periodic Safety Review (PSR) which gave both stations the go-ahead to continue operating until 2016. (As the NDA indicates in footnote 6) The Unions at Hunterston say they expect this to be extended again to 2021 or even 2026. (33) It is probably reasonable to assume that several other AGRs will achieve a life extension of up to a decade. Torness, for example, might be expected to remain in operation until 2028 or later.

It is obviously difficult to second guess what the Health and Safety Executive and British Energy might do in terms of extending the life of AGRs, but the assumption in the NDAs Upper Inventory that AGR lives are extended to 40 years appears reasonable. What this does indicate, however, is the importance of producing an alternative Upper Inventory which does not assume extra spent fuel is reprocessed. The closure date for THORP is clearly uncertain, but it would seem very unlikely that it will still be operating in 2028. This could be particularly important given how close the current inventory with proposed new build is to requiring a second GDF.

9.4 NDA Responses on Summary and Conclusions

1. Identifying a set of principles for a process for changing the Baseline Inventory would seem to be a sensible way forward.

2. We will have to agree to disagree on this. I do not want to stray too far away from the issue of the inventory here, but I do think it is important for the Partnership to hear from some of those former CoRWM members who disagree with the NDA's interpretation. One former CoRWM member, for example, told me

   "*CoRWM members were unanimous in their view that new build waste should be subject to a separate process.* [The] *separate assessment, building on the CoRWM process and examining the social, political and ethical issues around new build and the waste it will generate has not taken place and to argue that the flawed consultation which took place in 2007 ... represented the sort of examination foreseen by CoRWM is risible*."

3. The community is right to continue to seek assurances about the Government's commitment to voluntarism. The MRWS White Paper says "*in the event that ... voluntarism and partnership does not look likely to work, the Government reserves the right to explore other approaches*." This is repeated in a document published in November 2009. (34) It could have said it would explore other ways of implementing the voluntarism principle, but it didn't. The Partnership will no doubt welcome the NDA's assurances that "other approaches" refers to other ways "*to make the voluntarism and partnership approach work better*".

4. I am satisfied that with what the NDA calls its "Modified Upper Inventory based on a 16GW programme" the Partnership is beginning to get an idea of what a Maximum Inventory might look like. If the NDA was now able to tweak this to allow for the fact that un-contracted AGR spent fuel might not be reprocessed and for the likelihood of further AGR life extensions, then that is probably as far as we can get at the moment.

5. Noted. Increasing by 2.5 times and "almost tripling" are not that different.

6. Clearly the Partnership needs make itself aware of the factors which might determine whether or not a second GDF might be necessary and to decide what its attitude might be if asked to consider hosting a second site. It is hoped that the Partnership will be able to be kept abreast of discussions planned between the NDA and Nuclear Waste Advisory Associates. One issue likely to crop up is recent research on copper corrosion rates. (35)

7. If it takes until 2130 to emplace all legacy waste in the repository, reducing the cooling time of new build spent fuel is not going to make a huge difference to the closure date for the GDF. Perhaps the NDA could say, after it has completed the work for the NIA, when it might expect to have finished emplacing new build waste from a 16GW programme.

(31) Geological Disposal Facilities on Land for Solid Radioactive Wastes: Guidance on Requirements for Authorisation, page 46 para 6.3.10, Environment Agency, February 2009 http://publications.environment-agency.gov.uk/pdf/GEHO0209BPJM-e-e.pdf
(32) Generic Design Assessment UKEPR nuclear power plant design by Areva NP SAS and Electricite de France SA, Assessment Report: Disposability of ILW and Spent Fuel. Environment Agency, June 2010, para 40, section 3.2.3 https://consult.environmentagency.gov.uk/portal/ho/nuclear/gda?pointId=1276871149397
(33) Largs & Millport Weekly News 1st September 2010 http://www.largsandmillportnews.com/news/roundup/articles/2010/09/01/404629-hunterston-unions-want-new-nuclear/
(34) DECC (November 2009) "The arrangements for the management and disposal of waste from new nuclear power stations: a summary of evidence" para 106 https://www.energynpsconsultation.decc.gov.uk/nuclear/managementdisposalwaste/summaryevidencepaper/
(35) "*Water Corrodes Copper*" G. Hultquist et al [July 2009 – (online)] Catal Lett (2009) 132: 311–316: Received: 29 June 2009 - Accepted: 19 July 2009 (Published online: 28 July 2009) Springer Science+Business Media, LLC 2009. http://www.mkg.se/uploads/Water_Corrodes_Copper_-_Catalysis_Letters_Oct_2009_-_Hultquist_Szakalos_et_al.pdf