The Potential for a Regional Uranium Enrichment Centre in Australia

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Australia has the world's largest uranium reserves—one third of the world total[1]—and is part of the Asia-Pacific region, the region of largest growth in nuclear power utilisation. Accordingly, Australia seems well placed to become a major supplier of uranium enrichment services in the future. This is not simply a commercial issue, but could help advance non-proliferation objectives. Uranium enrichment is a dual-use technology—a country with a national enrichment program has the potential to use this for producing nuclear weapons. Increasing awareness of this proliferation risk has prompted efforts to develop a new international framework for nuclear energy, emphasising international cooperation as an alternative to national fuel cycle programs. A multilaterally-based enrichment centre in Australia, with regional participation, could obviate further national enrichment programs in the region and would be a significant step towards establishing multilateral approaches to the nuclear fuel cycle as a global norm.

Background: Uranium Enrichment Activities in Australia

The former Australian Atomic Energy Commission (AAEC—the predecessor to the Australian Nuclear Science and Technology Organisation, ANSTO) operated a centrifuge uranium enrichment research and development (R&D) program from the mid-1960s to the mid-1980s. On the basis of this work, Australia was one of the participants in the Hexapartite Safeguards Project which developed International Atomic Energy Agency (IAEA) safeguards arrangements for centrifuge enrichment facilities.[2] The AAEC's centrifuge work was terminated following the election of the Hawke Labor Government in 1983. The AAEC and later ANSTO also conducted a small laser enrichment R&D program, which was closed in the early 1990s.

[1] Australia has 33 per cent of the world's reasonably assured uranium resources recoverable at less than USD $130/kg—'Australia's Uranium Resources', Department of Resources, Energy and Tourism, June 2012, <http://www.ret.gov.au/resources/Documents/Mining/uranium/Uranium-Industry-factsheet.pdf> [Accessed 7 November 2013].

[2] The Hexapartite parties were United States, United Kingdom, Germany, Netherlands, Japan and Australia.

In the 1970s a private sector consortium, UEGA (Uranium Enrichment Group of Australia)[3] was formed to study the possibility of commercial uranium enrichment in Australia. The AAEC was involved as technical adviser. UEGA looked at a number of technologies, and settled on URENCO centrifuge technology.[4] However, the commercial terms offered by URENCO at that time were not favourable, and when the incoming Hawke Government announced it would withdraw government support, UEGA terminated the project.

As part of the UEGA project, and also as a separate activity associated with the South Australian Government, the prospect of uranium conversion[5] in Australia was also studied in the 1970s. The study concluded that uranium conversion would be viable only if associated with an enrichment project.

In 1992 a private sector company, Silex Systems Ltd, commenced R&D into a new laser enrichment process, named SILEX. This work was conducted in laboratories leased from ANSTO at Lucas Heights, but was otherwise independent of ANSTO. In May 2006 Silex Systems and General Electric (GE) announced agreement on the sale of an exclusive licence for the SILEX technology to GE and the further development of the technology in the United States. Under the terms of this agreement the SILEX uranium enrichment process will not be developed further in Australia.

Prospects for Uranium Enrichment in Australia: Relevant Considerations

The main factors influencing whether uranium enrichment is established in Australia in the future are as follows:

Domestic politics—unless both the major political parties (the Coalition and Labor) support a nuclear industry in Australia, no investor will be prepared to commit the substantial funds needed for uranium enrichment, or any other nuclear activity. In view of the costs and the long lead-times for a nuclear facility, support of only one of the major parties would not be sufficient to provide the necessary business confidence. Labor has held an anti-nuclear position since the 1980s, permitting only nuclear research and uranium mining (until 2007 Labor opposed any new uranium mines)—essentially, establishment of a commercial nuclear facility would require a change in Labor policy.

Historically the Coalition has supported nuclear power and other nuclear industry activities in Australia. A Coalition Government studied building a

[3] Uranium Enrichment Group of Australia (UEGA) comprised BHP, CSR, Peko-Wallsend and WMC.
[4] URENCO is a United Kingdom/Germany/Netherlands consortium.
[5] Conversion is the process of producing the feed material for uranium enrichment, uranium hexafluoride (UF_6).

power reactor at Jervis Bay (on the coast east of Canberra) in the 1960s, and the UEGA enrichment study proceeded during a Coalition Government in the 1970s and early 1980s. The Howard Government established the 2006 Uranium Mining, Processing and Nuclear Energy Review (UMPNER—see below). The Industry Minister in the recently-elected Coalition Government, Ian Macfarlane, is reported as saying "the government has no plans to introduce nuclear power in Australia" and, underscoring the discussion in the previous paragraph, "nuclear power will not be introduced in Australia without bipartisan political support and widespread community support."[6]

Today nuclear power—and by association, uranium enrichment?—is generally considered to have insufficient public support in Australia. Pressure for change on nuclear power may come from increasing public concern about greenhouse gas emissions and climate change—Australia is one of the world's highest carbon emitters per capita,[7] and some 77 per cent of electricity generation is coal-fired.[8] It is conventional wisdom that the Fukushima accidents have negated possible Australian public support for nuclear power as part of carbon reduction efforts. However, if governments (of either persuasion) are serious about carbon reductions, it will not be realistic to exclude nuclear power from the energy mix. As regards enrichment, nuclear power in our region is growing in spite of Fukushima. While domestic nuclear power could provide base demand for an Australian enrichment project this is not essential, the project could be wholly export-oriented.

Availability of technology—Australia is an enrichment technology holder, through the centrifuge technology developed by the AAEC in the 1960s-1980s. It is not likely however that the AAEC technology could be revived and developed to commercial viability in any reasonable time frame. Australia's other indigenous enrichment technology, the SILEX laser process, has been sold for further development in the United States. Accordingly, any company wishing to pursue uranium enrichment in Australia would have to import suitable technology—this would require agreement of both the technology holder and the technology holder's government.

[6] Peter Hannam, 'Race Against Time: Scientists Push for Energy Switch', The Sydney Morning Herald, 4 November 2013, <http://www.smh.com.au/environment/climate-change/race-against-time-scientists-push-for-energy-switch-20131104-2wxdh.html> [Accessed 19 November 2013].
[7] Australia's carbon dioxide emissions were 16.9 tonnes per capita in 2010, second only to the United States amongst major developed economies—'CO2 Emissions (Metric Tonnes per Capita)', World Bank, 2013, <http://data.worldbank.org/indicator/EN.ATM.CO2E.PC> [Accessed 7 November 2013].
[8] Australian Coal Association, 2013, <http://www.australiancoal.com.au/energy.html> [Accessed 7 November 2013].

Commercial factors—any enrichment project in Australia would be conducted as a commercial, not government, activity. Accordingly any project would require investors with access to the substantial capital sums required. Investors would have to be satisfied about issues such as political risk (i.e. stability of government policy) and rate of return. The possibility of enrichment in Australia was considered by the 2006 UMPNER Review. The Review noted the significant value-adding potential of enrichment in Australia, but considered that high commercial and technology barriers could make market entry difficult. Ultimately the commercial viability of an enrichment project would be a matter for determination by the companies involved.

International issues—although enrichment for power reactor fuel would be a commercial venture, establishing an enrichment capability could have major strategic implications. The Iranian enrichment program in particular has focused attention on the proliferation potential of national enrichment programs. This issue of 'nuclear latency' is very much in the background in the protracted negotiations for the renewal of the US/Republic of Korea (ROK) nuclear cooperation agreement, where the ROK is seeking consent to undertake enrichment and reprocessing.

An enrichment project in Australia (as in other countries) would have to meet Nuclear Suppliers Group (NSG) guidelines for the transfer of enrichment technology. In 2011 the NSG issued guidelines on the transfer of sensitive nuclear technology. These include encouragement of supplier involvement and/or other appropriate multinational participation in enrichment and reprocessing facilities as an alternative to national plants, and supply of technology on a 'black box' basis (see below).

More important than meeting particular technology transfer requirements, the long term strategic implications of an Australian enrichment program would have to be considered. Although Australia is one of the non-proliferation regime's leading supporters, there is no doubt that other governments would consider the possibility that Australia's position could change over the longer term—not that Australia is in any way suspect, this would be a consideration about any country proposing a national enrichment program. This could lead other countries to seek a matching capability for strategic reasons—clearly an undesirable outcome from the non-proliferation perspective.

New national enrichment programs would be a set-back to international efforts to develop multilateral approaches as an alternative to national projects in proliferation-sensitive nuclear areas. This should be a serious consideration for any country contemplating a new enrichment program.

A Multilateral Approach to Enrichment

The concept of international or multination operation of sensitive nuclear facilities goes all the way back to the 1946 Baruch Plan. The concept was examined in the 1980 International Nuclear Fuel Cycle Evaluation (INFCE) report. Australia's commercial centrifuge enrichment proposal of the 1970s was envisaged as a regional project, with the possible involvement of Japan and others—a concept consistent with the INFCE recommendations. International fuel cycle centres are an important component of the Global Nuclear Infrastructure Initiative proposed by President Putin in 2006, and Russia established the first such centre in 2007, at Angarsk. The idea of international fuel cycle centres, with multination participation, was specifically endorsed by the G8[9] at the 2006 St Petersburg Summit. Subsequent G8 Summits have reiterated support for multilateral approaches to the nuclear fuel cycle.

Currently, the principal measures to address the proliferation risk posed by uranium enrichment are: to try to minimise the number of national enrichment programs; and to avoid technology transfer.

Minimising the number of national programs—any legitimate need for countries to consider establishing their own enrichment programs can be obviated by long-term fuel supply assurances/guarantees provided by existing enrichers and fuel suppliers. The form of such assurances is being studied in the International Framework for Nuclear Energy Cooperation (IFNEC)[10] as well as by several governments and others. Supply assurances can be made more tangible and strengthened if the recipient is able to participate in the enrichment venture. In addition to supply assurances, participation can also provide equity benefits, e.g. through profit-sharing.

A historic example of a multilateral enrichment venture is Eurodif.[11] Eurodif is a commercial entity under French law. There was a protracted legal dispute between France and Iran over Eurodif supply issues—Iran uses this dispute to claim that supply assurances cannot be relied on.[12]

The contemporary example of a multilateral enrichment venture is the International Uranium Enrichment Centre (IUEC) at Angarsk.[13] In contrast to Eurodif, participation in the IUEC is based on government-to-government agreements, hence the conditions of participation have the force of

[9] Group of 8—Canada, France, Germany, Italy, Japan, Russia, United Kingdom and United States.
[10] The International Framework for Nuclear Energy Cooperation (IFNEC) is the successor to the Global Nuclear Energy Partnership (GNEP).
[11] In addition to France, the parties in Eurodif are Belgium, Italy, Spain and Iran.
[12] In fact the dispute arose initially because Iran refused to take scheduled product deliveries.
[13] In addition to Russia, participants in the Angarsk International Uranium Enrichment Centre are Kazakhstan, Ukraine and Armenia, and Mongolia is joining.

international law. The supply assurance aspects of IUEC are further strengthened through IAEA involvement—supply cannot be refused to a participant which the IAEA determines is meeting its safeguards obligations. Mention should also be made of URENCO, which has some multilateral attributes.[14] URENCO does not offer participation to enrichment customers.

Supply of technology only on a 'black box' basis—under black box arrangements, technology is not transferred, but is limited to the technology holder. Recipients of enrichment equipment have no access to classified aspects of the technology—manufacturing, installation and maintenance are carried out by the technology holder. This is the established practice of URENCO, which is supplying centrifuge installations to France and the United States on a black box basis, and also of Tenex,[15] which has supplied centrifuge installations to China.

It is noted that to date technology supply by URENCO and Tenex has been limited to nuclear-weapon states (France, United States, China), where 'horizontal' proliferation (i.e. acquisition of nuclear weapons by those states) is not an issue.[16] In future, however, supply to non-nuclear-weapon states will also need to be considered. Russia's Global Nuclear Infrastructure Initiative envisages that international fuel cycle centres may be established in a number of countries. Customer countries' confidence in supply assurances may be stronger where international centres are located outside the major powers.

Non-proliferation Principles for Enrichment Centres

Drawing on the above discussion, the author suggests the following principles for minimising proliferation risks from uranium enrichment projects:

- enrichment centres should be established only in countries with strong non-proliferation credentials—in the case of non-nuclear-weapon states, they should be fully cooperating with IAEA safeguards under an additional protocol as well as a comprehensive safeguards agreement, and there should be no proliferation concerns;

- technology should be supplied only on a black box basis, so the host country has no access to sensitive aspects of the technology.

[14] URENCO is based on the Treaty of Almelo, between the United Kingdom, Germany and the Netherlands.
[15] Tenex is the abbreviation of Tekhsnabexport, the Russian enrichment operator.
[16] Currently proliferation is usually thought of in 'horizontal' terms, i.e. acquisition of nuclear weapons by further states. In the future, if substantial progress is made with nuclear disarmament, vertical proliferation will also be an important concern—so a black box approach for technology transfers to nuclear-weapon states, which may have been adopted more for commercial reasons, is also important on non-proliferation grounds.

Manufacturing, installation and maintenance would be undertaken by the technology holder;

- the technology holder should be involved in the operation of the facility, to ensure it is not misused and to ensure the host country does not acquire sensitive technology or know-how;

- customer countries can participate in the centre: as part of the supply assurance arrangements; as part of the commercial arrangements (e.g. share-holding/profit sharing); and for building confidence that the facility is not misused by the host country. Arrangements will need to be developed so participants have access to material accountancy aspects of the facility sufficient to satisfy themselves that the facility is being operated as declared, but without any possibility of accessing technology and know-how;

- in addition to its safeguards functions, the IAEA might have a broader oversight role, e.g. ensuring that any decision to suspend supply to a particular country on safeguards grounds is made impartially.

A Multilateral Enrichment Centre in Australia?

One could imagine a future enrichment centre in Australia, based on URENCO or Tenex centrifuge technology supplied on a black box basis. In addition to the technology holder, there would be participation by regional countries with nuclear power programs—Japan, ROK and China, and looking ahead, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. The IAEA might also be involved in an oversight role (in addition to safeguards).

There would be no technology transfer to Australia or the other participants—thus avoiding potential proliferation risk—and regional countries would have assured supply of low enriched uranium (LEU) product, thus removing any reason they might have to develop their own enrichment capability.[17]

In addition to supply assurances, the participants would have the opportunity to invest in the centre and obtain commensurate profit-sharing. The centre would be covered by treaty-level agreements amongst the participants, guaranteeing the peaceful status of the facility and setting out the supply assurances. Perhaps the centre could be part of broader arrangements for

[17] Noting of course that Japan and China already have enrichment programs.

an Asia-Pacific nuclear energy community ('Asiatom'?)—a discussion that goes beyond this comment.[18]

At this stage the potential capacity of such a centre is speculative. Centrifuge enrichment plants are modular—the centre could start at a relatively modest size (say 500,000 SWU[19]) and expand as markets are established. In round numbers, a facility of the present size of Angarsk (2.6 million SWU) would produce around 500 tonnes of low enriched uranium a year, sufficient to fuel twenty-five 1,000 MWe[20] reactors. The feed would be around 4,500 tonnes of uranium, half Australia's current capacity and perhaps a fifth of Australia's uranium production in 2025. To put the figure of twenty-five reactors into context—by 2025 China could have seventy reactors, the ROK thirty-two, and South East Asia between six and seventeen.[21] Japan has fifty reactors which currently[22] remain shut down post-Fukushima. It is not clear how many reactors Japan may have in operation in 2025. Leaving aside what Australia's own requirements might be by then, it is clear that the Asian market could accommodate an enrichment capacity in Australia considerably larger than the current Angarsk facility.

There would be many specific issues for Australia to consider, including: the form of the product to be exported (enriched uranium hexafluoride only, or complete fuel assemblies where practicable?); whether supply to a particular country could be suspended for serious safety and security issues as well as safeguards concerns; and whether customer countries might seek to persuade Australia to accept spent fuel. On the latter point, spent fuel take-back was part of the former Global Nuclear Energy Partnership (GNEP) concept, but this was on the basis that suppliers offering take-back would be in a position to recycle spent fuel in advanced reactors—clearly not Australia's situation.

Conclusion

Establishment of an enrichment centre in Australia would require government support—both at the Commonwealth level and also by a State or Territory willing to host the facility—as well as companies prepared to

[18] See for example J. Carlson, 'An Asia-Pacific Nuclear Energy Community', APLN/CNND Policy Brief No. 4, June 2013, <http://cnnd.anu.edu.au/files/2013/policy-briefs/Policy_Brief_No._4_-_An_Asia-Pacific_Nuclear_Energy_Community.pdf> [Accessed 8 November 2013].
[19] Separative Work Units.
[20] Megawatts (electrical).
[21] Currently China has eighteen reactors in operation and thirty under construction. ROK has twenty-three in operation and five under construction—IAEA Power Reactor Information System, 31 October 2013; 'World Nuclear Power Reactors & Uranium Requirements', World Nuclear Association, 1 October 2013, <http://www.world-nuclear.org/info/Facts-and-Figures/World-Nuclear-Power-Reactors-and-Uranium-Requirements/> [Accessed 8 November 2013].
[22] November 2013.

make the necessary investment. It would also require an expansion of Australia's nuclear regulatory arrangements (including amendment of legislation). The case for government support is that the centre would have a major non-proliferation benefit, forestalling the development of further national enrichment capabilities by others in the region and helping to establish the multilateral norm. It is to be hoped that the Commonwealth and State/Territory governments, together with industry, would be prepared to seriously consider such a project on its merits.

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