

Questions and Answers

Nuclear Energy Agency - IFNEC Joint Webinar - *Strategies and Considerations for the Back-End of the Fuel Cycle* February 24, 2021

#	Question	Asker Name	Answer(s)/[Answered by]
1	Recent news stories indicate that the South African back-end fund is little more than an accounting entry in a government that is financially distressed. How is this different from the US nuclear waste fund?	Edward Kee	[William McCaughey] The Expert Group on Back-end Strategies did not research or analyze South Africa's back-end strategy or its nuclear waste fund. We are not now tracking the recent developments.
2	Why do you leave out disposal in the Multi Recycle which is misleading because it sounds like there is never any waste at all and that is not true nor honest? There will always be some waste, TRU, HLW etc. This gives politicians a false impression that they do not need to address the social problem of siting and building a disposal capability. Very unhelpful and scientifically false.	Lake Barrett	[William McCaughey] Section 2.1 of the report points out that deep geologic disposal is required for all three fuel cycle options. This point is repeated in the conclusions in Section 5.2. "All fuel cycle options require deep geologic disposal and none of those are operating anywhere in the world."
2 bis	Do you not want to address this question? Why? Embarrassing to all that you are doing to get money for Orano and others and avoiding the real Back End problem of social-political acceptance in Democracies.	Lake Barrett	
3	William, on slide 5, with multi-recycling, assuming you do have enhanced recycling for minor actinides, do you anticipate requiring a deep geological repository?	Nicholas McMurray	[Answered during session] With all fuel cycle options you have fission products and at least trace amounts of uranium and transuranics, so you always need a geologic repository. However, the size and design of the repository may be affected by the fuel cycle.
4	Why is Germany not part of the group?	Markus Vester	[Hiroyuki Goto (NEA secretariat)] The members of the expert group were nominated and sent from the NEA member countries that had interests in and could cooperate with this activity.

5	By proliferation do you mean safeguards, including the challenges of safeguards approaches at the back-end - not just about diversion?	Lawrence Johnson	[William McCaughey] Proliferation is discussed in Section 2.2.3, R.1, of the report. It refers to the IAEA definition: "...the diversion or undeclared production of nuclear material or misuse of technology by states in order to acquire nuclear weapons or other nuclear explosive devices." Security is discussed in Section 2.2.3, R.2. It refers to the IAEA definition of physical protection which includes theft and sabotage.
6	You say there aren't discriminators among the options. What about cost?	Steve Nesbit	[Brent Dixon] Costs of the fuel cycles are projected to be similar, with higher front-end costs for open-cycle versus higher back-end costs for multi-recycle. There is more cost uncertainty for multi-recycle, as the parts have been demonstrated but the fuel cycle has not been implemented. There also remains uncertainty about HLW disposal costs for all fuel cycles, as operation of a geologic repository for HLW has not been implemented. In general, open-cycle has lower near-term costs and existing facilities in many countries, but results in longer-lasting waste hazards where uncertainty increases with time. Mono- and multi-recycle have higher near-term costs but lower long-term waste uncertainties. Multi-recycle, once established, has minimal front-end cost risk due to changes in uranium and enrichment prices. Mono-recycle needs the fuel cycle facilities of both open-cycle and multi-recycle, but at smaller scales.
7	If SMRs become a popular choice of reactor types (especially for newcomers) how might this affect back end choices?	Charles McCombie	[Brent Dixon] SMRs include smaller versions of the light water reactors used in the open-cycle and mono-recycle, as well as fast reactors that could be used in multi-recycle. The main impacts on fuel cycle choices are a) if they result in more growth of nuclear energy, which could make the reduced resource needs provided by recycle more attractive and b) if they impact cost differences between thermal and fast reactors, where thermal reactors are used in open- and mono-recycle and fast reactors in

			multi-recycle. Note that some SMRs may also advance the potential for multi-recycle in a thorium-based fuel cycle.
8	How did you quantify the benefit of separating and transmuting actinides? If all cycles require a repository, you can simply throw the actinides away in the multi-recycle repository and save lots of money.	Steve Nesbit	[Brent Dixon] I assume your question is referring to the minor actinides (MA) neptunium, americium and curium, as multi-recycle uses uranium to produce and consume plutonium. This remains an area of investigation, where the added cost of MA recycle may or may not be offset by waste management benefits. Variables include the approach to transmutation, repository geology, etc.
9	I am surprised to see that the risk for proliferation is not considered as a discriminator. Certainly one can find acceptable solutions but the degree of difficulty will not be the same	Gian Luigi FIORINI	[William McCaughey] The expert group discussed proliferation issue as one of potential differentiating characteristics and concluded that given the relative attractiveness of materials handled in each fuel cycle option and the effectiveness of the safeguards approached applied accordingly, the differences in terms of proliferation risk are not very significant among three fuel cycle options. (See pages 28-29 of the report for details.)
10	Why is disposal not listed as a risk on slide 9 point 5.3? This implies there is no waste in multi-cycle and no need for addressing disposal challenges. Misleading and false wishful thinking for spending money on this option. Good technology, terrible to hide problem. A great disservice to moving forward on BE fuel cycle by pretending there are no waste problems. False nuclear promises, such as in the 1950s. Just self serving money grab for advanced technology	Lake Barrett	Addressed in answer to question #2
11	Q for M. Verhoef : Do you know why some countries are not participating to ERDO WG ?"	Jerome Van der werf	[Answered during session] It is difficult to speak for other countries; for the Netherlands it is way to execute the dual track policy (considering a national and multi-national repository) of the Netherlands. The association will invite more countries in Europe to participate.

12	Regarding ERDO, multinational repository solution in the area of Europe. Is it according to EU acceptable?	Jari Makkonen	[Answered during session] A multinational repository in Europe is possible according to the 2011/70/Euratom directive.
13	Does the International Atomic Energy Agency (IAEA) have interest in Geologic Disposal Facilities (GDF) being planned in some Nuclear Weapon States, particularly those with complex inventories?	Lawrence Johnson	[Jeremy Whitlock] The International Atomic Energy Agency (IAEA) is always open to learning from technical expertise shared by Member States, including the specialized experience of Nuclear Weapons State (NWS). To clarify, my presentation addressed safeguards applied in a Non-Nuclear Weapons State (NNWS) under a comprehensive safeguards agreement (CSA) with the IAEA, as noted on slides 2, 3, and 4. In a NWS (USA, UK, France, Russia, China) these back-end facilities would not generally be under Agency safeguards, as the NWS itself would not be under a Comprehensive Safeguards Agreement (CSA) with the IAEA. Rather, under a Voluntary Offer Agreement (VOA) with the IAEA, the NWS may choose to make specific facilities available to the IAEA for the application of safeguards, for various reasons including the enhancement of IAEA knowledge. In general, a GDF that does contain radioactive waste with no “Nuclear Material” content as defined by the IAEA (essentially, uranium, plutonium or thorium) would not be subject to safeguards, under a CSA or a VOA. For more information on types of safeguards agreements, see www.iaea.org/topics/safeguards-agreements .
14	Can there be cases where Spent Nuclear Fuel (SNF) is reprocessed and conditioned, resulting in safeguards being terminated on the material, before being disposed of underground? If so, would there still be safeguards reporting related to the Additional Protocol (AP) at High-Level Waste (HLW) Deep Geologic Repositories (DGRs)?	Cindy Vestergaard	[Jeremy Whitlock] It is unlikely that conditioned Spent Nuclear Fuel (SNF) waste would meet the requirements for termination of safeguards, due to the concentration and accessibility of fissionable nuclear material. However, in general yes, Additional Protocol (AP) measures could potentially be applied to terminated nuclear material. For background, an Additional Protocol (in force in 136 countries as of December 2020) is an additional agreement with a country that provides the IAEA with

			a fuller picture of the country's nuclear activities (particularly Non-Nuclear Weapons States under comprehensive safeguards). This is enabled through strengthened measures such as broader access for the IAEA to information about the country's nuclear program, increased physical access by the IAEA, and improved administrative arrangements. For more information about the Additional Protocol, see www.iaea.org/topics/additional-protocol .
15	Burning the fissile material in reactors would eliminate it, so should it be a better option than permanent disposal?	George Xu	[Answered during session] With all fuel cycles you have fission products and at least trace amounts of uranium and transuranics, so you always need a geologic repository. However, the size and design of the repository may be affected by the fuel cycle.
16	You state that underground environments are harsh for instrumentation. Isn't this contingent upon the underground media. While it is true for salt, is it true for granite? It seems a blanket statement on this is not fully accurate.	Eric Knox	[Answered during session] Very true - some underground conditions are harsher than others. Even in granite repositories however there is dust, vibration, and large movement of vehicles and machinery.
17	It is also accessibility for care/maintenance for any Safeguards equipment underground	Lawrence Johnson	[Answered during session] Agreed.
18	Will the safeguards approach at the more advanced Geologic Disposal Facilities (GDFs) be shared for example with the ESARDA Final Disposal WG?	Lawrence Johnson	[Jeremy Whitlock] The general concepts behind the IAEA's approach to safeguarding geologic repositories can certainly be shared as they evolve, perhaps at a slightly more detailed level than I presented in the IFNEC webinar. However, the details of a safeguards approach for any specific nuclear facility, including a geologic repository or encapsulation plant, would not be shared as this is confidential information, including implementation arrangements between the host country and the IAEA.

19	Q to Cecile: What is MOX-2 fuel?	哲生 深澤	[Cécile Evans] MOX2 fuel corresponds to fuel technology that would allow multiple recycling of plutonium in LWRs. There is an ongoing R&D programme in France to evaluate the technical economic feasibility of such a fuel cycle option while maintaining the perspective of the potential deployment of Fast neutron reactors.
20	For Sophie: How was the Belgian 2110 disposal date set - the SF will be cooled well before that!	Charles McCombie	[Sophie Pedoux] The date is estimated by our RWMO, Niras-Ondraf. The GDF will be used for medium-level waste, HLW, SNF. The operations will be sequential in the reference scenario, that is why the date for SNF and HLW disposal is after we finished all disposal of medium-level-waste and is "later" than usual cool down delays.
21	I guess the recycling option is limited to those States that are currently reprocessing, proliferation concerns of separated Pu May be additional obstacles?	Eva Gyane	[Answered during session] There are additional and significant safeguards requirements for reprocessing facilities in a NNWS (e.g. Japan), but I would not say this is a limiting obstacle, compared to the economics of the step as a whole. [Cécile Evans] In addition to the above, recycling services have been, are and can be provided from existing recycling infrastructures for other countries, this is an example of sharing existing infrastructures.
22	For the GenIV reactors, what is the general R&D carried out for the safeguards measures? Or are there resources that we can reach out to have more information?	Ozge Ozkan	[Answered during session] GIF has a crosscutting Proliferation Resistance & Physical Protection (PRPP) Working Group that developed a methodology for assessing this.
23	Anyone know how the hydrogen electrolyser test is going at the Idaho Lab with the Fuel Cell Energy technology?	Colin Wales	[Hiroyuki Goto (NEA secretariat)] It is not the scope of Expert group BEST. Please contact the INL.
24	With the potential diverse set of ATF coming to market (FeCrAl, coated clad, pellet mods), has the impact of these been accounted for on open,	Sven Bader	[Brent Dixon] Coated clad concepts should have minimal impact. Different fuel meat chemical forms may require additional technology development to address recycle and could also impact performance in a repository if direct-disposed. There are

	mono, and multi-recycles? Can ATF all be recycled? How do they impact disposal? etc.		no obvious technical show-stoppers to recycle of the ATF concepts.
25	Why such an emphasis on financial costs and not life-cycle analysis of the three options?	Paul Carbol (JRC)	<p>[Brent Dixon] Some life-cycle analyses of fuel cycle facilities have been performed based on a range of assumptions about deployment scenarios (to address economies of scale), future yellowcake and enrichment costs, etc.. Significant uncertainty remains on changes to disposal life-cycle costs.</p> <p>[Cécile Evans] This is an area which needs further attention and development as it would allow to integrate socio political consideration and also contribute to gaining of public support. Such consideration would most probably be included in the subsequent work to be launched by NDC on the analysis of the benefits of the recycling options.</p>
26	I am stella from Ghana. Ghana's has already establish its operating organizations. Been at the early phase of it phase 2 what will be the recommendation on the backend stage at this state of our program. Do we need need to start locating a site for our geological disposal. what will be the recomendation at this stage	Stella Ntiwaah	<p>[William McCaughey]</p> <p>The expert group found there is no “one-size-fits-all” strategy for all country. Every country that is developing a nuclear program has to decide its back-end strategy at some point in future. There are many aspects to consider and the expert group report will provide guidance for these countries. See especially Section 4.3.3 and Section 5.4.</p>
27	what method will be recommended, the open or mono recycle for a new comer country,	Stella Ntiwaah	<p>[Answered during session] All fuel cycles have pluses and minuses and each country needs to consider their specific circumstances. The open-cycle requires the least facilities and technologies, while mono-recycle requires additional facilities for recycle but reduces uranium needs and high-level waste volumes.</p> <p>[Cécile Evans] Possibility to use already existing infrastructure for recycling is also one important component to consider, as implementing a mono-recycling strategy does not require that each country develops its own infrastructure; such schemes have been implemented for 40 years</p>

28	Am and Np are currently subject to voluntary safeguards reporting - would an increase in the quantities being separated increase the consideration of being formal Nuclear Material (NM)?	Lawrence Johnson	[Jeremy Whitlock] A significant increase in the quantity and frequency of separated Am and Np being either exported to, or created within, Non-Nuclear Weapons States (NNWS) would conceivably be cause for the IAEA Board of Governors to consider an amendment to the IAEA Statute that adds them to the definition of Nuclear Material (NM).
29	The overview of the BEST report specified LWRs for the open cycle option and incorporation of fast reactors for multi-recycle. Was the potential incorporation of other non-fast Generation IV/advanced reactors considered?	Rowen Price	[Brent Dixon] Other options were discussed. The objective of the report was to provide a simplified “understandable” picture of fuel cycle options for a less technical audience, and inclusion of too many variations was contrary to this objective. The main features of the three fuel cycles discussed do not change significantly with other reactor options. The most significant difference technically would be a thorium-based multi-recycle system, but it would have many performance features similar to the multi-recycle system described, including: <ul style="list-style-type: none"> • The need for a different reactor instead of LWRs • Similar reductions in resource requirements • Similar waste benefits • Similar financial uncertainties • Similar levels of safeguards and security issues
30	Q to Sophie: Myrrha needs P&T which will generate secondary wastes. Is it difficult to minimize the waste?	哲生 深澤	[Answered during session] By minimization of the waste, we are referring to the minimization of HLW, which are the most component in the public perception. The minimization is in terms of radioactivity that needs to be disposed of in GDF, but it could lead to an actual increase of volume in the medium and low level wastes.
31	Question to Ms Evans: France is using both MOX fuel and UO2 fuel now. What about their costs? Which is cheaper? Could reprocessing reduce the	Jinfeng Li	[Cécile Evans] Only comparing cost of MOX fuel and UO2 fuel will not account for benefits of reprocessing which spares storage capacity, conditions HLW in an engineered, durable glass matrix alleviating constraints for its predisposal management and

	costs of producing electricity in nuclear power plants?		geologic disposal facility design and operation, and reduces the use of natural uranium resource. The overall fuel cycle cost including those of the back end, up to the disposal of ultimate waste have to be considered and integrated in the cost of electricity. Reprocessing/recycling is the retained option of several countries with large nuclear programs as well as countries with small nuclear capacity using recycling services commercially available.
32	With a repository being a rare and valuable commodity and hence the usage of its space very judiciously utilized, did the BEST report identify the benefits of processes for saving space in a repository? For example, does Belgium believe it will save space in its future repository by following the open over the mono-recycle fuel cycle?	Sven Bader	[Sophie Pedoux] This point was discussed in the expert group, and the precision is made, in the fuel cycle's descriptions, as to whether much or less space is needed. Concerning Belgium, the difference in space (or gallery length) has been evaluated to 10 to 15 % in favor of the mono-recycle fuel cycle. This surprisingly low difference in length is due to two different factors: first the fact that, in the Belgian's reference scenario, the medium level waste produced by the reprocessing will take space in the same GDF; and the second factor is that because of the concentration of the radioactivity and of the heat of the HLW, the operations safety requirement foreseen are such that more spacing is needed between each waste.
33	And if you would have such advanced technologies, how would that balance with the safety/security/safeguards needs in the fuel cycle facilities ???	Luc Van Den Durpel	[William McCaughey] These implementation risks discussed in Section 2.2.1 of the report were found to be not so different among the fuel cycle options to make them discriminators when comparing the options. All of the fuel cycle options have to address these risks and can mitigate them.
34	Why is depleted uranium safeguarded?	Nancy Wanna	[Jeremy Whitlock] By concluding a Comprehensive Safeguards Agreement (CSA) with the IAEA, a Non-Nuclear Weapons State (NNWS) under the Non-Proliferation Treaty (NPT) commits to accepting IAEA safeguards on "all source or special fissionable material in all peaceful nuclear activities within the territory or State". Depleted uranium (DU) and natural uranium (NU) are

			source materials (i.e. can be used to breed weapons-useable material), as is Thorium.
35	Safeguarding depleted uranium as said by J. Whitlock ??? Is this true?	Henri ZACCAI	[Answered during session] Yes, DU is included in the IAEA's statute as a source material. See above.