International Atomic Energy Agency

Trend of Spent Fuel Management (SFM) in the World

ISSF-2010

Tokyo, Japan

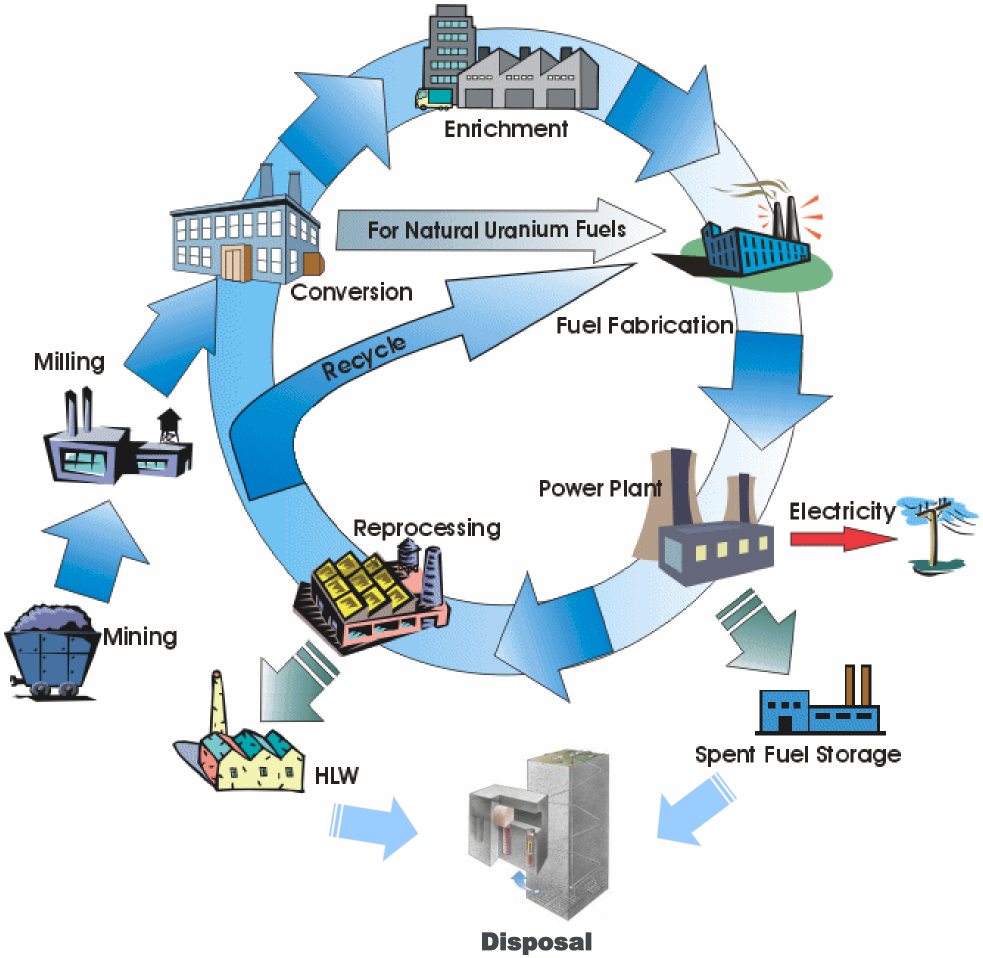
15-17 November, 2010

Hojin RYU

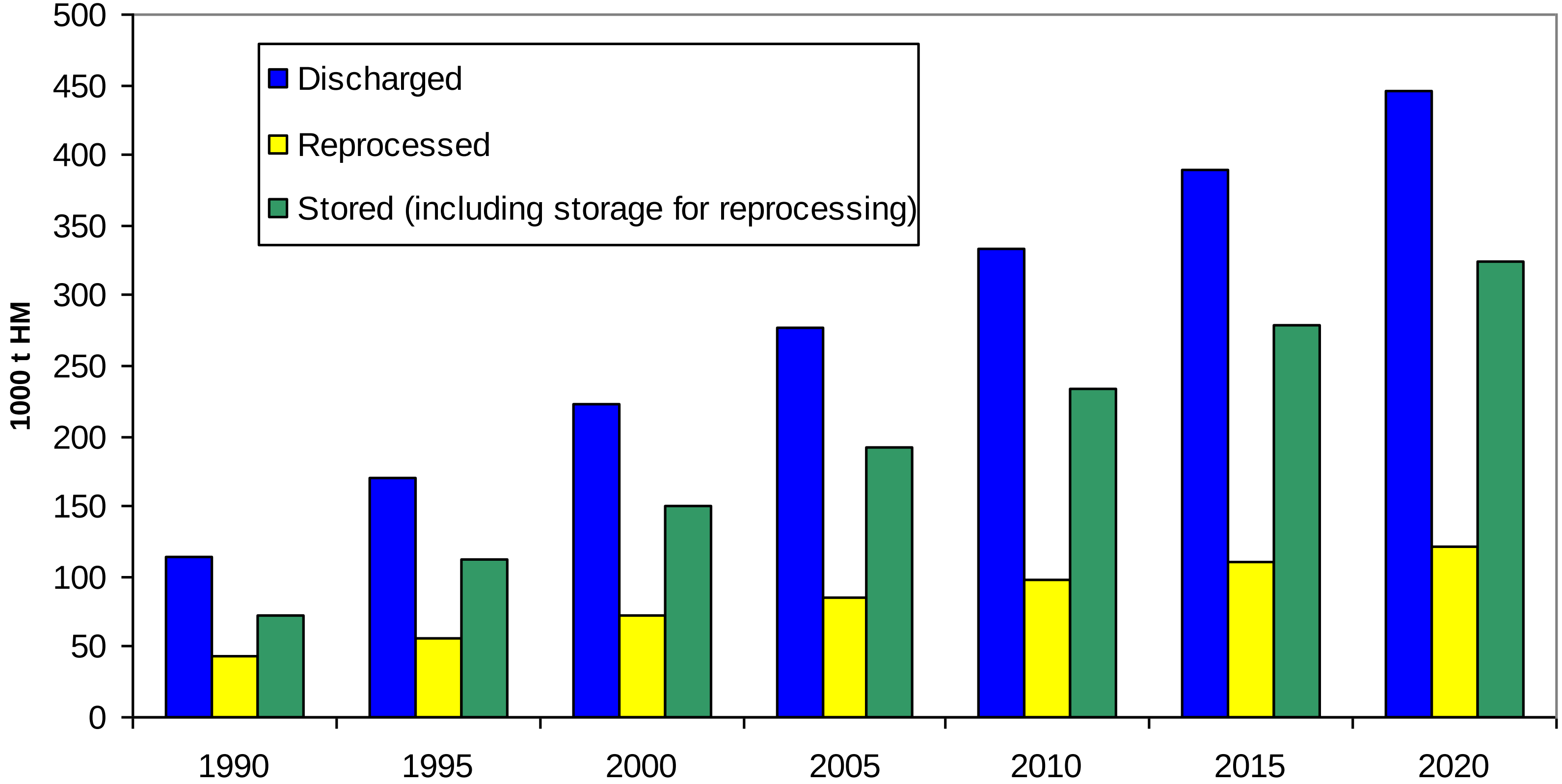
Nuclear Fuel Cycle and Materials Section

Nuclear Fuel Cycle and Spent Fuel

- **Open Fuel Cycle**
  - **Direct disposal**
- **Closed Fuel Cycle**
  - **Reprocessing & recycling**
- **Innovation in the fuel cycle can place new demands on spent fuel management**

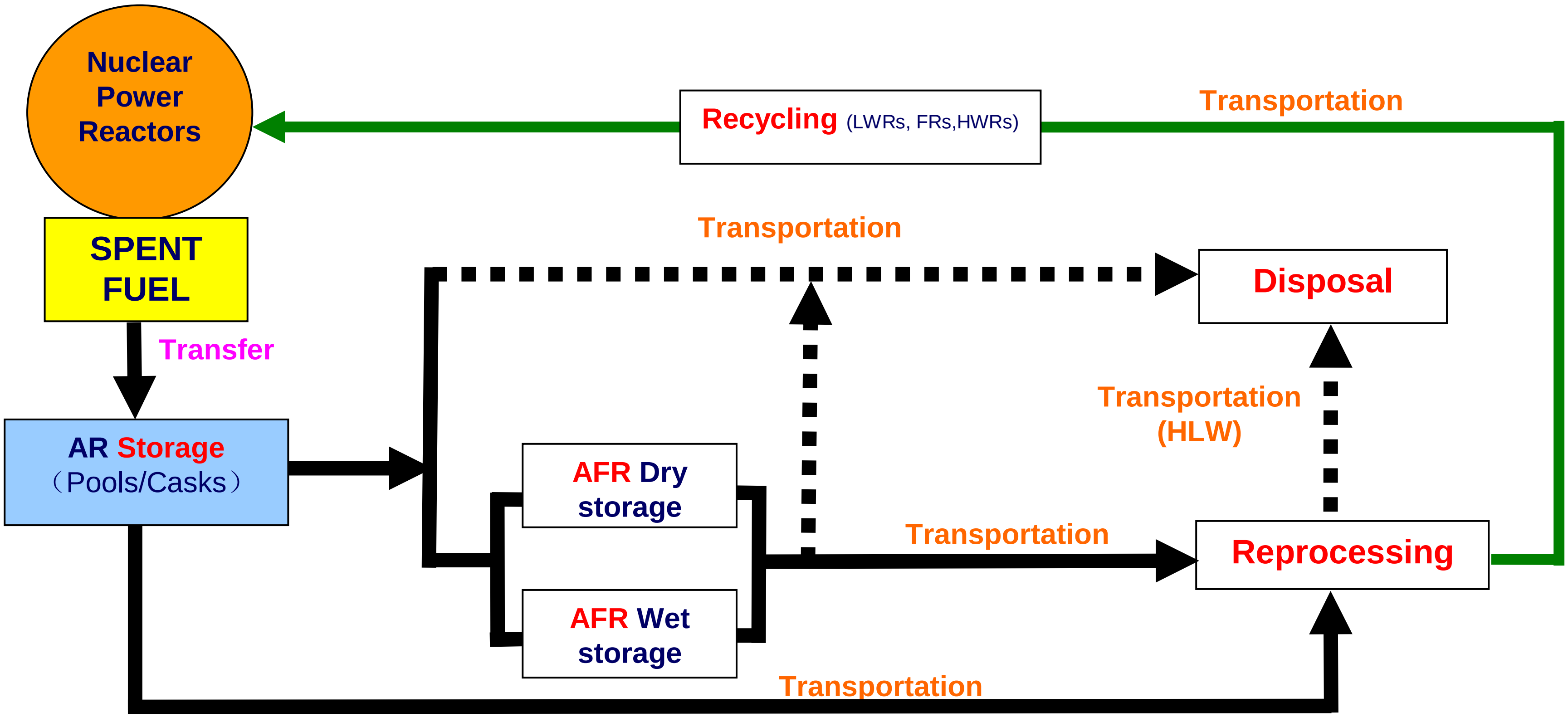


Status of Spent Nuclear Fuel



- **The total amount of spent fuel that has been discharged globally is approximately 334 500 tonnes of heavy metal (t HM).**
- **The annual discharges of spent fuel from the world's power reactors total about 10 500 tHM per year.**

Spent Fuel Management Options



- **Increasing interest for recycling in a longer time perspective**
- **Slow developments in disposal**

Challenges - Spent Fuel Management

- **Strategy for spent fuel management – resource or waste;**
- **Long term storage becoming a progressive reality…storage durations up to 100 years and even beyond possible;**
- **Use of MOX and higher enrichment/burnup lead to higher decay heat levels and more brittle fuel;**
- **License extensions for existing facilities.**

Long-term Integrity Demonstration

- **New challenges of spent fuel storage**
  - **High burnup, high enrichment, MOX fuel**
  - **Very long term storage over 100 + years**
  - **Transport after long term storage**

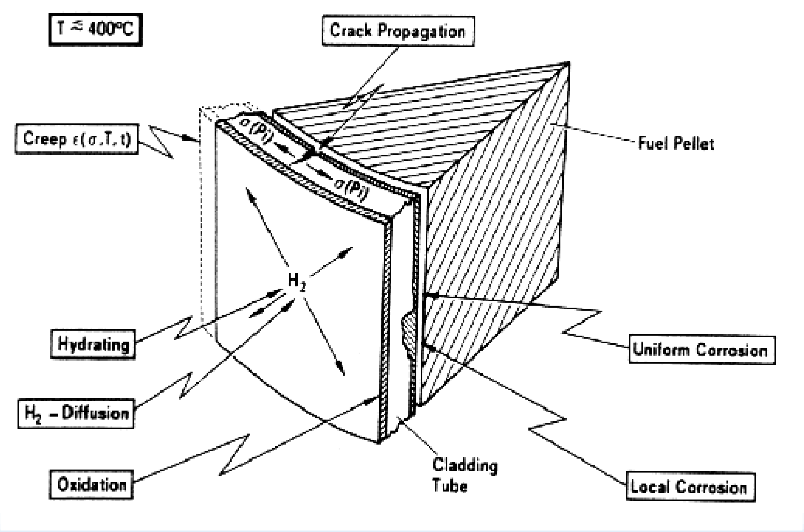
- **Long term integrity of spent fuel storage should be confirmed by appropriate demonstration methods**
  - **Experimental design, monitoring and inspection, mechanisms and modeling, extrapolation and validation**

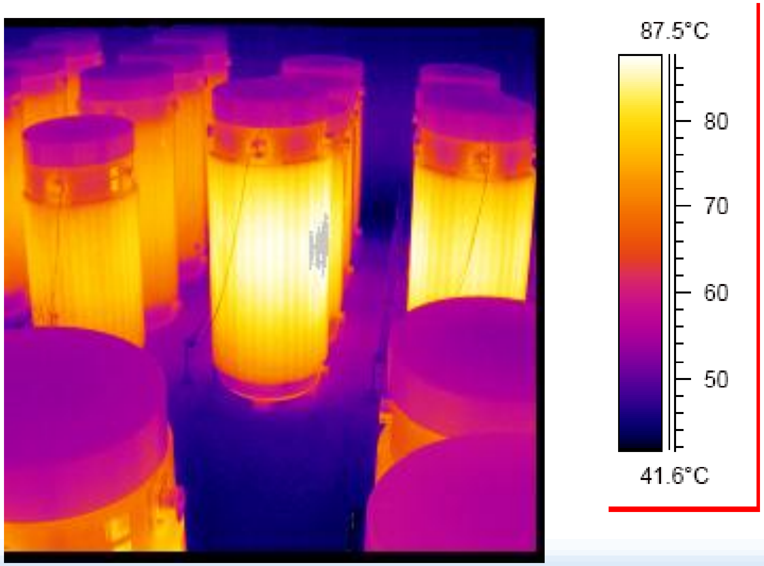
Spent fuel assembly inspection during the dry storage (US EPRI)

➔ Coordinated collaboration research

Major Degradation Mechanisms

- Uniform Corrosion, Pitting, Galvanic corrosion
- Creep (Rupture)
- Air Oxidation
- SCC (Stress Corrosion Cracking)
- DHC (Delayed Hydride Cracking)
- Hydride Reorientation



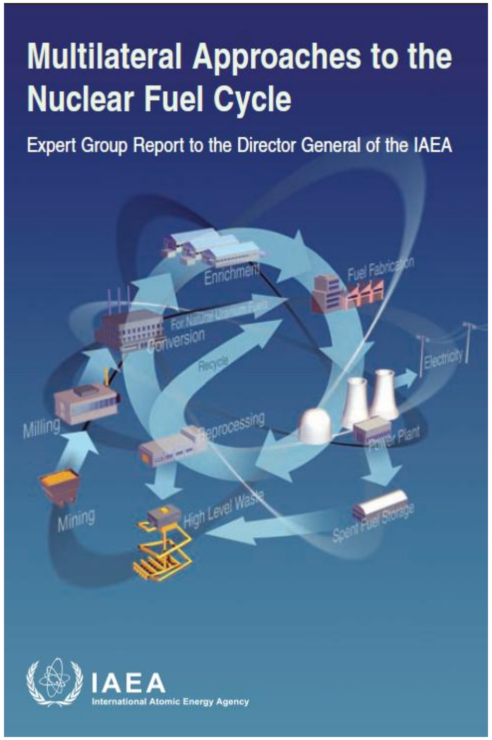


Integrity of Spent Fuel in Dry Storage

- **The use of an inert atmosphere has been implemented to protect against oxidation.**
- **Creep under normal conditions of storage will not cause gross rupture of the cladding, provided that the maximum cladding temperature does not exceed 400°C.**
- **As the combination of SCC agent and stress conditions required for crack propagation are normally absent, it can be concluded that cladding failure via SCC is not expected to occur.**
- **DHC is not expected to be an active degradation mechanism in cladding tubes, given that the cladding does not appear to have enough wall thickness to generate much tri-axial stress.**
- **Hydride re-orientation and hydrogen migration are unlikely to result in failures.**
  - the potential to impair the ability of the cladding to withstand potential mechanical challenges resulting from handling or transportation accidents.

Multinational Approaches to Spent Fuel Management

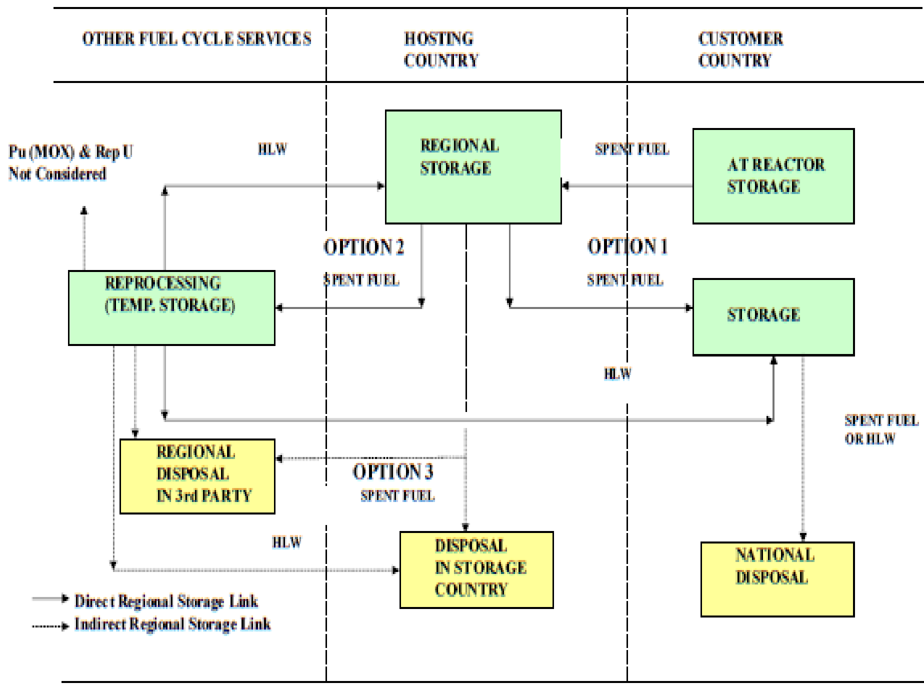
- **~60 potential entrant countries considering nuclear power**
- **Concerns raised about the expansion of sensitive fuel cycle technology**
- **Not practical for each countries to develop the nuclear fuel cycle technology**



MLAs offer a potentially useful contribution to meeting prevailing concerns about assurances of supply and non-proliferation

International Spent Fuel Storage

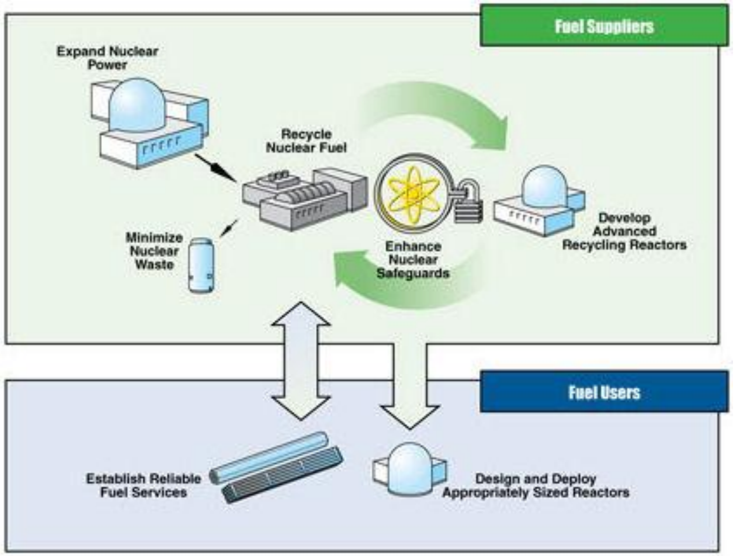
- No international market for SF storage services
- **Technical, Economic and Institutional Aspects of Regional Spent Fuel Storage Facilities**, (TECDOC-1482, 2005)
- Storing spent fuel in a few safe, reliable, secure facilities could enhance safeguards, physical protection and non-proliferation benefits
- **The political and public acceptance issues are real and difficult to address**



International Initiatives

- Global Nuclear Energy Partnership (GNEP), 2006 (USA)
  - envisages the development of comprehensive fuel services, including fuel leasing while maximizing non-proliferation benefits.

- The International Framework of Nuclear Energy Cooperation (IFNEC)
  - Cradle to Grave (CTG) concept
  - Reliable global commercial services
  - Comprehensive fuel supply, spent fuel management and disposal services



International Initiatives

- Global Nuclear Infrastructure Initiative, 2006 (Russia)
  - envisages international nuclear fuel cycle service centres (INFCCs) as joint ventures financed by other countries.
  - enrichment, reprocessing & storage, training and R&D

VVER SFAs from Bulgaria and Ukraine (and Hungary) are transferred to “MCC” Krasnoyarsk

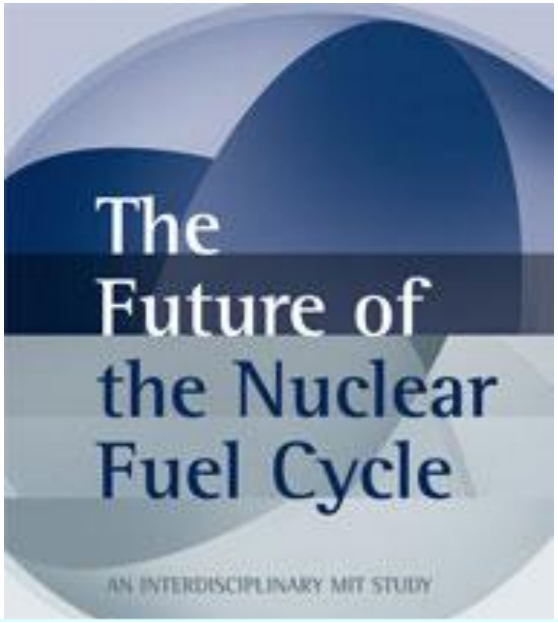
International Uranium Enrichment Center

Multi-purpose Pyro Complex (MPC)

Multifunctional Fast Test Reactor (MBIR)

Spent Fuel Take-back Options

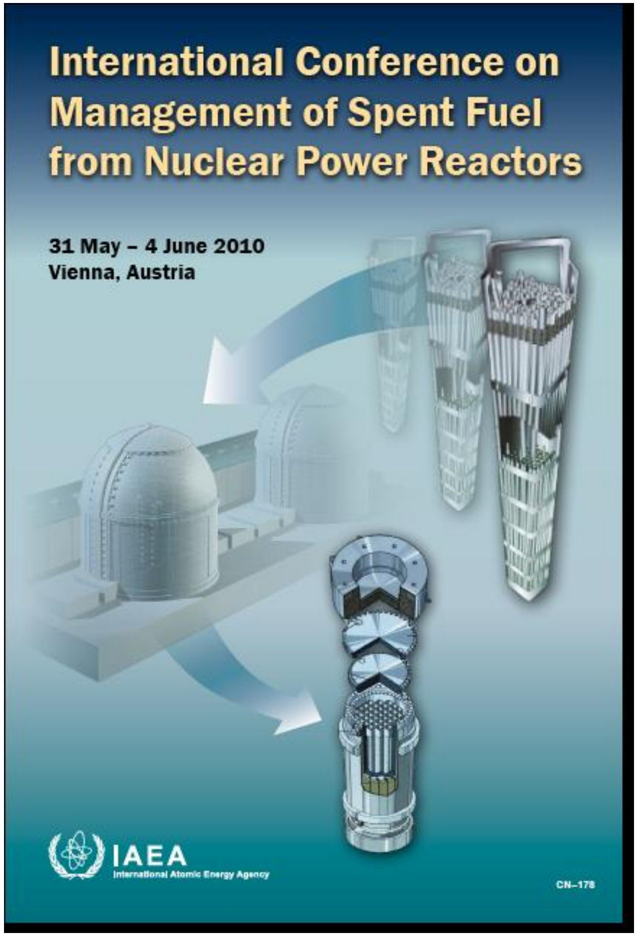
- MIT Report (2010) recommended,
- The US and other nuclear supplier group countries should actively pursue fuel leasing options for countries with small nuclear programs, providing
  - financial incentives for forgoing enrichment,
  - technology cooperation for advanced reactors,
  - spent fuel take back within the supplier's domestic framework for managing spent fuel,
  - and the option for a fixed term renewable commitment to fuel leasing.



Newcomers consider the assured take-back as the most attractive option, as yet few are willing to provide the leasing service

IAEA activities on Spent Fuel Management

- Coordinated research project on spent fuel performance assessment and research (SPAR-III)
- Influence of high burnup and MOX fuel on storage design
- Burnup credit application
- Regional spent fuel storage
- Spent fuel treatment options
- Costing of spent fuel storage
- Storage facility operations lessons learned



Publications – Spent Fuel Management

- **2007**
  - Selection of AFR Facilities for Spent Fuel Storage
  - Operation and Maintenance of Spent Fuel Storage and Transportation Casks/Containers
- **2008**
  - Spent Fuel Reprocessing Options
- **2009**
  - Costing of Spent Fuel Storage
  - Management of Damaged Spent Nuclear Fuel
- **2010 in press**
  - Influence of High Burnup and MOX Fuels on SFM
  - Final Report of CRP on Spent Fuel Performance Assessment and Research (SPAR-II)
  - Spent Fuel Data Collection and Management for Long Term Storage

SPAR-III Coordinated Research Project

SPAR-II (2004-2008)

1st Research Coordination Meeting
Karlsruhe – June 2005
2nd Research Coordination Meeting
Tokyo – November 2006
3rd Research Coordination Meeting
Budapest – June 2008

SPAR-III (2009-2013)

- **Participants**
  Argentina, Hungary, Slovakia, France, Germany, Japan, ROK, Spain, USA, EC (ITU)
- **1st Research Coordination Meeting**
  - Tokyo, 8-12 Nov 2010

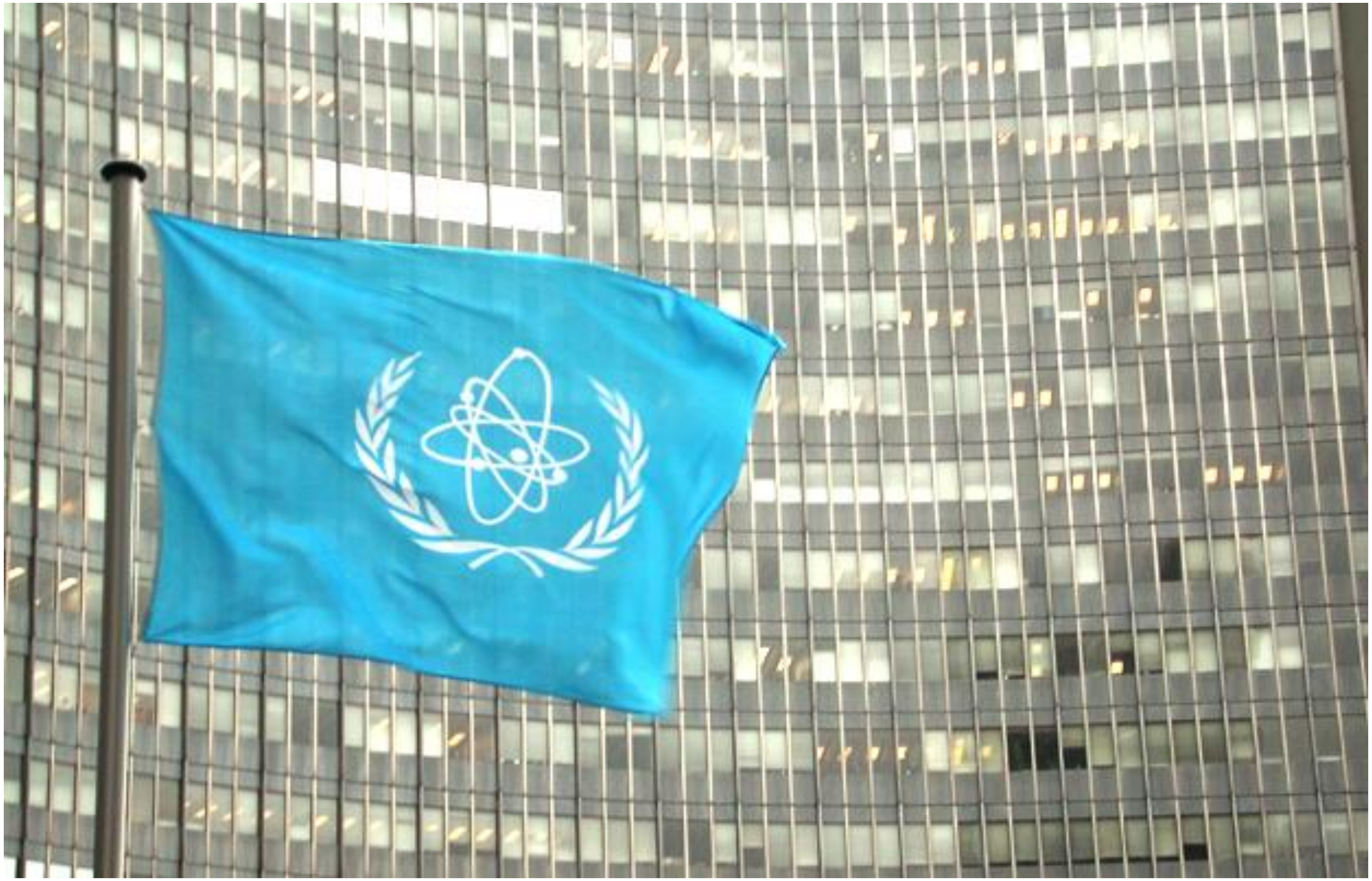
Important Issues for Future

- **Very long-term storage beyond 100 years**
  - **Demonstration of long-term spent fuel performance and transportability after long-term storage**
- **Multilateral approaches**
  - **Technical, legal, regulatory and public acceptance issues in multilateral spent fuel management**
- **Innovation in spent fuel recycling**
  - **Spent fuel can be considered as resource**
- **Support newcomer countries**
  - **Experiences of safe operations in spent fuel storage facilities should be shared**

Invitation to IAEA Technical Meetings

- **TM on spent fuel treatment options including reprocessing and recycling**
  - **16-17 Dec. 2010 @ Vienna, Austria**
- **TM on MOX fuel and MOX spent fuel management**
  - **21-24 Feb. 2011 @ Vienna, Austria**
- **TM on very long term storage of used nuclear fuel**
  - **26-28 April 2011@ Vienna, Austria**
- **TM on hot cell post-irradiation examination and pool side inspection of nuclear fuel**
  - **23-27 May 2011 @ Smolenice, Slovakia**

Thank you for your attention



…atoms for peace.