Sellafield Nuclear Facility

Response to the Nuclear Fuel Cycle Royal Commission Tentative Findings Document

March 2016

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1 Executive Summary

In summary, Mott MacDonald supports the findings of the Nuclear Fuel Cycle Royal Commission (NFCRC) Tentative Findings Report (the Report) dated February 2016. Previous international experience however, suggests that a number of broader options should also be assessed for extending nuclear fuel cycle services activities in South Australia that have the potential for far-reaching socio-economic benefit.

Exploration, extraction and milling
South Australia has recognised expertise in the extraction of Uranium ore. This expertise, coupled with the availability of economically recoverable reserves, will enable this service to be continued into the future. The potential for ongoing and increased extraction of Uranium is predicated on the market value of Uranium, supply and demand forces. Significant international competition exists in this service provision, with Uranium extraction taking place in other parts of the world. Commercial linkages between Uranium provision and other aspects of the fuel cycle have the potential to give market advantages to South Australia.

Further processing and manufacture
The technology and operational expertise surrounding Uranium conversion and enrichment is well established internationally. These technologies are subject to significant security restrictions, reflecting the challenges associated with nuclear proliferation. At present, there is some over-capacity in the supply of enriched Uranium and in Uranium conversion services. Service offerings that incorporate the capability to refine and process Uranium within a fuel leasing arrangement alone may not create a viable industry.

Electricity generation
Based on the energy demand profile between baseload and transient load-following requirements and the opportunity to utilise a mix of power sources, particularly renewables, Mott MacDonald agree with the Royal Commission that large scale nuclear power generation in South Australia is not viable at present. Use of Small or Medium Reactor (SMR) technology may be of more benefit to South Australia, recognising that technology's potential for load following capability; however the application of this technology has not been substantiated for use in civil applications.

Management, storage and disposal of waste
A number of key factors influence decision making around the demand for the management, storage and disposal of nuclear waste. It is clear that with the significant number of new reactor builds planned throughout the world, requirements for both spent nuclear fuel and other nuclear waste storage and disposal will grow. Mechanical barrier systems highlighted in the Report, utilised in specific locations that have appropriate geology and hydrology, suggest long-term storage or disposal is feasible in South Australia. The technologies for the long-term storage and disposal of spent nuclear fuel are of interest to all IAEA member states and in countries such as Sweden and the United Kingdom works are ongoing to develop that capacity domestically. The storage of nuclear wastes, such as Intermediate Level Waste or Higher Activity Wastes, can offer increased complexity and challenge to that of spent nuclear fuel due to their broader chemical and physical properties and their long term stability.

Fuel leasing
Fuel leasing is an option for extending nuclear fuel cycle services provision in South Australia. The approach has been recognised as an option within the IAEA and assessments of its potential have been documented in the USA. Recognising the current overcapacity in conversion in addition to the security and proliferation issues associated with enrichment, consideration should also be given to leasing options which exclude the use of this capability in Australia and options which involve 'storage leasing concepts' . However, in light of the international joint conventions associated with spent fuel, the feasibility of fuel leasing in conjunction with storage/disposal must be determined.

Regulation
Finally, with regard to Regulation, technology assessment and an overall information gathering process, Mott MacDonald recommends a program methodology aligned with IAEA guidelines associated with Milestones for Infrastructure Development.

2 Exploration/Extraction and Milling Aspects (Paragraphs 10 to 22)

Australia has established capability in Uranium mining and provides a significant proportion of the supply capability to the world market. Further, Australia is the only producing country in the Pacific region[1]. Expansion in exploration/extraction activities may provide increased social and economic benefits to South Australia, but this is predicated on achieving commercially economic extraction, which is subject to the market value of Uranium. Variation in mineral price can occur through the markets perception of demand and scarcity and there is a potential for oversupply with significant competition for this service provision from other parts of the world. It is noted that the largest global reserves of economically recoverable Uranium are held within stable and politically mature countries and this brings an element of long term stability to international prices set for Uranium Ore commodities. The current low price for Uranium Ore could be viewed as the new norm. Commercial linkages between Uranium provision and other services such as conversion and enrichment, fuel manufacture or waste management can potentially provide a market advantage.

2.1 Specific commentary and observations on the report covering Exploration/Extraction and Milling

Mott MacDonald support the view expressed within the Report that expansion of Uranium mining has the potential to be economically beneficial, however it may not be the most significant opportunity when considering the value proposition of other potential services associated with extending South Australia's involvement in the nuclear fuel cycle.

With respect to the reference to the Thorium cycle in Paragraph 22, the IAEA recognise both the benefits and challenges of the Thorium fuel cycle. The relative abundance of the material and aspects of intrinsic proliferation-resistance are potentially significant drivers for its use. The overall commercial incentives for its introduction will be dependent upon the supply and demand drivers of Uranium.[2] Consideration of the use of Thorium for power reactors is ongoing throughout IAEA Member States, most particularly in India and China. However, the technology is not yet internationally considered mature and it represents a Generation IV reactor technology requiring significant development and investment before its economic viability can be established.[3]

2.2 Further aspects for consideration (Other potential strategic options)

Fuel leasing is considered within the Report, however other commercial linkages between specific fuel and spent fuel services could also be considered. These are covered in Section 5.2.

[1] Uranium 2014: Resources, Production and Demand Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency

[2] IAEA-TECDOC-1450 Thorium fuel cycle — Potential benefits and challenges

[3] Technology Roadmap Update for Generation IV Nuclear Energy Systems January 2014 OECD

Regarding Paragraph 14, in the case of direct underground extraction mining as opposed to in-situ leaching (ISL), Mott MacDonald consider that options with regard to uranium mine re-purposing for Intermediate Level Waste (IWL) storage or potentially long term spent fuel storage should be explored.

3 Further Processing and Manufacture Aspects (Paragraphs 23 to 37)

The technology and operational expertise covering Uranium conversion and enrichment is well established internationally and current projections suggest there is over capacity to 2020[4] . These technologies are subject to significant safeguarding and security restrictions, reflecting the challenges associated with proliferation.

3.1 Specific commentary and observations on the report

With reference to Paragraph 34, Mott MacDonald references the potential use of reprocessing as:

I. A method for recycling depleted Uranium and Plutonium for reuse in reactors either as feed stock for enrichment, Rep U enriched or Mixed Oxide fuels.
II. Support for Fast Reactor fuels
III. Recognising the issue of long-term chemical stability of metallic uranium based spent fuel, reprocessing provides a means of conversion to a stable form.
IV. Reprocessing of spent fuel to recover fissile Plutonium will be a core component of most Generation IV power generation systems.

3.2 Further aspects for consideration (Other potential strategic options)

Conceptually, a service offering option for the incorporation of Uranium conversion and enrichment into a fuel leasing arrangement is considered within the Report however this option alone may not create a viable industry. Necessary considerations associated with this option are discussed in Section 5.2.

[4] http://world-nuclear.org/our-association/publications/publications-for-sale/nuclear-fuel-report.aspx

4 Electricity Generation Aspects (Paragraphs 38 to 61)

Based on the energy demand profile between baseload and transient load-following requirements and the opportunity to utilise a mix of power sources, particularly renewables, Mott MacDonald agree with the Royal Commission that large-scale nuclear power generation in South Australia is not viable at present

4.1 Specific commentary and observations on the report

With respect to Paragraph 44, Mott MacDonald supports the view regarding nuclear reactor siting requirements and the access to large water sources needed for secondary cooling.

Mott MacDonald also believe the most significant challenge to development of a nuclear power station is associated with uncertainty regarding technology and design substantiation and consider the approach raised in Paragraph 45 to be prudent.

4.2 Further aspects for consideration (Other potential strategic options)

Due to fuel enrichment and transient design requirements, large-scale power reactors are normally deployed to provide baseload capability. With respect to Paragraph 45a, the use of Small or Medium Reactor (SMR) technology, which has load following capability, could be considered for future needs in South Australia. Although this technology has been deployed for military uses, the regulatory design substantiation and specific technologies have not been substantiated for civil applications. Furthermore, the associated detailed economics have not been demonstrated. Mott MacDonald also supports the position as documented in Paragraph 45b with respect to Fast Reactors and other power sources with innovative designs.

5 Management, Storage and Disposal of Waste Aspects (Paragraphs 62 to 102)

The spent fuel generation rate has been quoted at about 10 500 t HM/year worldwide and is expected to increase[5]. Depending upon the reactor type, fuel is discharged into cooling ponds for short term storage and then, after a period of initial short half-life isotopic decay, transferred to intermediate wet and dry storage interim capability. Less than one-third of the global fuel inventory is reprocessed and about 8 000 t HM/year on average will need to be placed into interim storage facilities.[6] At this time, a number of deep geological disposal facilities are in development for conventional oxide based spent fuels however, as yet, direct disposal of the spent fuel has not taken place. The technology for the geological disposal of non-oxide based spent fuels is immature, primarily due to the need for extensive conditioning prior to disposal.

A number of key factors influence decision making around the offering of 'back end' spent fuel services that Australia could provide. These key factors include the form and condition of the waste, its long term chemical stability and the availability of demonstrable technologies and expertise, which enable safe transport and retention whether this is storage or/and disposal. Recognising the significant time frames associated with the radioactive decay of spent fuel and trans-uranic materials, segregation of this material from the environment will demand the use of resilient and stable geological and mechanical barrier systems. For disposal, these systems will require demonstrable performance over significant time frames in order to be substantiated as a safe option.

Mott MacDonald notes that the key attributes of a robust safety case for a nuclear facility within the IAEA Safety Series framework is the assurance that the base case characterisation data is correct and that the behaviour of the spent fuels and wastes is predictable over extremely long time frames. In assessing the viability of a back end spent fuel and higher activity waste service, consideration should be given as to how much certainty can be given to the characterisation of the received spent fuels and wastes from the varies consignors operating under their own domestic regulatory oversight. To assure the safe storage and/or disposal packages, a potential disposal service offering should include an additional service to assay, sort, condition, and package both fuels and wastes to ensure that the packages meet the disposal facility's radiological and radio-chemical conditions for acceptance. Alternatively, an international regulatory service would be necessary to assure adherence to agreement quality standards commensurate with the facility waste acceptance criteria at point and country of consignment.

Mechanical systems highlighted in Paragraph 75 and Figure 5 of the Report, when used in combination with specific locations within Australia of the appropriate geology and hydrology as listed in Paragraph 78, suggest that potential long term storage or disposal options are feasible. The securing of appropriate political and stakeholder support and certainty of delivery through the development and execution phases are necessary to project success. These are further considered in Section 6.

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[5] IAEA/ Policy/ GC50 Storage and Disposal of Spent Fuel and High Level Radioactive Waste and IAEA-CN-102/60 IAEA Overview of global spent fuel storage

[6] IAEA-CN-102/60 IAEA Overview of global spent fuel storage

5.1 Specific commentary and observations on the report

Mott MacDonald supports the points expressed in Paragraph 62 of the Report.

With respect to Paragraph 63, Mott MacDonald considers that the conceptual approach selected will influence whether technical issues or planning and development issues will require the greatest attention. Mott MacDonald notes that, dependent upon the regulatory regime, while many nuclear developments have achieved concept planning the subsequent effort to achieve engineering substantiation of the safety case for the development has challenged / negated the overall commercial feasibility of the enterprise. In the UK, the search for a valid deep geologic repository over a period of 30 years has collapsed twice from two chains of determinants; firstly due primarily to technical problems with the host rocks and water movement at the selected locations and secondly due to socio-economic and political influences.

Recognising Paragraph 66, consideration could be given to centralised state based higher activity wastes and Low Level Waste (LLW) facilities, evaluated against potential economies of scale and cost reduction against increased transport costs. A balance of judgement would also be required against the security threats of a single State or multiple Federal facilities.

Mott MacDonald support the comments made in Paragraphs 67 to 70. Mott MacDonald notes that the key factor in determining the suitability of the engineered barriers is their long term corrosion behaviour in the postulated storage environment. To illustrate, UK Intermediate Level Wastes (ILW) geologic disposal packages have a target Chloride / Stainless Steel corrosion resistance of 500 years in the facility, specific to the ground water flow. This target date is driven by the decay time of the problematic soluble radioisotopes that may, on package failure, escape the engineered containment. For spent fuels, the predominant packaging method proposed is their encasement in iso-statically pressed, thick walled (100mm) copper canisters backfilled with bentonite. Disposal is then undertaken by emplacement of the engineered copper package in engineered cores within the geologic facility, with further bentonite backfilling to remove water corrosion challenges.

Some fuels discharged from reactors are constituted from metallic Uranium. Please refer to Section 3.1 II. These fuels are problematic as, being metallic, water corrosion results in the evolution of hydrogen. When conditioned in a grout matrix, further corrosion can result in the cracking and swelling of the conditioned monolithic package. However, the use of metallic Uranium is a Generation 1, low burn-up, technology that is being phased out as the Generation 1 plants move into decommissioning. Mott MacDonald considers that it would be prudent to exclude the disposal of such spent metallic fuels from a management framework due to their specific complexities.

5.2 Further aspects for consideration (Other potential strategic options)

Service scheme selection will strongly influence the potential for success in the area of spent fuel and nuclear waste disposal. Fuel leasing as an option for extending nuclear fuel cycle service provision in South Australia is highlighted in the Report. This approach has been recognised as an option within the IAEA[7] and assessments of its potential have been documented in the USA[8]. The fuel leasing option may be considered to include conversion and enrichment capability within South Australia as well as the ability for direct fuel disposal. The feasibility of this option is yet to be determined. An additional consideration to reflect upon is the legal ownership and remediation of leased fuel that 'fails in service' and the subsequent compensation for any operator liability or loss of profit that may arise from the leased fuel failure in the context and framework of the relevant international nuclear liability conventions (Vienna Convention).

Paragraph 82 of the Report makes reference to the international conventions, with respect to spent fuel management,[9] that seek to address the management of spent fuel domestically, avoiding international transport of such material. Alternatives to this will require international transport of such material and application of protocols for transboundary movements[10]. Although a number of accepted precedents exist for spent fuel transport, these are not on the basis of disposal, but for spent fuel services (i.e. reprocessing). Therefore, options which may be worthy of consideration are packaged services which involve uranium sales and a 'long term spent fuel storage/retrieval leasing concept'.

Mott MacDonald notes that the Report tends to consider spent nuclear fuel and nuclear wastes in the same category. In reality, the technical challenges associated with the safe management of spent nuclear fuel and ILW, are different. The reason for this is that the physical arrangement and the radio-isotopic assay of reactor discharged, pool cooled spent oxide fuel is generally known, whilst the physical arrangement, chemical properties and corrosion behaviour of secondary nuclear wastes may be unknown. Safety substantiation of long term storage or disposal demands that waste material and aspects of the mechanical barrier system meets the specifications used to substantiate the storage/disposal facility. This demands that international agreements will need to be established for consigned materials and their packages at an international level (refer to the further considerations listed in Section 7).

Paragraph 86 suggests possible revenues (charges) associated with the disposal of spent fuel and nuclear wastes. Mott MacDonald note that these are not recommended charges. In the UK, the Nuclear Decommissioning Authority (NDA) who hold the accountability for the development of the geologic repository via its subsidiary RWMD, assessed in 2011 that the disposal costs per canister of spent oxide fuel was around £400K GBP and around £10K GBP per cubic meter of conditioned ILW (undiscounted). These costs excluded all regulatory oversight, transport, receipt, package provision, conditioning, packaging processing, management and operations and must be considered optimistic. The report

[7] IAEA GOV/2008/22-GC(52)/INF/4

[8] Nuclear Fuel Leasing, Recycling, and Proliferation: Modeling a Global View Victor H. Reis, Matthew P. Crozat, Jor-Shan Choi, Robert Hillation Nuclear Technology Volume 150/Number 2/May 2005/Pages 121-131 American Nuclear Society

[9] The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management INFCIRC/546 24 December 1997

[10] Article 1(3) of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989)

highlights that the cost of the copper cask alone would double the spent fuel disposal costs. On this basis, and given the likely need for further conditioning to be necessary upon receipt, Mott MacDonald considers that the suggested charge costs at this level may be too low.[11]

[11] NDA Technical Note 165110061

6 Social and Community Content and Land, Heritage and Respecting Rights (Paragraphs 103 to 115)

Mott MacDonald notes the content of this section of the report. Critical to any development in nuclear cycle services will be gaining a ‘social licence’ which provides the appropriate overall political, public and social support for expansion. The overall socio-economic benefit delivered from and justification for a project will form a key part of any proposal. The following key aspects may be worthy of consideration:

I. Establishing domestic nuclear generating capacity will reduce reliance on fossil fuels and enable reduction in CO_2 emissions and other aerial pollution, maintain security of supply, and utilises Uranium which is an abundant source of fuel within Australia.
II. Expansion of nuclear fuel services will promote economic development and employment and capability building in engineering, manufacturing and construction in addition to potentially attracting international investment. South Australian companies have significant capabilities in manufacture and site installation and could provide a significant proportion of the delivery capability.
III. Much of the raw materials for building and development can be sourced from with Australian promoting further growth in the mining and material processing sectors.

Development of nuclear fuel cycle services will demand the support of R&D programs which could provide South Australian industry with further opportunities to sell goods and services worldwide.

7 Uncertainty and risk, opportunities and challenges (Paragraphs 116 to 132)

Mott MacDonald, with reference to Paragraphs 116 to 135, considers that additional areas for consideration not expressly covered in the Report are as follows:

I. Achieving international agreements associated with spent fuel ownership and nuclear indemnity reflecting existing international conventions.
II. Implementation of robust and effective regulatory environment, reflecting Federal and State requirements within desired timescales
III. Establishing internationally acceptable agreements around waste acceptance criteria and packaging requirements as bounded by the site specific safety case.
IV. Establishing scope of waste treatment requirements in order to achieve waste acceptance into a long term retrieval storage or disposal facility.
V. The establishment of an acceptable safety case for disposal within the regulatory regime established.
VI. Establishing the operating model for a nuclear operator and the appropriate level of Federal and State control.

8 Transport (Paragraphs 133 to 138)

Nuclear fuel cycle services are totally dependent on secure transport routes and supporting nuclear transport capability. Land and marine spent fuel transport capability is well established internationally and utilises specialist vessels, dedicated marine terminals, secure heavy rail links and licensed spent fuel flasks and handling systems. Extension of fuel cycle services into spent fuel management through fuel leasing or other arrangements would require the technology and infrastructure listed. The technology is, however, proven and exists in a number of countries. International transport of High Level Waste (HLW) and ILW is less well established in terms of economic factors and is likely to require investment in international transport packaging and security envelops whilst providing for economic material movements.

9 Licensing and regulation (Paragraphs 139 to 132)

Any proposed extension to nuclear fuel services, which includes international spent fuel of other nuclear waste receipts into Australia, will need to recognise transboundary conventions. This would require a regulatory framework which encompasses both Federal and State requirements. With regard to the complex stakeholder engagement and technology assessment required, Mott MacDonald would recommend the use of best practice program methodology, reflecting on the principles outlined IAEA guidelines associated with Nuclear Infrastructure Development[12].

[12] NG-G-3.1 Milestones in the Development of a National Infrastructure for Nuclear Power and NG-T-3.6 Responsibilities and Capabilities of a Nuclear Energy Program Implementing Organization.