Spent Nuclear Fuel Management:

Challenges and Opportunities for Emerging Nuclear Countries

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Emerging Nuclear Countries

More than 60 countries have expressed their interest or declared their intention to introduce nuclear power

Asia:

1. Azerbaijan
2. Bangladesh
3. Georgia
4. Iran
5. Kazakhstan
6. Mongolia

Africa:

1. Ghana
2. Namibia
3. Nigeria
4. Senegal
5. Uganda

SE Asia:

1. Australia
2. Indonesia
3. Malaysia
4. New Zealand
5. North Korea
6. Philippines
7. Singapore
8. Thailand
9. Vietnam

Arab-world:

1. Algeria
2. Egypt
3. Israel
4. Jordan
5. Libya
6. Morocco
7. Saudi Arab
8. Syria
9. Tunisia
10. UAE
11. Yemen

Europe:

1. Albania
2. Belarus
3. Estonia
4. Ireland
5. Italy
6. Latvia
7. Norway
8. Portugal
9. Poland
10. Serbia
11. Turkey

South America:

1. Chile
2. Ecuador
3. Venezuela

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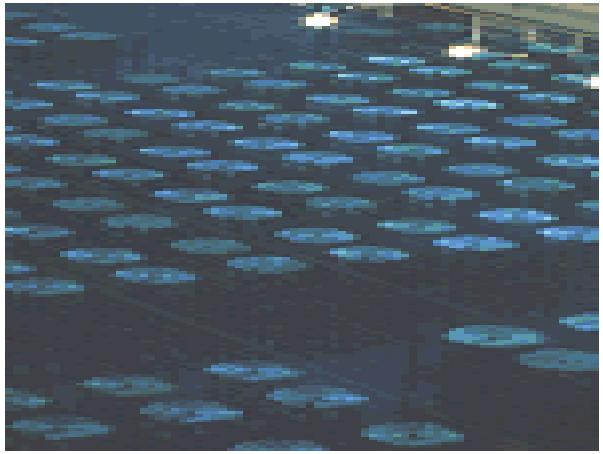
Introduction of Nuclear Power

- The introduction of nuclear power will result in the generation of spent nuclear fuel that require
  - Safe
  - Secure
  - Efficient management
- Countries will have to
  - Establish a Clear SNF Policy
  - Address the political, environmental, economical and technical issues associated with SNF

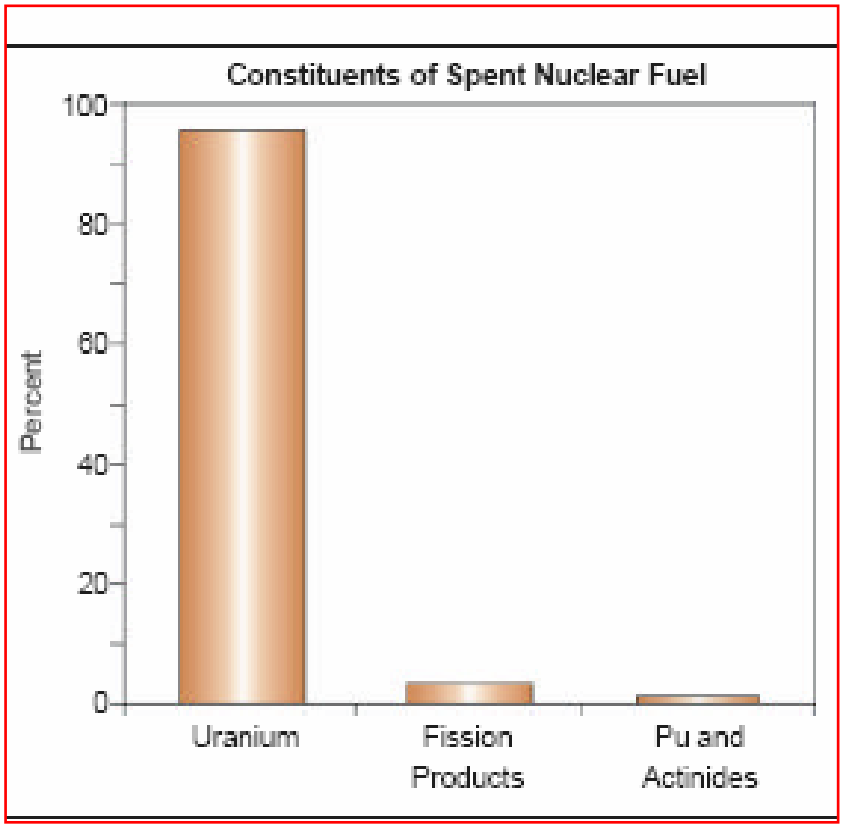


SNF Generated Annually

- A typical 1000 MWe light water reactor will discharge per year approximately
  - 27000 kg of spent fuel
  - Having a volume of 20 m^3
  - Requiring a disposal volume of 75 m^3
- Worldwide over 10,000 tons of heavy metal (HM) are produced annually from 443 nuclear power reactors 2005
- The total amount of spent fuel generated worldwide in the 52 year history of civilian nuclear power is around 280,000 t HM 2005

Constituents of Spent Nuclear Fuel

- 95.6% Uranium
- 3.0% Stable/Short-lived fission products
- 0.9% Plutonium
- 0.3% Cs / Strontium
- 0.1% Minor Actinides



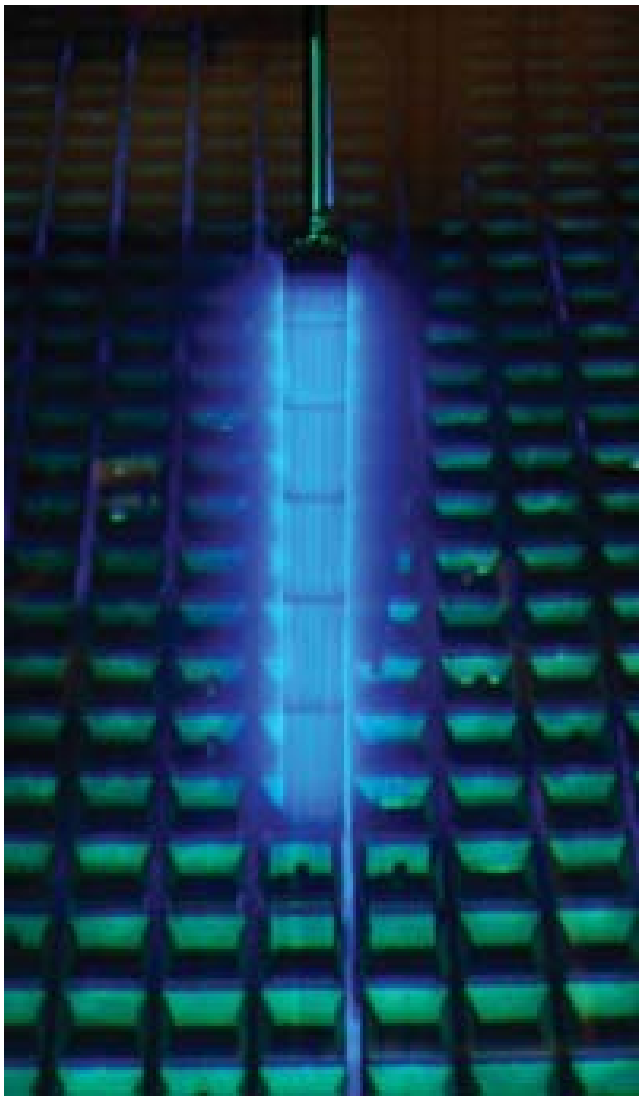
- 97% can be used to manufacture new nuclear fuel
- Resulting in dramatic reduction of HLW

Spent Fuel Managment Options

- Wet storage
  - SNF pool at Reactor site
  - Fuel pool at Reprocessing plant
- Dry cask storage
  - At Reactor site
  - Away from Reactor site
- Reprocessing
  - About 30% of spent fuel in the world has been reprocessed
- Geological Repository
  - No geological repository for SNF or high level waste (HLW) has yet been built and operated in the world

Spent Fuel Storage

- Most countries have adopted a wait and see position
- Spent fuel storage for long periods (100 years) is being adopted
- Spent nuclear fuel is initially stored as spent fuel assemblies in water-filled pools on power plant sites
- The pools provide radiation shielding and cooling
- New NPP designs can accommodate the SNF for the life of the plant



Dry Cask Storage

- Spent Fuel is usually placed in dry cask storage after 5 years in wet storage
- Dry cask storage uses concrete or steel containers as a radiation shield
- It is cooled by inert gas or air
- The casks are built to withstand the elements and accidents
- Do not require electricity, water, maintenance, or constant supervision

Nuclear Fuel Reprocessing

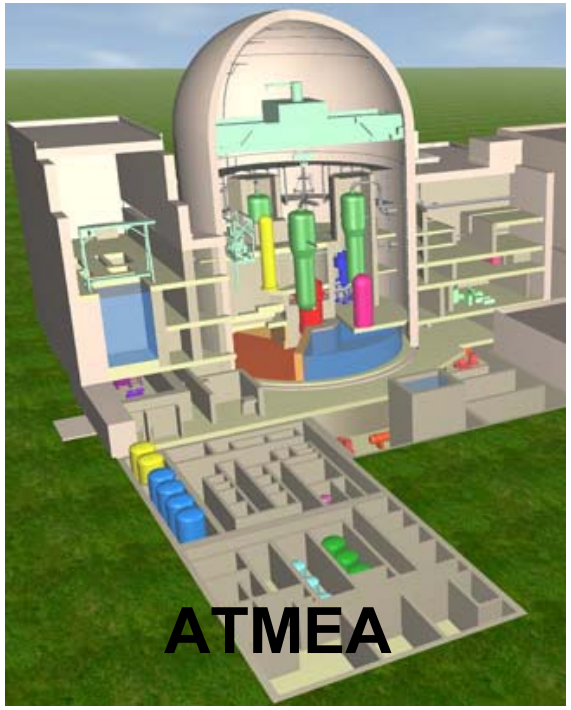
- Reduce Spent Fuel to be disposed of as HLW about
  - Only 3 % of the original fuel quantity remains as HLW
  - The 27000 kg/ Yr. of HLW is reduced to about 800 kg
  - After vitrification and packaging the waste will be contained in 5 tons of glass
  - Packed in about twelve small canisters with a total volume of less than 4 cubic meters
- Reclaim Spent Fuel's Valuable Energy by recovering unused uranium and plutonium
  - 97% of the spent fuel can be used again in manufacturing fresh fuel
  - 230 kilograms of plutonium is separated in reprocessing
  - Saving about 30% of the natural uranium otherwise required

Chalenges of SNF Reprocessing

- Reprocessing is a sensitive technology
- Emerging countries will not be allowed to posses it
- Must rely on commercial services in nuclear developed countries
  - United Kingdom
  - Japan
  - France
  - Russia
- Limited capacity of commercial reprocessing plant in the world (5800 t HM/yr)
- Difficulties of transporting SNF to Europe, Japan or Russia
- Cost

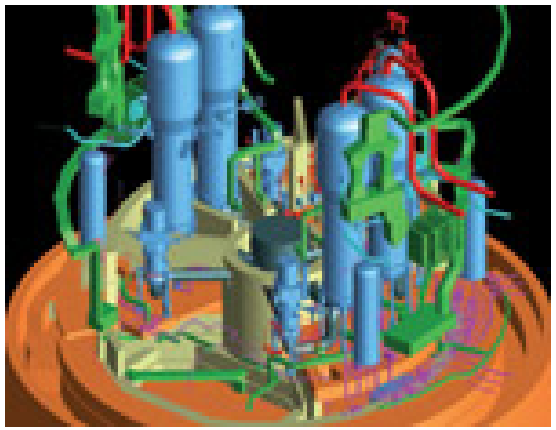
Opportunities for Small Countries

- Nuclear industrial nations are eager to penetrate the emerging markets for the sale and services of NPP
- Nuclear fuel services including the back end can be negotiated as part of the NPP contract
- Vender countries have discussed such options
- This presents unique opportunities to a small country



Opportunities for Small Countries

- **Fuel take-back**
  - This is probably the best option for any nuclear country
  - Russia and China may offer such services with NPP sale and fuel supply
  - USA may consider such services out of proliferation concerns
- **Reprocessing**
  - France, Japan and Russia may offer such services with NPP sale and fuel supply



Questions

Thank You