GLOBAL 2011

December 11-16, 2011

Makuhari Messe, Chiba, Japan

Trends towards Sustainability in the Nuclear Fuel Cycle

Global Nuclear Energy Policy

Thierry DUJARDIN

Deputy Director, Science and Development

OECD Nuclear Energy Agency

Outline

THE STUDY
- **Scope and objectives**
- **Approach**

TRENDS
- **Technical progress (past and coming decade and the longer term)**
- **National and international progress**
- **Policies**

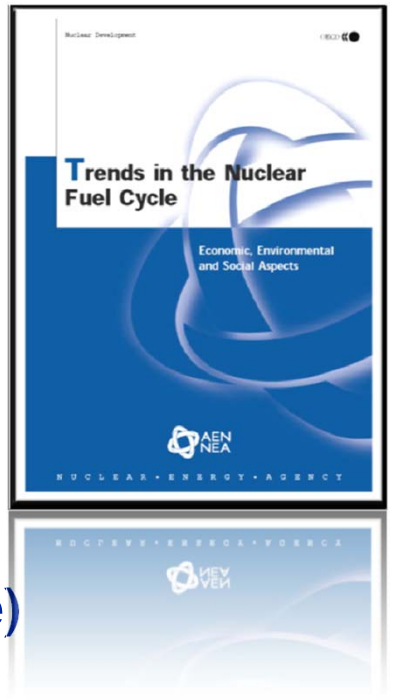
FINDINGS & RECOMMENDATIONS

Note: assessments largely developed prior to Fukushima

STATUS
- ***Forthcoming publication (expected by the end of the year)***

Scope and Objectives

- **Update the 2002 publication:**
  "Trends in the Nuclear Fuel Cycle: Economic, Environmental and Social Aspects"



- **Investigate developments in the NFC**
  - Over the past decade
  - In the next ten years
  - In the longer term
- **Analyse the sustainability elements of NFCs**
  - Economic (cost, optimise use of resources)
  - Social (enhance safety, proliferation resistance)
  - Environment (reduce impacts)
- **Focus on policy and strategies**
  - Review experience and perspectives in policy making

Approach

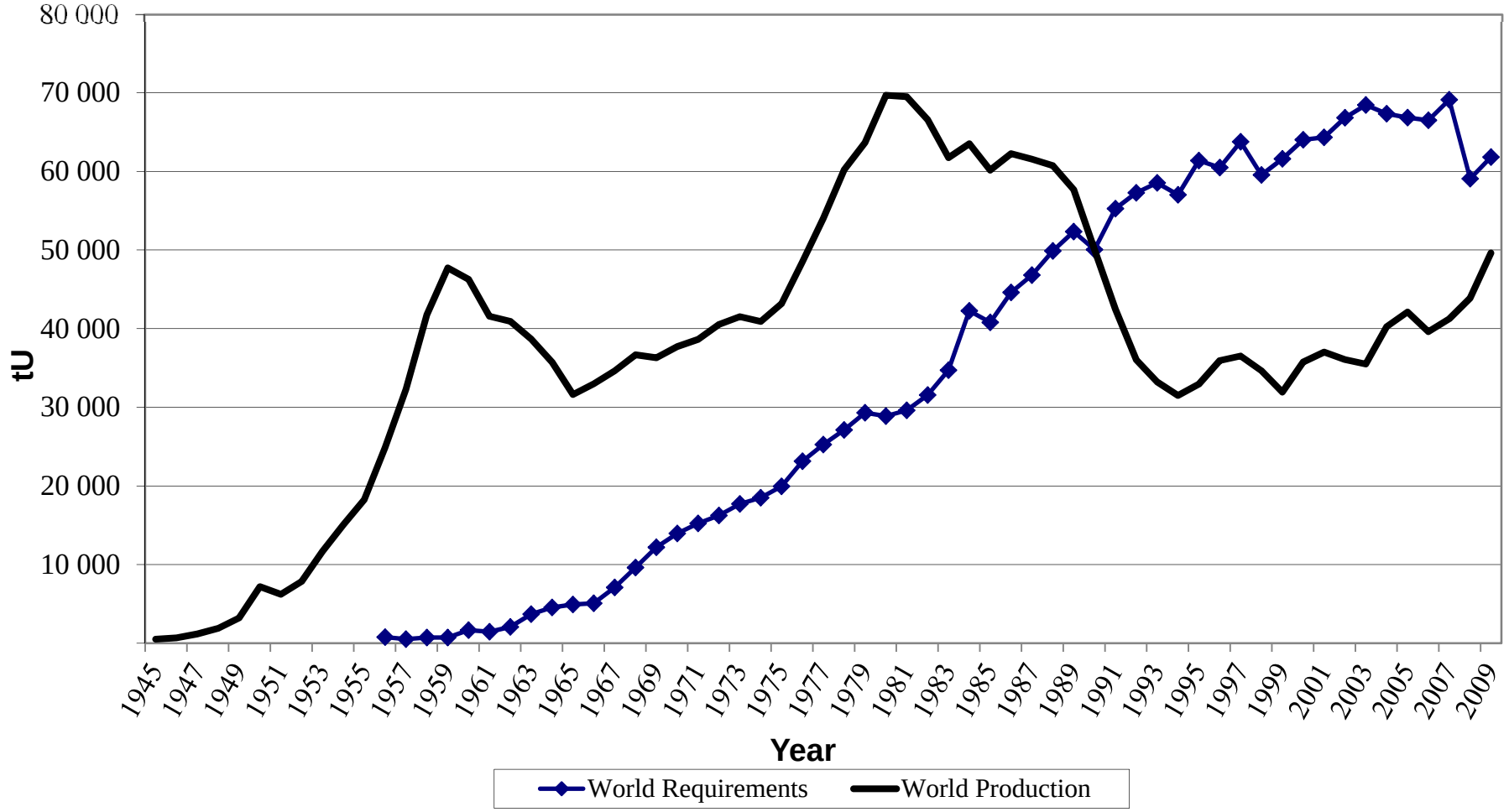
Emphasis on sustainability

- **Sustainability criteria**
  - Environment
  - Resource Utilization
  - Waste Management
  - Infrastructure
  - Proliferation Resistance and Physical Protection
  - Safety
  - Economics

Mining & milling

- Increase of uranium demand and resource base
- Increase in mining and milling costs, uranium prices & price volatility
- Change around 2003/04
  (new reactors on line, improved capacity factors & up-rating of existing NPPs, stocks almost used up)
- Price reduction post Fukushima
- Resources expected to be sufficient for ~100 years of supply (at 2008 reactor requirement levels) provided timely achievement of existing and committed plans of capacity expansion
- Challenges due to more difficult approval processes & increasing public resistance to mining
- Greater use of in-situ leaching (ISL)
- Consolidation of best practices
- New entrants

Trends in the past decade and near future
Front end



Trends in the past decade and near future

Front end

Conversion

- Higher conversion prices
- 4 big players account for 90% of nominal capacity
- Replacement, modernisation and expansion of capacity

Enrichment

- Centrifuge displacing diffusion enrichment (20% in 2001 ↗ 40% in 2010)
- Reduced enrichment tails assays
- Enlargement of enrichment capacity
- Development of laser enrichment still continuing, approaching pre-industrial readiness

Fuel design & fabrication

- Optimisation of designs & improvements of behaviour
- Increased burnup and initial enrichments
- Wider use of MOX and REPU fuel utilisation - but some uncertainties in the future use post Fukushima
- Possible bottle neck: zirconium fabrication in case of strong nuclear development

Trends in the past decade and near future
Reactor & Back end

Reactor operations

- Longer fuel cycles
- Increasing output: higher load factors & upratings
- Load following
- Lifetime extension

Spent fuel & waste management

- Progress with deep geological repositories for the disposal of SF and HLW
- Reversibility / retrievability
- Interim storage of SF and HLW – greater adoption of dry storage capacity

Reprocessing

- Technological progress favouring efficiency, flexibility & reduction of discharges
- Growing reprocessing capacities

In the longer term

Advanced systems and fuel cycles

- Gen IV reactors
- Fuel design & fabrication R&D
- Partitioning & transmutation
- ADS
- Thorium Fuel Cycle
- Unconventional uranium resources

Innovative nuclear energy applications & concepts

- Small & Medium Reactors
- High conversion thermal reactors
- Non-electric use of nuclear

Trends in countries and global effort
Policy considerations (1)

- **Principal policy drivers**
  - Security of supply / heavy reliance on energy imports
  - Environmental concerns
- **Little emphasis of policies squarely on sustainability**
- **Discussion mainly focused on historical challenges**
  - Disposal of spent fuel and high level waste
  - Reprocessing of spent fuel
  - Non-proliferation and safeguards
  - Safety

Trends in countries and global effort
Policy considerations (2)

- **Disposal of spent fuel and high level waste**
  - Geological repository – favoured option
  - Legal and institutional frameworks
  - Greater public consultation
  - Establishment of agencies for radwaste management
  - Progress with site identification, i.e. in Finland & Sweden, but high profile setback with Yucca Mountain
  - Regional and transnational approaches
  - Council Directive 2011/70/EURATOM & Joint Convention
- **Reprocessing of spent fuel**
  - Dichotomous approach maintained
  - Some increase of recycling (sizeable in France)

Trends in countries and global effort
Policy considerations (3)

- **Safety**
  - Still overarching priority
  - Fukushima Dai-ichi events - strengthen safety standards and international cooperation, focus on accident response, influence on policy decisions ?
  - Council Directive 2009/71/EURATOM
  - Harmonisation: MDEP, ENSREG
  - Independence of regulatory authorities
- **Non-proliferation and safeguards**
  - Broaden focus to complete fuel-cycle and infrastructure assessments and comprehensive State-level approach
  - Attention to vulnerabilities of societal infrastructure
  - Increased attention to non-traditional targets, e.g. cyber-attacks & information theft

Findings (1)

- New build & prospects of growth (could slow-down post Fukushima)
- Prevalence of OFC, with some partial recycling for existing fleet and NPPs under construction
- U demand from non-OECD countries expected to impact OECD countries
- Increased U prices & price volatility, but
- No short-term constraints from shortage of resources
- Yet – need for investments and timeliness of mining projects

Findings (2)

- **Little incentive to close the fuel cycle (from a resource utilisation perspective)**
- **Overall only incremental progress towards sustainability**
  - **Step changes not market-driven ➡ government action required**
- **Step changes in sustainability linked to deployment of Advanced FCs**
- **Increased weight of global strategies (GENIV, INPRO & IFNEC) & international approaches (e.g. fuel banks or regional repositories)**

Recommendations (1)

- **To support nuclear development governments would need to:**
  - **ensure efficiency in necessary approval processes**
  - **ensure long term security of supply (from conventional & unconventional sources)**
  - **consider coupling energy policies with supporting fiscal policies (& market incentives) to ease risk management, particularly for the implementation of new technologies with long lead times**
  - **work with mining industry to ensure that best practices are applied**
- **Waste management - Progress towards implementation of deep geological repositories must remain a high priority**
  - **further R&D to optimise geological disposal solutions and to address issues related to prolonged interim storage of spent fuel**
  - **challenges such as licensing, public acceptance, knowledge retention must be addressed**

Recommendations (2)

- **Advanced reactors and closed fuel cycle**
  - **Governments need to ensure adequate regulatory frameworks & resources to enable transition to fast neutron systems**
  - **On-going R&D and international cooperation in advanced FC should be further promoted**
- **Integrated approach to the analysis of the economy of the fuel cycle (from mining to waste management) needs to be further developed**
- **Work towards universally agreed indicators to assess sustainability of NFC must continue**

Global Nuclear Energy Policy

Nuclear Energy Policy – Key Drivers

- Global energy demand
  - Population growth
  - Economic growth, especially in developing countries
- Increasing prices of fossil fuels
- Increasing volatility of prices
- Security of energy supply (& diversity)
  - Nuclear energy – domestic source
- Climate change
  - Need to "decarbonise" electricity production

None of these drivers was modified due to the Fukushima Daiichi accident

However, the public opinion has been very much impacted by the accident

Although there is no certainty, the accident will likely slow the development of nuclear power in the medium term

Challenges Ahead - Before

- Financing capital-intensive nuclear units
  - Reducing business risks
- Enhancing economic and safety performance simultaneously
- Implementing HLW repositories
  - Social acceptance
- Strengthening involvement of civil society on nuclear energy issues
- Developing innovative reactors and fuel cycles
- Penetrating new markets (hydrogen, heat, potable water)
- Securing qualified human resources

Challenges Ahead - After

- The same ones

+

- The lessons from Fukushima need to be integrated in the design and the sitting of new plants
- Adequate measures should be taken from the result of the safety reviews on existing reactors
- Restoring public confidence

Concluding Remarks (1)

- Current world energy model not sustainable
  - It prepares a "*dirty, unsecure and expensive*" future
- There is no "silver bullet"
- It is essential to keep all low-carbon energy options open and to avoid idolising or demonising any technology
- Nuclear energy is part of the solution (triple win)
  - Reduction of CO2 emissions
  - Increased security of energy supply
  - Economics benefits

Concluding Remarks (2)

But

- **All lessons from Fukushima need to be drawn**
  - **Existing reactors**
  - **Future reactors**
- **Transparency and increased international cooperation essential**
  - **Identifying and implementing best practices**
- **Restoring public confidence likely the most difficult challenge**

Thank you for your attention