SUMMARY

NUCLEAR FUEL CYCLE ROYAL COMMISSION

Jacobs MCM (2016), Radioactive waste storage and disposal facilities in South Australia—quantitative cost analysis and business case

OBJECTIVE

To develop cost estimates and assess the potential viability for four conceptual waste storage and disposal facilities in a combination of generic stand-alone and collocated scenarios in South Australia.

BACKGROUND

The physical, demographic and security characteristics necessary for above-ground temporary storage and deep geological disposal of radioactive waste are present across large areas of South Australia.[1]

The baseline scenario assumes:

- An interim storage facility (ISF) is established at a greenfield location with a capacity to store 72,000 tonnes heavy metal (tHM) of international used nuclear reactor fuel (UF) and 175,000 cubic metres (m^3) of intermediate level waste (ILW) in above ground dry casks and containers.[2]
- A combined geological disposal facility (GDF) with a design capacity of 138,000 tHM for used fuel, collocated with an intermediate depth repository (IDR) with a design capacity of 390,000m^3 for ILW.[3] These collocated facilities will receive UF and ILW from the separate ISF.[4]
- A near surface low level waste repository (LLWR) for the disposal of low level waste (LLW) arising from the operations and decommissioning of the ISF, IDR and GDF. The LLWR is at a location independent of the other facilities.[5]
- The current federal government program to develop a LLW facility for Australian radioactive waste has not been considered in this analysis.[6]
- The development of new port, road, rail, airport and supporting power and water infrastructure is included in the capital cost estimates.[7]
- Australia does not develop a civil nuclear power program that would generate domestic UF, ILW or LLW. However, if a nuclear power program were to be developed this would have a marginal impact on the quantities of UF and waste defined in the baseline scenario and could easily be accommodated in the facilities.[8]
- The ISF would receive UF and ILW in project year 11 after the decision to proceed, siting, licensing and construction were completed. Receipt of UF and ILW would continue at the ISF until project year 83, initially at a rate of:
  - 3000 tHM a year of used fuel for the first 30 years, then at the production rate of approximately 1500 tHM a year or less thereafter[9]
  - 10,000 m^3 a year of ILW until project year 38, then approximately 4,000 m^3 a year or less thereafter.
- UF would be transferred to the GDF for disposal in project year 28 at a rate of 1500 tHM a year for 92 years. ILW transfers start in project year 26 at a rate of 8000 m^3 a year for 49 years. The difference in times is primarily due to the need to store used fuel for typically 40 years before permanent disposal.[10]
- Ownership and liability of the UF and waste transfers to a South Australian state-owned enterprise when it is delivered ashore at a South Australian port. At the point of ownership and liability transfer, payment for storage and disposal is made in full.[11]
- Revenue generated through payments made to a government owner will be used to meet capital and operating costs, as well as to building up a reserve account to meet lifetime monitoring and maintenance costs of the facilities. An initial 15 per cent royalty from the revenues received and annual distributions of surplus operating income are paid to a state wealth fund to provide long-term benefits to South Australia and its citizens.[12]

The assumed timeline for UF and ILW management and disposal facilities to be developed and operated in South Australia is depicted at Figure 1.[13]

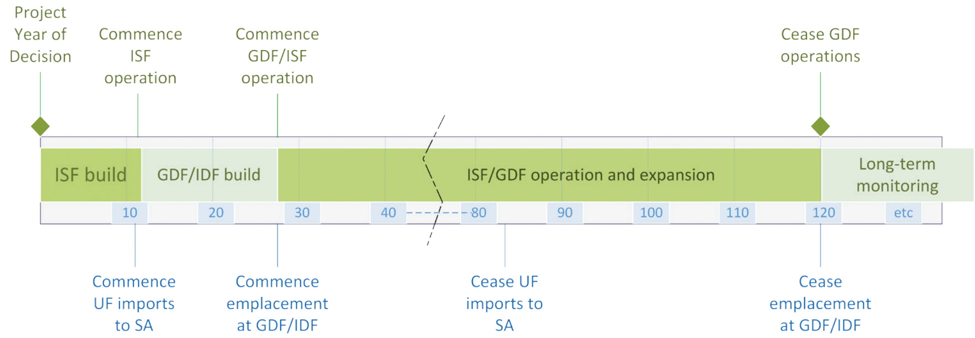

Figure 1: Assumed facility deployment timeline

MARKET

There is substantial and ongoing global demand for services to manage and permanently dispose of radioactive waste and in particular UF.[14]

The global inventory of UF is currently about 390,000 tHM[15] and for ILW it is currently about 9.9 million m^3. This inventory is expected to grow to more than 1 million tHM of UF and just less than 24 million m^3 of ILW by 2090.[16,17] These figures conservatively exclude waste that accrues from nuclear power plants built after 2030.

An assessment of the proportion of the global market that South Australia might be able to access was made. The potential accessible market is assumed to be up to 26 per cent[18] of the global inventory of UF and up to 3.3 per cent of global ILW, which equates to about 276,000 tHM of used fuel and 780,000 m^3 of ILW respectively.[19] The potential market excludes major nuclear countries with prospective national disposal programmes and countries with declared policies that prohibit exporting radioactive waste.[20]

The proposed facilities modelled in South Australia have a maximum design capacity of 138,000 tHM of UF and 390,000 m^3 of ILW[21], which represents about 13 per cent of the global inventory of UF and about two per cent of the global ILW inventory (anticipated in 2090).[22]

PRICE TO CHARGE

In the absence of a market for this service, a potential customer's willingness to pay was determined by analysing a number of different market proxies, including[23]:

- national waste disposal funds
- the cost of developing and operating national disposal facilities
- the cost of reprocessing services
- reductions in the cost of capital from guaranteed back-end solutions
- distress payments for plant shutdowns.

An assessment of a potential customer's willingness to pay for an international UF/ILW service hosted in South Australia, the costs of building infrastructure and the benefits that should accrue to the host community established that a conservative price to charge for this service is A$1.75 million per tHM for UF and A$40,000 m^3 for ILW. There is believed to be the potential to negotiate higher prices under some circumstances.[24]

FINANCIAL ANALYSIS

A facility is viable only with the establishment of a surface ISF capable of accepting UF/HLW prior to construction of geological disposal facilities.[25]

The total capital cost for the construction, decommissioning and closure of the baseline facilities is estimated to be about A$41.0 billion, which includes a 25 per cent growth allowance and scope contingency.[26]

Approximately 1550 direct full-time jobs would be required in South Australia on average during the 25 year construction phase of the project, with a peak of about 4,500 full-time jobs during the GDF construction phase (in years 21 to 25). A total ongoing operational workforce in South Australia of approximately 600 full-time direct jobs is anticipated once all facilities are completed.[27]

Total international revenue generated by South Australia under the base case model would be about $257 billion (AUD 2015 real undiscounted) over the 120 year life of the project, with total expenditures of about $145 billion (including construction, operating, decommissioning and closure costs, but excluding royalties) over the same period.[28]

Figure 2 shows the cashflow profile over the operating life of the facilities. In the lead up to the beginning of imports there will be an accumulated construction cost to the project of about $2.4 billion, which would need to be financed by the State if advance reservation fees were not negotiated with customers.[29]

Once established, total annual revenue to South Australia would be about $5.6 billion a year on average during the first 30 years of the operation of the facilities, and about $2.1 billion a year over the following 43 years, until receipt of used fuel ceased.[30]

To put this in perspective, $5.6 billion:

a. if divided by the population of SA (1.7 million), equates to additional revenue of about $3,300 per person per year on average during the first 30 years of operation, or

b. is equivalent to approximately 34 per cent of current State government revenue ($16 billion a year).

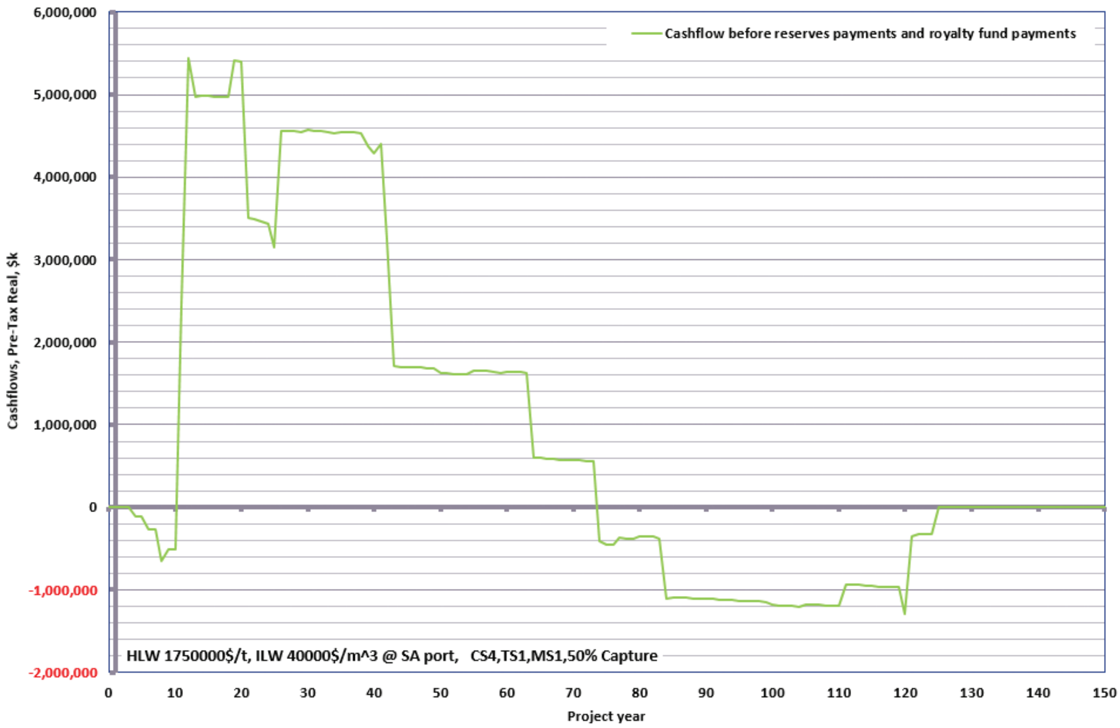

Figure 2: Baseline facility gross cash flows[31]

A separate project reserve account (or sinking fund), in addition to the state wealth fund, is maintained to fund decommissioning, remediation, closure and long-term monitoring activities. The reserve account is estimated to accrue more than $32 billion before drawdowns start.[32] Following the last revenues from used fuel and ILW arriving in South Australia, ongoing operations and decommissioning are funded from drawdowns of the project reserve account.[33]

The overall benefit to the state from the baseline scenario (that is, the NPV of commercial position *and* a royalty payment of 15 per cent of gross revenue accruing to South Australia) would equate to a NPV of A$14.4 billion at a commercial pre-tax discount rate of 10 per cent, or A$51.4 billion at an intergenerational discount rate of 4 per cent.[34]

Assuming that all revenue net of expenditures (that is, royalties and dividends paid) accrues in the state wealth fund at a compound return of 4 per cent a year, *and that 50 per cent of the interest income from the fund is distributed to the state budget each year*, interest payments to the State would grow to about $9 billion a year and the fund would grow to about A$445 billion (AUD 2015 real undiscounted) by the time the receipt of UF/ILW ceased 73 years after the first shipment. If no interest payments were made to the state each year the fund would grow to about $1,364 billion over the same period.[35]

At the baseline price of $1.75 million per tonne of spent fuel, South Australia would need to secure forward contracts of 15,500 tHM of spent fuel for the minimum-scale facilities required to break even at the commercial discount rate, and for this project to be considered for implementation.[36]

The potential benefits from indirect employment and industry development, or from the potential use of the UF as a future economic resource, has not been modelled in this analysis.[37]

To assess risks to the baseline scenario being achieved, sensitivity analysis was conducted to determine the impact of a 50 per cent facilities cost overrun, a 50 per cent reduction in the inventory/revenues received, a 43-50 per cent reduction in the price received, and a four-year delay in the receipt of used fuel.[38] The project remained highly viable under all of these scenarios.[39]

REFERENCES

[1] Jacobs and MCM, *Radioactive waste storage and disposal facilities in SA—Quantitative cost analysis and business case*, report prepared for the Nuclear Fuel Cycle Royal Commission, Adelaide, 2016, available at http://nuclearrc.sa.gov.au/tentative-findings/, p. 1 and p. 17 section 1.

[2] ibid, p. 146 section 7 and p. 174 section 2.7.1 and 2.7.2.

[3] ibid, p. 1-4 and p. 146.

[4] ibid, p. 1-2.

[5] ibid, p. 2 and p. 198.

[6] ibid, p. 4 and p. 80, footnote 13.

[7] ibid, pp. 138–140, section 4.

[8] ibid, p. 110, section 2.1.

[9] ibid, pp. 4-5 and pp. 115

[10] ibid, pp. 116 Figures 2.1–2.2

[11] ibid, p. 126, section 3.8.

[12] ibid, p. 196, section 2.5.

[13] ibid, p. 5, Figure 3 and p. 201, Figure 3.1.

[14] ibid, p. 1 and pp. 106-114.

[15] ibid, p. 3.

[16] ibid, p.113, section 2.3.4.

[17] ibid, p.113, section 2.3.4.

[18] ibid, p. 3.

[19] ibid, pp. 3–4.

[20] ibid, p. 108, section 2.1.

[21] ibid, p. 114, p. 144 section 7.

[22] ibid, pp. 113–114, section 2.3.4.–2.3.7

[23] ibid, p. 118, section 3.

[24] ibid, p.4, p. 125, Figure 3.4 and p.127, section 3.9.

[25] ibid, p. 204, section 4.1.

[26] ibid, pp. 198–200, section 3 and p. 203, section 3.4.

[27] ibid, p.1 and p.144, section 5.12.

[28] ibid, p. 6 and p. 204, section 4.1.

[29] ibid, p. 7, p. 207, section 4.5, p. 200.

[30] ibid, pp. 125–127, section 3.10 and p. 116 section 2.3.7 combined.

[31] ibid, p. 7.

[32] ibid, p. 209, section 4.6.

[33] ibid, p. 209, section 4.6.

[34] ibid, p. 211, section 4.8.

[35] ibid, p. 210, section 4.6.

[36] ibid, p. 206, section 4.3.

[37] ibid, pp. 213-214, sections 5.9 and 5.10.

[38] ibid, p. 203.

[39] ibid, p. 8, pp. 203-211, section 4 and p. 216, section 6.1.