INPRO Dialogue Forum 8
Toward Nuclear Energy System Sustainability: Economics, Resources Availability, and Institutional Arrangements
Vienna, 26-29 August, 2014

Group Summary
Resource Availability

Brent Dixon Group Leader
Breakout Session

IAEA
International Atomic Energy Agency

Overview

- Attendance
  - Mr. B. Dixon (USA); Ms. O. Gorbatenko (Kazakhstan); Mr. H. He (China); Mr. T. Djibo Daouda (Niger); Ms. C. A. Margeanu (Romania); Mr. C. Niane (Senegal); Mr. S. Furst (Slovenia) Mr. T. Ocilaje (Uganda); Mr. L. Benkovskyi (Ukraine); Mr. A.A. Ali Al-Shami (Yemen); Ms. G. Fesenko (IAEA); Mr. V. Kuznetsov (IAEA); Mr. H. Tulsidas (IAEA)
- How the breakout session proceeded
  - There was considerable fruitful discussion with questions on how the assessment is to be performed by, and what is its added value to, small countries or countries just starting (planning) nuclear energy programmes

Overview

- What was presented
  - Sustainability of existing or planned (considered) nuclear energy systems from the standpoint of resource availability in Ukraine, Romania, Niger, Senegal, Slovenia, Uganda and Yemen.
- What was discussed
  - The added value of the Methodology assessment was discussed and suggestions for the improvement of the INPRO methodology in this subject area were made

Highlights of Presentations

- **Ukraine** – wants to be completely independent domestically for uranium supply. Produces 30% (800 tonnes) of domestic consumption of yellowcake, supply of nuclear fuel and reprocessing are provided by RF. Establishing commercial partnership with Westinghouse (from 2007). Plans to construct nuclear fuel fabrication plant but as the political and economic situations are difficult this project can be postponed.

Highlights of Presentations

- **Romania** – independent domestic Uranium supply. No Uranium market in Romania; Uranium National Company is the one and only supplier of UO_2 powder used as raw material for domestic fabrication of the nuclear fuel needed for Cernavoda NPP operation. Sustainability was assessed, using the time horizon 2050, for existing nuclear capacities (2 CANDU reactors, 700 MWe each) and projected commissioning of another 2 CANDU reactors (720 Mwe each) after 2030. In the considered approach, the sustainability of the NES was assessed, all the INPRO Methodology criteria being fulfilled.

Highlights of Presentations

- **Niger** – huge supplier of uranium sources, has no NPPs and conversion technologies but has started to plan a nuclear program. Estimation of uranium deposits (840 000 tones) was made by Areva (France), European Commission and Japan. Primarily uses CRIRSO classification of resources, but also uses IAEA system.
- **Senegal** – huge crisis in electricity sector for more than 10 years with a lot of problems; unaffordable level of subsidies (200 – 240 millions USD per year); limited access to electricity for the population & difficulties to attract investors.
  Nuclear program planning currently on hold (after Fukushima)
  NPP with West African countries to be considered. Need IAEA support.

Highlights of Presentations

- **Slovenia** – has one power unit (700 MW) co-owned with Croatia. Planning to construct a new NP unit but government has not made final decision. Government policy is to use only proven reactors, so SMRs are not being considered.
- **Uganda** – Pre-feasibility studies for NPP under way. Uranium exploration in progress, but no mines under development at this time.
- **Yemen** – Seeks to establish a long-term national strategy for Nuclear Energy based on clearness and transparency to produce electricity from NP and desalination of sea water.

Issues and Findings

- For newcomer countries or countries with small nuclear energy programmes it is difficult to assess global balance of material demand and resources on a national basis
- The boundary of 100 years in the Methodology Criteria is somewhat artificial; a cliff edge effect should not be observed after it expires, and technology development progress is difficult to predict for such a long period
  - The 100 year value is acceptable for use, but needs to be understood as a general guideline (longer than potential extended lifetime of a single reactor), not as an end target
- In some areas, extracting uranium from low grade ores with ISL methods is more economical than mining high grade ores using traditional methods

Issues and Findings

- CR2.1 and CR1.3 (time to regain spent energy and power needed to operate the system) makes little sense for evolutionary reactors (LWR, PHWR), as it is definitely met by all of them.
  - However, it may make sense for some innovative systems, e.g., for those in which external neutron sources (accelerators or fusion) are used for goals of breeding or transmutation
- CR1.4 (and, potentially CR1.5) may contradict the requirement of efficiency improvement. If a country buys a proven reactor, it is unlikely it will make better energy use of uranium compared to “Maximum achievable end use for the existing NES”

Issues and Findings

- Although OECD-NEA study shows non-nuclear materials for LWR and PHWR are abundant for any conceivable scenario growth in the 21st century, some advanced technologies (e.g., SNF final disposal with lots of bentonite clay or copper), if widely accepted, could create bottlenecks in availability (or on-time availability) of such materials.
- For newcomer countries with low investment capability but large resources of uranium, uranium trade may help improve the economy and raise the investment capacity to build power plants. Regional solutions may be considered for this.

Issues and Findings

- In a number of African countries rich with natural uranium, such uranium is considered as a strategic resource. Although export and trade of U are on-going, export policies could be changed at any time subject to changed economic conditions and progress of national nuclear energy programmes
- The rate of technological improvements in the areas of extraction efficiency and fuel resource usage efficiency should be tracked and projected and taken into account when considering future supply and demand

Feedbacks on Sustainability Assessment of NES using INPRO Methodology

- Some Methodology indicators should be evaluated once at a global level and documented in the methodology rather than each user needing to re-evaluate them each time the methodology is used
  - CR2.1 and CR1.3 on energy usage and return on energy investment do not need to be re-evaluated for evolutionary reactors
- The projected rates of global efficiency improvement for fuel resource extraction and usage should be determined as input to global resource sufficiency and updated periodically

Feedbacks on Sustainability Assessment of NES using INPRO Methodology

- For national assessments, it might be useful to measure the savings in non-nuclear fuel resources through the use of nuclear energy.
  - These savings could be measured based on the resources required to produce the same quantity of energy
- For disposal, if a unique material is used in large quantities for a planned disposal concept (bentonite clay, copper, titanium, etc.), the use of that material should be evaluated as if that disposal concept was adopted globally.
  - This could be revisited once multiple geologic disposal sites are in operation
- For CR1.4 and CR1.5, the acceptance limit should be changed from $U_{eu} > U_0$ to $U_{eu} \geq U_0$

Conclusions and Recommendations

- *Currently, fuel resources are sufficient to meet projected global needs (to mid-century). Projections beyond mid-century are difficult to make with acceptable accuracy due to potential changes in technology and demand.*
- *A fruitful discussion on the INPRO Methodology on Resources Depletion resulted in several recommendations for improvements in the methodology and its application. Key recommendations included:*
  - *Some indicators should be evaluated globally instead of by each country*
  - *Technology improvement projections should be included in global assessments of fuel resources supply and demand*