Management of Spent fuel from PHWRs in India--An Integrated approach

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Three stages of Indian Nuclear Energy Programme

In the Indian context closed fuel cycle approach is the best option.
NUCLEAR FUEL CYCLE

Geological disposal

URANIUM MINES & MILLS → CONVERSION TO OXIDE → CONVERSION TO FUEL

RECOVERED URANIUM → PLUTONIUM

REPROCESSING → REACTOR

WASTE STORAGE → WASTE MANAGEMENT

BY PRODUCTS FOR USE IN MEDICINE, AGRICULTURE & INDUSTRY
Flow Sheet of Recycling

- Spent Fuel Storage
  - Chopping & Dissolution
    - Hull Waste
      - Pu Purification
        - Oxide Conversion & Storage
      - U Purification
        - Oxide Conversion & Storage
    - Co-Decontamination & Partitioning
      - Raffinates
        - Waste Management
- Waste Management
Waste Management

- Reprocessing
  - Hull Waste
  - Cs/Actinide Separation
- Evaporation
  - LLW
  - ILW
  - HLW
    - Cs Pencil for Irradiators
    - Air cooled vault (VWSF)
- Compaction & Storage
- Long Term Storage Facility
- Long Term Storage
- Disposal in SWMF
  - Cement Drums
  - Canisters

- Raffinates
  - Delay tank
    - Effluent to sea

- Int Conf on Spent Fuel Management, Vienna, June 15–19, 2015
Objective of An Integrated Recycle Facility (IRF)

- Works on solid-in solid-out concept
- Designed to Recycle spent fuel from Pressurized Heavy Water Reactors (PHWRs) (220 & 540 MWe).
- Depleted Uranium and Plutonium from these plants will be supplied for FBRs and Advanced Heavy Water Reactor Programme
Plutonium

Uranium

Cs 137, Actinides

Vitrified Waste Canisters In Air Cooled Vault

Compacted Hull Canisters In Shielded Vault

Non Hull Alpha Waste In Shielded Cells

Long Term Storage

Plant inputs

Spent Fuel

Inactive Chemical

Interim Storage

Recovery

Discharge

Gaseous / Liquid Discharge (As Low As Reasonably Achievable)

Short Lived Waste For Disposal

Objectives of Integration

- Integrated management & responsibility for back end fuel cycle activities
- Reduced Capital and O&M Cost
- Standardization in all stages, from design to Commissioning
- Optimised Man /material movement
- Minimise duplication of systems/ equipment
INTEGRATION

Common Process Evaporation & Analytical Labs Integrated

Common Services & Utilities Integrated

Reprocessing & Waste Management

Block Wise Process Integration

Operation/ Monitoring Of Entire Facility from Central Control Room
Main Blocks concept

- Spent Fuel Storage Block
- Process Block
- Evaporation & Storage Block
- Control & Reconversion
- Vitrification Block
- Control Room Block
- Nuclear Material Storage
- Vitrified Waste Storage
- Hull Compaction & Storage
- Utility & Services Block
Utilities–Benefits

- Reduction in overall capital cost
- Common utilities
- Reduced man power
- Ease of O&M

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- Steam condensate recovery and reuse – Reduce water consumption
- Energy conservation concepts adopted
- Centralized supply & exhaust air blocks
- Dedicated Exhaust filter banks in each block
- Standardization of equipment for ease of O&M
Segregation of Services Lines

• A two tier Personnel cum service corridor connects all process blocks and will carry about 25 services lines
Integrated Main Control Room For All Process Blocks.

Six Control Centers In One Control Room.

- Radiation Monitoring Systems Integrated With I&C

Secondary Control Room For Initial Commissioning And Back Up Requirements.

- 25,000 Input/Outputs PLC/SCADA

Provision For Online Monitoring And Diagnostics Of I&C Systems
Wet Storage concept followed
Minimum 3 year cooled fuel from PHWRs
Provided with safety systems like
- Pool water cooling system
- Pool water polishing system
- Single failure proof EOT Crane
- Ventilation system
- Infiltration Gallery
- Leak collection and Detection system
- Pool water level, Temp and Radiation monitoring system
The spent fuel storage tray stack is qualified for seismic stability.

The EOT cranes and Pool Bridge have anti toppling lugs and are qualified under DBE.

Ground water table is maintained below raft of pool by an Infiltration system.

The cooling system is functional under external event and has dedicated Class III power supply.

Additional water filling provision given in event of extended power outages.

Provision for handling and storage of failed fuel bundles.
New Technologies being implemented

- Automation in Fuel Transfer (DFTS)
- Common Multiple (gang) type Spent Fuel Chopper (SFC) for both types (37 pin and 19 pin) fuel bundle
- Linear Auto Sampler (LAS) for automated sampling
- Remote Maintenance device for metering pumps
- Hull compaction for volume reduction and assaying
- Cs removal and production of Cs pencil source
- Extensive use of Power Manipulators and remote devices
- Improved Material of Construction
Direct Fuel Transfer System

Remote Pump Maintenance

Linear Auto Sampler
Main Waste Management Blocks

- Waste Evaporation Block
- Vitrification Block
- Vitrified Waste Storage Block
- LLW, ILW & OLW Blocks
- Hull Compaction & Storage Block
Waste Evaporation

- A Centralized facility for waste evaporation and storage.
- Has Sub–cells for TSEs with provision of replacement with minimum downtime.

This block also houses following Processes

- U Separation for more oxide loading in vitrification
- Provision for separation of Cs and Actinides for effective waste management
Vitrification

- Vitrification by Two Independent JHCM Systems, each having 100% capacity

- Dedicated common Decommissioning Cell

- Roll-in & Roll-out concept for Melter replacement
Vitrification contd..

- High capacity melter for vitrification of HLW

- Immobilisation of higher activity per canister

- Designed for remote replacement

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Vitrified Waste Storage

- Stacking of four canisters in each thimble tube
- Stack assisted natural convection cooling
- Provision for HEPA filtration
Hull Compaction

- The facility has been designed for the first time in India and facilitates remote operation & maintenance.
- Large hull volume from high capacity plant necessitates compaction of hull wastes.
- Volume reduction factor achieved is 5 by using 2000 Te Supercompactor.
Recent Developments in Waste Management

- Novel Solvents have been Developed for minimisation of long term radio toxicity of the waste by following 3 major steps.

1) Separation of residual U & Pu from HLW
2) Separation of fission products like Cs & Sr
3) Bulk separation of trivalent actinides along with lanthanides from U lean HLW
OVERALL SOCIETAL BENEFITS OF WASTE REDUCTION

- Volume of High Level Vitrified waste generated for power consumption of an average family for entire life
- Volume of waste if actinide is also separated from HLW
THANK YOU