Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Uranium Regulation: Mining, Transportation, Trade and Control

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Outline

- General Information
- Regulating mines – old vs. new
- Environmental impact assessment
- Licensing and corporate social responsibility
- Safety and radiation protection
- Transportation of uranium
- Uranium trade and supply
- Non-proliferation, export control
- Conclusions

Some Terminology

- **uranium**: natural element, common in most of the Earth's rock, soils, rivers, oceans – it is a factor of its concentration in natural deposits, as well as the price of uranium, that determines whether it is feasible to extract
  - average-grade ore – from 0.1% uranium, fairly common today
  - very high-grade ore – up to 20% uranium, Athabasca basin, Canada

  Uranium is of regulatory interest and importance once it is part of the nuclear fuel cycle – which is to say, once it is to be extracted, as its potential to generate energy is its major use

- **radon**: radon is produced by the decay of uranium; radon gas is released into the air when uranium ore is mined and, to a lesser extent, during the production of uranium reactor fuel
- uranium that has been mined and milled is **uranium concentrate** (U_3O_8) or **yellowcake**; several further steps are required before uranium may be used in a reactor as nuclear fuel

Uranium at the "Front End" of the Fuel Cycle

Mining

Rock containing on average 0.1–19% uranium (uranium ore) is extracted from the ground. The ore is transported to a regional mill.

Milling

Uranium ore is ground and the uranium (U_3O_8) is chemically separated from most other constituents. The uranium concentrate, containing approximately 98% uranium (yellowcake) is shipped to a refinery.

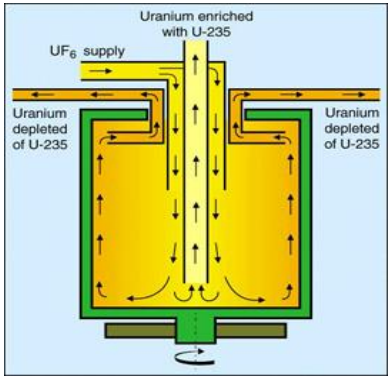
Refining

The remaining contaminants in the uranium concentrate are chemically separated from the uranium. The purified uranium (UO_3) is shipped to a uranium conversion facility.

Conversion

The chemical form of uranium is converted to UO_2 (for CANDU reactor fuel) or to UF_6 (for enrichment).

Enrichment



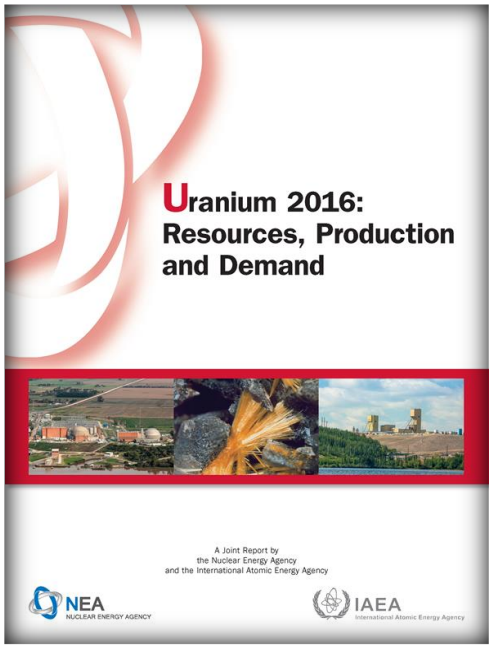
Fuel fabrication

Fuel assembly

The fuel bundles are shipped to a nuclear generating station.

Uranium Market Information and Data

- Resources, production, demand – the “Red Book”
- Uranium supply for energy security – statistical profile of the world uranium industry



Resources:

- Identified resources are sufficient for “over 135 years of supply” for global nuclear power fleet
- But this depends on timely investment, and challenges remain in a market with “high levels of oversupply and inventories, resulting in continuing pricing pressures”
- Identified resources have changed little over 2 years – lower investment and exploration efforts
- Exploration and mine development expenditures up 10%, majority made by China

Current Red Book Information – Production

- Production has decreased 4.1% since 2013, but still above 2011 level
- Production in 21 countries – top 6 have 90%:
  - Kazakhstan – 40%
  - Canada – 23%
  - Australia – 10%
  - Niger – 6%
  - Namibia – 6%
  - Russia – 5%
- Mining methods:
  - *In situ* leach – 51%
  - Underground – 27%
  - Open-pit – 14%
  - By-product – 7%
- World production has varied between 70 and 80% of production capability
- Environmental and social aspects of uranium production are of ever-increasing importance, especially for newer mining countries

Current Red Book Information – Demand

Will uranium supplies be adequate for future needs of nuclear power?

- The currently defined resource base – existing, committed, planned and prospective mines – will meet high case uranium demand, to 2035.
- Demand projections have a lot of uncertainty:
  - Capacity growth in Asia, Middle East will increase uranium demand
  - North America – capacity estimate between same and 11% increase
  - EU – capacity estimate between 48% decrease and 2% increase
- Market transition in future from supply-driven to demand-driven?

"Regardless of the role that nuclear energy ultimately plays in meeting future electricity demand, the uranium resource base…is more than adequate to meet projected requirements for the foreseeable future. The challenge in the coming years is likely to be less one of adequacy of resources than adequacy of production capacity development due to poor uranium market conditions."

Uranium Mining Regulation: Part of Nuclear Law

Commonalities with other aspects of nuclear law:

- Worker safety and radiation protection
- National interest in control over the resource
- Non-proliferation and export control
- Radioactive waste – low-activity, high-volume, long-lived
- Key part of nuclear fuel cycle
- Environmental protection
- Social acceptance

Old Uranium Mining vs. New Uranium Mines

- Legacy sites: old mining practices, Cold War secrecy, lack of remediation, no closure plans, worker exposures
- New sites: environmental stewardship, site rehabilitation, social responsibility, financial guarantees, internationalized standards, prevention and mitigation of risks to health, environment – highly regulated
- Canadian example:

  Rio Algom v. Canada, 2012 ONSC 550

  (Jan 4, 2012 decision of Ontario Superior Court)

Decommissioning and Restoration

- Legacy sites needing remediation are all over the world, a remnant of past inappropriate or nonexistent standards
- Governments are financing necessary cleanup – e.g., European Bank for Reconstruction and Development fund for Central Asia sites, set up in 2015 at request of European Commission
- Remediating former sites can be more technically challenging than new sites
- Acceptability of new mines is judged against how governments are perceived to have dealt with legacy sites
- These photos show a ***modern*** mine decommissioning project


Cluff Lake, 1999


Cluff Lake, 2005

Regulating Uranium Mining

Protecting workers

- Control of radioactive materials
- Control of workers' radiation doses
- Measurement of radiation
- Conventional health and safety

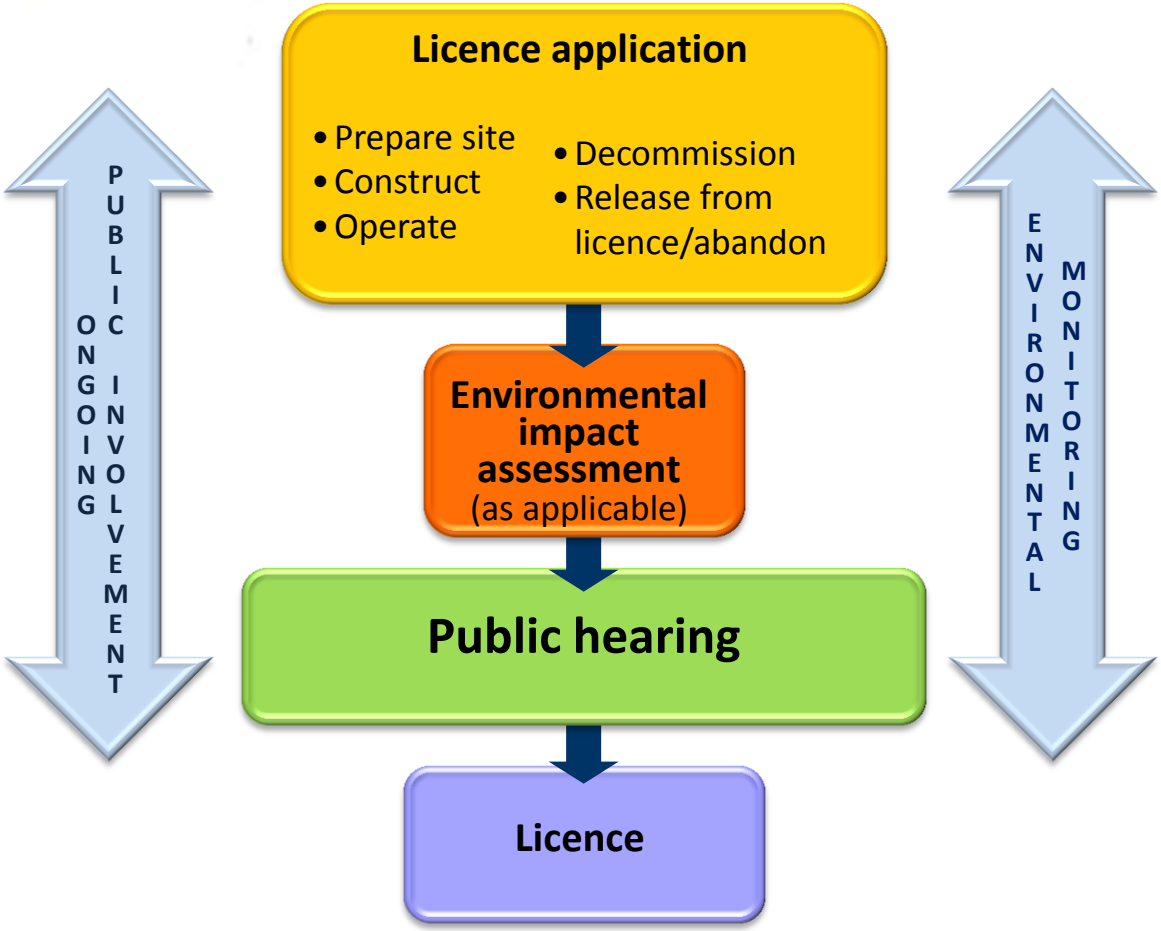
Protecting the public

- Measure key parameters in the environment
- Estimate potential dose to the public

Protecting the environment

- Control releases to the air, to surface water and to ground water
- Measure releases: effects
- Take action, when required

Licensing Uranium Projects in Canada – Lifecycle Approach



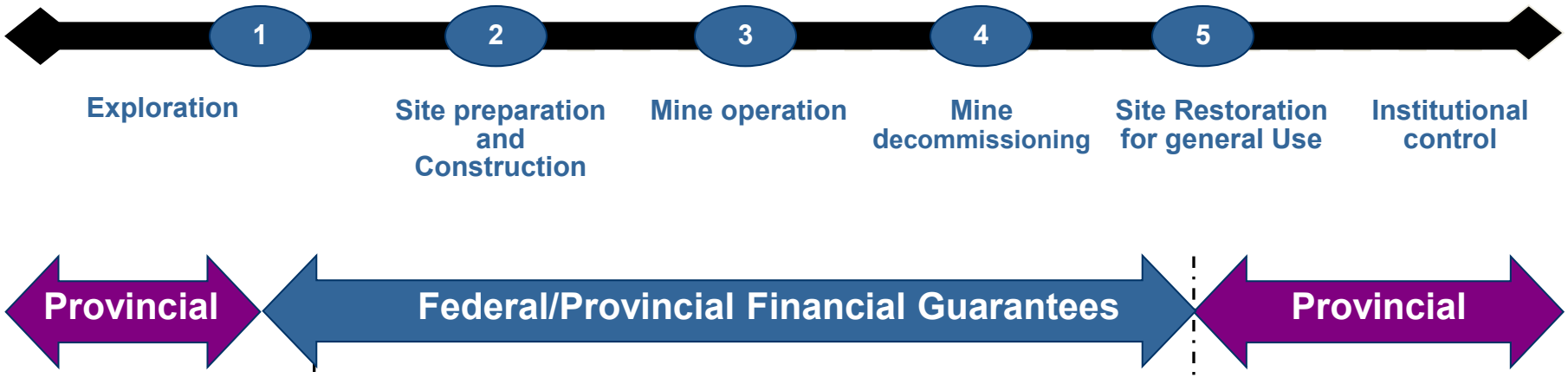
Regulatory oversight

- Licence conditions
- Inspections
- Compliance verification

Licensee obligations

- Health and safety
- Environmental protection
- Security
- Monitoring
- Reporting
- Financial guarantee

Uranium Mines and Mills: Financial Guarantees – Life cycle Management



Responsibility is transferred to the province once the site has been decommissioned, for monitoring and maintenance

Environmental Impact Assessment

- International conventions:
  - *Aarhus Convention* (access, public participation)
  - *Espoo Convention* (environmental assessment (EA) in transboundary context); *Kiev Protocol*

- Environmental protection: a tenet of nuclear law

- Environmental impact assessment (EIA) is a process to predict the environmental effects of proposals:
  - assessing whether proposal would cause adverse effects – physical, biological, human environment
  - ensuring public discourse on a project
  - crafting monitoring programs, mitigation measures, remediation plans – lifecycle approach

- International Environmental Standards – ISO 14001: environmental management system, to measure and improve environmental impact

EIA Components for Uranium Production

- Baseline data – topography, hydrogeology, flora, fauna, local air, water, soils, biota
- Detail of ore body, mining method proposed, milling process, transportation
- Socio-economic issues – need to include potential impacts on culture, potential positive economic effects, long-term plan for land
- Cumulative impacts
- EIA is a planning tool, with procedural and substantive elements

Uranium Production EIAs – Social Impact

- Links social impact (political) to environmental protection (scientific)
- ‘‘Social acceptability’’ of uranium mining –
  - Ranger Inquiry (Australia):
    1975–77 Fox Report – ethics of mining, social and Aboriginal opposition
  - Matoush Project (Canada):
    2013 Quebec government decision: inadequate social acceptability; moratorium on uranium exploitation in the province

Ressources Strateco Inc. v. Procureure Générale du Québec

(21 June 2017, Quebec Superior Court, file 200-17-022389-159)

- Strateco unsuccessfully sought $200M in damages for failure to authorize advanced exploration on the basis that the project lacked social acceptance
- The governing statute (*Loi sur la qualité de l’environnement*) did not include or define the term “social acceptability”; the Court was nonetheless satisfied both that the concept came from the statutory principles, and that the environment includes the social environment.
- Just as important, the Court found that Strateco had, as evidenced from its own reports and statements, acknowledged the importance of social acceptability of the project throughout its life.

Indigenous Rights and Uranium Mining

- ***UN Declaration on the Rights of Indigenous Peoples:***
- *29(2): States shall take effective measures to ensure that no storage or disposal of hazardous materials shall take place in the lands or territories of indigenous peoples without their free, prior and informed consent.*
- *32(2): States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources.*

Fond du Lac Denesuline First Nation et al. v. Canada (Attorney General)
2012 FCA 73
March 2012 Federal Court of Appeal
(see NLB 2012/1, No. 89)

International Guidance and Industry Tools

- *Managing Environmental and Health Impacts of Uranium Mining (NEA, 2014)* *http://www.oecd.org/publications/managing-environmental-and-health-impacts-of-uranium-mining-9789264216044-en.htm*
- *Lessons Learned from Environmental Remediation Programmes (IAEA Nuclear Energy Series No. NW-T-3.6, 2014)* *http://www-pub.iaea.org/books/IAEABooks/10509/Lessons-Learned-from-Environmental-Remediation-Programmes*
- *Sustaining Global Best Practices in Uranium Mining and Processing: Principles for Managing Radiation, Health and Safety, Waste and the Environment (WNA Policy document, 2010)* *http://www.world-nuclear.org/our-association/publications/position-statements/best-practice-in-uranium-mining.aspx*

  "This document holds the status of a policy and ethical declaration by the full WNA membership... In the category of uranium miners, the WNA membership includes all major uranium mining and processing companies as well as many mid-size and junior companies.

  The principles affirmed here are supported by key relevant international organizations, including the International Atomic Energy Agency. Indeed, these principles have been affirmed as an outgrowth of an IAEA cooperation project aimed at encouraging expanded exchanges between professionals from governments and industry. These principles are also supported by the global mining community through relevant international and national associations that cover uranium mining and processing."

Corporate Social Responsibility and Accountability

Equator Principles

"Environmental and social risk management for project finance"

- 80 banks, covering more than 70% of project financing in emerging markets; includes such things as human rights due diligence, Greenhouse gas emissions tracking

Mine companies may have financing tied to corporate social responsibility (CSR)

Canada's Office of the Extractive Sector CSR Counsellor

- Promotes the International Finance Corporation (IFC) performance standards, the Voluntary Principles on Human Rights and Security and the non-financial reporting frameworks of the Global Reporting Initiative
- Labour and working conditions, pollution prevention, Indigenous peoples, sustainable development, community health and security, land acquisition, etc.

So, voluntary standards find their way into contracts and trade.

Canada's *Extractive Sector Transparency Measures Act*

- Reporting of payments made on commercial development of oil, gas and minerals
- To deter corruption in the global extractive sector by making revenues from natural resources transparent to the public; meant to ensure citizens benefit

Such "publish what you pay" transparency rules are a global trend

Corporate Social Responsibility and Accountability

- Canada's *Corruption of Foreign Public Officials Act*
- U.S.: *Alien Tort Claims Act; Foreign Corrupt Practices Act*
  - Global companies need to have robust anti-bribery, anti-corruption policies in place
  - It is not enough to simply adopt such policies – even training employees and providing tools to comply may not be enough
  - Need to verify that compliance tools are put to use, and that employees are disclosing complete and accurate information – making policies effective in practice
- Bilateral trade treaties may refer to the promotion and enforcement of internationally recognized CSR standards as an exception to liberalization
- *Choc v. Hudbay Minerals*, 2013 ONSC 1414 (22 July 2013 – ongoing):
  - *Does a Canadian mining company owe a duty of care to protect Guatemalan Mayan Q'eqchi from human rights abuses by the company's subsidiaries in Guatemala?*
  - June 2015 motion decision ordering production of documents – on security at other mine projects; community relations activities; corporate control documents

Construction – Cigar Lake Mine

Operation – McArthur River Mine

Mining – Drill and Blast

A person operates a scoop tram remotely to scoop up the muck.

Radiation Protection

•Distance – The person maintains a line of sight with the scoop tram but is far away from the muck pile.

•Shielding – The walls are covered with cement.

•Reduction – The muck pile is kept damp to reduce dust.

•Dilution – The tunnel where the worker is working is ventilated with fresh air.

Health and Safety

•The orange plates and screening provide ground support.

• Personal protective equipment

Operation – Key Lake Mill

Operation – McClean Lake Mine and Mill

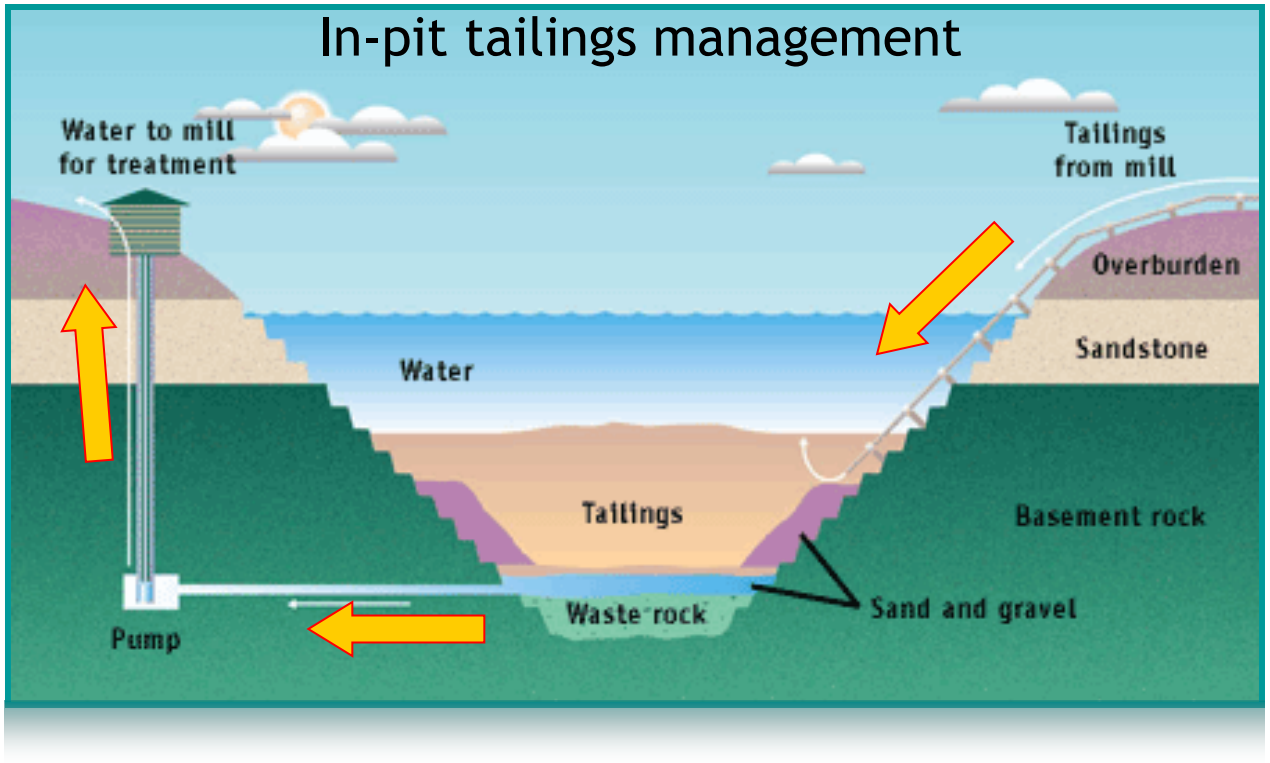
What Waste Do Uranium Mines and Mills Produce?

Remember: high volume, low activity

- **Clean waste rock and waste rock:** Mining produces both clean waste rock and waste rock that must be removed to retrieve the uranium ore. Clean waste rock is not harmful to the environment and is placed in surface rock piles for future use. Waste rock is usually found close to the ore body and contains low concentrations of radionuclides or heavy metals (mineralized waste). These must be managed during operations and properly disposed of so that contaminants are not released to the environment.

- **Tailings:** Milling uranium ore produces tailings. Tailings are what is left over once the uranium has been removed from the ground rock – they resemble fine sand. They contain long-lived radionuclides (such as thorium-230 and radium-226) produced from the decay of uranium, as well as trace metals like arsenic and nickel. They also contain chemical residues from the milling process.

Mine Waste Management



Waste Management for Mines/Mills

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

- Sets general safety requirements (article 11)
- Article 3(2) notes the Convention does not apply to “naturally occurring radioactive material … that does not originate from the nuclear fuel cycle unless … declared as radioactive waste … by the Contracting Party.”
- Contracting Parties have agreed to include mine/mill waste in reporting.

Protecting the Environment

Control releases

- To the air
- To surface water
- To ground water

Measure/monitor

- Releases
- Effects

Take action, when required

Radiation Protection: the Workers

- Management
- Control of radioactive materials
- Control of worker doses
- Measurement of radiation

Radiation Protection: the Public

- Measure radiation in the environment
- Calculate potential dose to members of the public

Packaging and Transport

Transportation

Producing vs. using countries + complexity of fuel cycle = a lot of shipments, different stages

- IAEA regulations
- Packaging requirements
- Security requirements, physical
- Use of reliable carrier
- Secure storage in transit
- Driver communications
- Emergency planning
- Security response
- Shipment notification

Transportation of Uranium

- Real-life examples of transport issues involving uranium:

  1. **At sea** – *MCP Altona* incident (January 2011)
  2. **On land** – yellowcake spill at Blind River Canada from containers travelling from Wyoming, U.S. (June 2012)

Non-Proliferation and Uranium Trade

- Peaceful purposes nuclear trade under safeguards
- Government policies respecting non-proliferation determine when/how a State puts ‘‘obligations’’ on its trade (beyond NPT requirements)
- Nuclear cooperation agreements – treaty-level assurance that nuclear material, equipment and technology will be used only for civilian, peaceful applications – include **obligations**:
  - exports only for peaceful, non-explosive end-uses
  - control over items subject to the nuclear cooperation agreement that are re-transferred
  - control over the reprocessing of any obligated spent nuclear fuel
  - control over the storage/use of any separated plutonium
  - control over high enrichment / its subsequent storage and use
  - bilateral safeguards if IAEA safeguards are unable to be applied
  - assurances of adequate physical protection – *Convention on the Physical Protection of Nuclear Material*
- Nuclear Suppliers Group Guidelines – INFCIRC/254

Uranium Trade – Fuel Supply

- Fuel supply: mining, conversion, enrichment, fuel fabrication – all are required to guarantee supply of fuel
- NPT article IV:
  - "inalienable right of all the Parties … to develop research, production and use of nuclear energy for peaceful purposes" and
  - "right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy"
- BUT: the relevant technology, materials and know-how for civilian nuclear energy production are all dual-use
- Proliferation risk – enrichment technologies

Fuel Supply

How to achieve assurance of supply and ensure non-proliferation?

- Ensuring commercial competitiveness and avoiding monopolistic conditions – challenging
- IAEA Low Enriched Uranium (LEU) Fuel Bank – facility to be inaugurated in Kazakhstan on 29 Aug 2017

LEU from the bank will only be supplied to a Member State (MS) that fulfills the following eligibility criteria:

- MS experiencing supply disruption of LEU to a nuclear power plant, is unable to secure LEU from the commercial market, through State-to-State arrangements, or by other such means
- The IAEA has made a conclusion that there has been no diversion of declared nuclear material, and no issues relating to safeguards implementation in the requesting State are under consideration by the IAEA Board of Governors
- MS has brought into force a comprehensive safeguards agreement requiring the application of IAEA safeguards to all its peaceful nuclear activities

LEU from the IAEA LEU bank, as a mechanism of last resort, can only be supplied to a MS upon advance payment, when the Director General concludes that these three criteria are fully met

Some General Takeaways

- As a strategic resource that is important for energy security, uranium is of both national and global importance.
- For health and safety, radiation protection, environmental stewardship and non-proliferation, control of uranium production and trade is an important part of national and international nuclear law.
- Evolution of environmental standards distinguishes current mining from legacy practices, but the perception of environmental damage and unsafe practices must still be addressed. Lifecycle management is key to current regulatory schemes.
- Mine operators need to be aware of CSR imperatives and social acceptability issues for projects – transparency is key.
- The internationalization of the fuel cycle has potential for non-proliferation gains and security of supply, but must also ensure competition and show respect for the NPT bargain.

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