

Potential Waste Volumes Arising from New Build

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1. Introduction and Context

There is a pressing requirement to understand the likely size of the waste management issues arising from a UK new nuclear build programme. This is in advance of a more detailed analysis of potential waste volumes to be carried out at a later date. In order to meet this pressing requirement, this short paper presents and discusses publicly available waste data to inform future decision making.

One of the difficulties in presenting information in this area is that the current UK civil nuclear “baseline” programme entails reprocessing most of the spent fuel, whereas a “new build” programme is currently assumed to package and dispose of spent fuel with no reprocessing. This provides an unbalanced comparison from one scenario to another, as reprocessing generates a comparatively small amount of HLW compared to the quantity of immobilised spent fuel, which would also be classed as HLW. Hence both the “package and dispose” option and the reprocessing option is discussed below.

2. Existing Nuclear Programme – Baseline

The existing fleet of reactors (Magnox, AGRs and the Sizewell B PWR) will operate in total over a period of almost 80 years up to 2035. During this time they will generate about 350GW(e)y. CoRWM has published the quantities of operational and decommissioning wastes, spent fuel that will be produced from these reactors and all other radioactive material that may need deep disposal¹.

The predicted quantities of waste and spent fuel resulting from the existing nuclear programme in the CoRWM inventory are:

	Mass (t)	Packaged Volume (m³)
Spent fuel from AGRs	3,500	5,410
Spent fuel from Sizewell B PWR	1,200	2,740
Vitrified HLW		1,290
ILW		353,000
Other materials		115,420
Total		477,860

It should be recognised that HLW has been produced from reprocessing several thousand tonnes of AGR fuel and about 55,000t of Magnox fuel.

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Using the packaging approach for spent fuel and HLW as presently advocated by Nirex (ie the SKB concept), Chapman has calculated the number of disposal containers² required:

	No. disposal containers
AGR fuel	3,391
Sizewell B PWR fuel	654
Vitrified HLW	3,291
Total	7,336

3. New Build Programme – Spent Fuel Conditioned

3.1 Factual Information

The reactors likely to feature in new nuclear build are more compact and hence contain less potential waste material than the existing reactor fleet. To illustrate this, the annual rate of waste production (operations and decommissioning) is given as:

Reactor Type	Quantity of waste (m3 per GW(e)y)
	ILW + LLW
Magnox ³	2697
AGR ³	960
Sizewell B ³	360
AP1000 ¹ (potential new build)	162

When existing waste packaged volumes (m3) are compared with the potential waste packaged volumes (m3) from a new build programme (illustrated here as 10 x AP1000 reactors), the following can be shown:

	HLW	ILW	LLW
Existing Inventory ³	1,750	349,000	2,252,000
New Build ¹	0	9,000	80,000

Clearly, the impact of new build here can be interpreted as being very small, and it illustrates the need to factor in the additional spent fuel volumes in order to obtain a balanced overview.

For Spent Fuel, information published in the CoRWM Inventory¹ for two candidate PWR reactor types shows that a programme of 10GW operating for 60 years would generate:

Reactor	Spent Fuel (tHM)	Packaged volume (m³)	No. containers².
AP1000	14,000	31,900	7,625
EPR	9,200	21,000	5,010 (pro-rata)

Such a programme would produce about 550GW(e)y – ie about 60% more electricity than the current programme will generate up to 2035. In addition to the spent fuel, the programme would also generate between 9,000 and 13,000m³ of ILW (i.e. equivalent to about 0.3% of the existing CoRWM baseline ILW inventory).

3.2 Discussion

Various comparisons can be made between the total quantities of higher activity wastes (spent fuel and ILW) produced by a new 10GW programme and the existing CoRWM baseline inventory. In packaged volume terms, a new programme would create less than 10% of additional higher activity waste (ie 31,900 m³ + 9,000 m³ compared with 477,860 m³).

Some comparisons concentrate purely on the packaged volumes of spent fuel. This will increase from a baseline value of 8,150 m³ up to a value in the range 39,150 m³ – 40,050 m³; this is an apparent increase of a factor of five.

The recent report by the Sustainable Development Commission⁴ (SDC) has attempted to overcome the complications inherent in comparing volumes by comparing the total amount of radioactivity in the baseline with the activity from a 10GW programme. They point out, however, that the reference time chosen for such a comparison is important given the presence of short-lived radionuclides which dominate the activity of spent fuel after it is taken out of the reactor.

Should one allow only minimum cooling time followed immediately by disposal (an extremely unlikely scenario), then it could be concluded that the activity increases by 900% compared to the existing inventory. However, allowing for the rapid initial decay in activity of spent fuel during cooling, an AP1000 based new build programme will produce just less than 90% of the existing baseline activity, assuming disposal 100 years after the fuel has been discharged. This is not particularly surprising since, as explained above, a new programme involving ten reactors will be more efficient while generating 160% of the electricity produced by the existing reactor fleet.

4. New Build Programme – Spent Fuel Reprocessed

4.1 Factual Information

If all the spent fuel (incorporating AGR, Sizewell B and new build) were reprocessed the packaged spent fuel volume would reduce to zero and the potential EXTRA packaged waste arising from the additional reprocessing operations would be estimated as:

	Packaged waste volumes / m3		
	HLW	ILW	LLW
From 3,500 te AGR fuel ¹	250	7,000	10,000
From 1,200 te Sizewell B fuel ¹	90	2,000	5,000
From 14,000 te from “AP1000” new build ⁵	1,050	23,333	58,333
From 9,200 te from “EPR” new build ⁵	690	15,333	38,333

It should be stressed that the volumes given in the above table are the best available estimate at this time, and that more data would need to be generated for the information to be considered anything more than illustrative.

4.2 Discussion

If all existing spent fuel from the baseline nuclear fleet was reprocessed, the packaged volume of HLW arising would be (1750+250+90) 2090 m3. That can be compared to the figures (given above) of 690-1050 m3 of HLW. In this illustrative scenario, the extra HLW for a new build programme (offering 160% of the electricity generated from the existing nuclear fleet) would be 33-50% above that of current operations.

5. Summary Table of Waste Volumes

The packaged waste volumes (m3) for each scenario can be summarised as:

	LLW	ILW	HLW	Spent Fuel
Existing programme (to 2035)	2,252,000	349,000	1,750	8,150
(Extra Waste) 10 x AP1000 – conditioned fuel	80,000	9,000	0	31,900
(Extra Waste) 10 x EPR – conditioned fuel	n/a	n/a	0	21,000
(Extra Waste) 10 x AP100 – reprocessed fuel	138,333	32,333	1,050	0
(Extra Waste) 10 x EPR – reprocessed fuel	n/a	n/a	690	0

6. Discussion on Conceptual Repository Considerations

The SDC report⁴ comments on the potential impact that a new build programme will have on the (underground) footprint of a combined HLW and ILW repository. This would be determined by a number of factors such as the geometry of the suitable rock mass, the characteristics of the rock, the detailed repository design (for example whether spent fuel containers are placed horizontally in tunnels or placed vertically in bore-holes drilled down from access tunnels), stacking of fuel and the timing of the emplacement of packages.

The underlying principle will be to ensure that the decay heat from the ILW, spent fuel and vitrified HLW is adequately distributed within the repository so that temperatures are kept within the envelope assumed for the disposal safety case. The SDC report quotes a Nirex report stating that the footprint of a repository would be about 50% greater than for a baseline repository. However, given the wide range of variables it is easily argued that the footprint could be increased by less than or greater than 50%, depending on particular biases. Whatever the footprint eventually turns out to be, the ability of the repository to contain the radioactivity to the required standards will not be compromised. Also, it is unlikely that repository cost will be directly proportional to repository cost. It is likely that additional repository capacity could be provided at relatively low marginal cost.

7. Conclusions

The data concerning the impact of new nuclear build on waste volumes can be presented in a variety of ways, depending on one's point of view. It is certain that new nuclear build will increase total waste volumes to a small degree. It is also certain that the radioactivity of the UK's total waste inventory would increase sharply immediately after spent fuel discharge from the "new build" reactors, but would be more proportionate in increase after a relatively short time (100 years). The impact on the repository footprint is difficult to predict, but could be around a 50% increase, depending on design and site issues. However, this is unlikely to be a significant issue as additional repository capacity could be provided at relatively low marginal cost.

¹ CoRWM Radwaste & Materials Inventory, (Full Report) July 2005

² Costs_of_SpentFuel_Disposal_from_New_Build_Reactors <http://www.mcm-international.ch/reports.htm>

³ 2004 Waste Inventory, Table 3.4

⁴ The role of nuclear power in a low carbon economy, Paper 5: Waste and Decommissioning, March 2006.

⁵ Calculated on the basis that spent AP1000 fuel is treated the same as conventional spent LWR fuel.