Nuclear Energy

Questions:

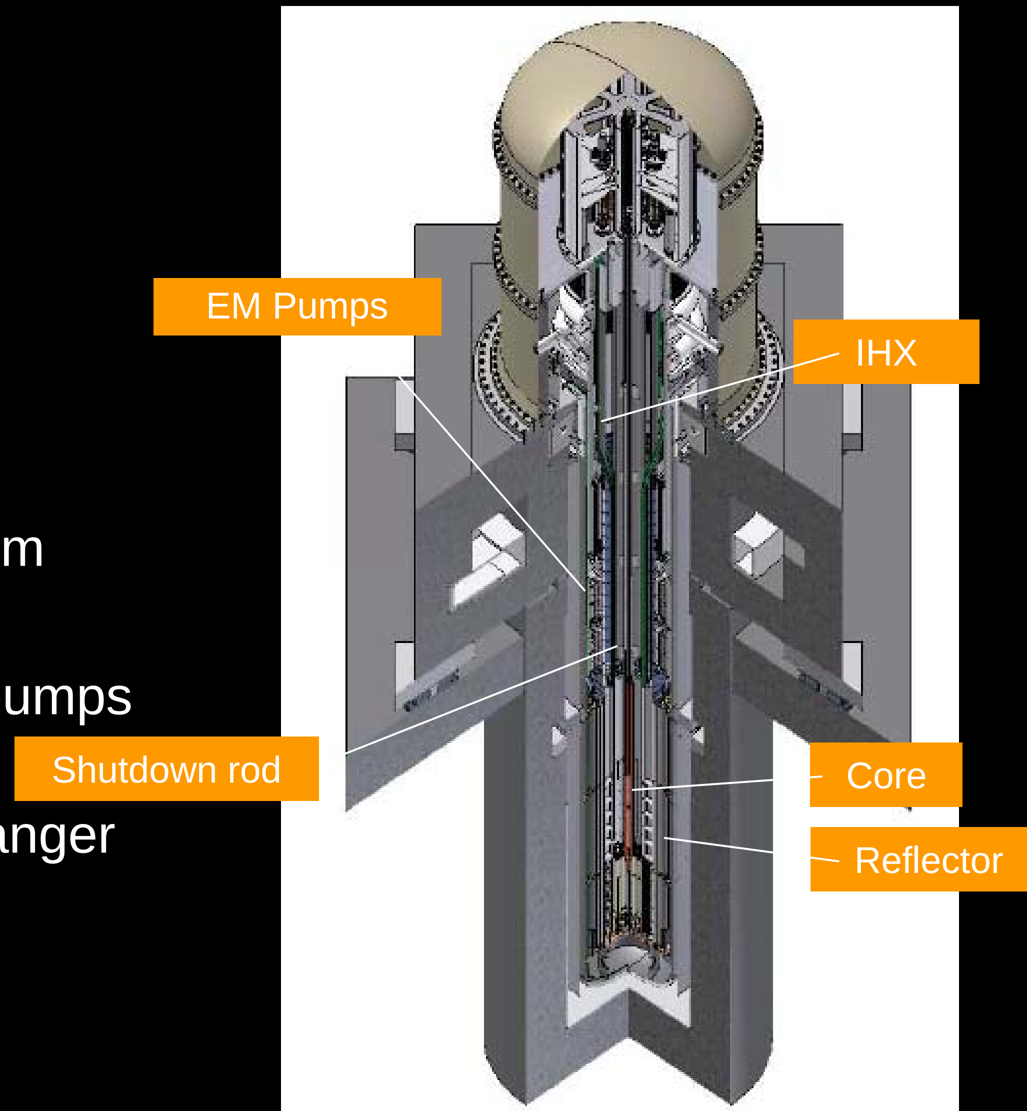
1. What about 3 mile Island?
2. What about Terrorists?
3. What happens to the waste?
4. How do you handle an emergency?

Nuclear Battery

- Battery

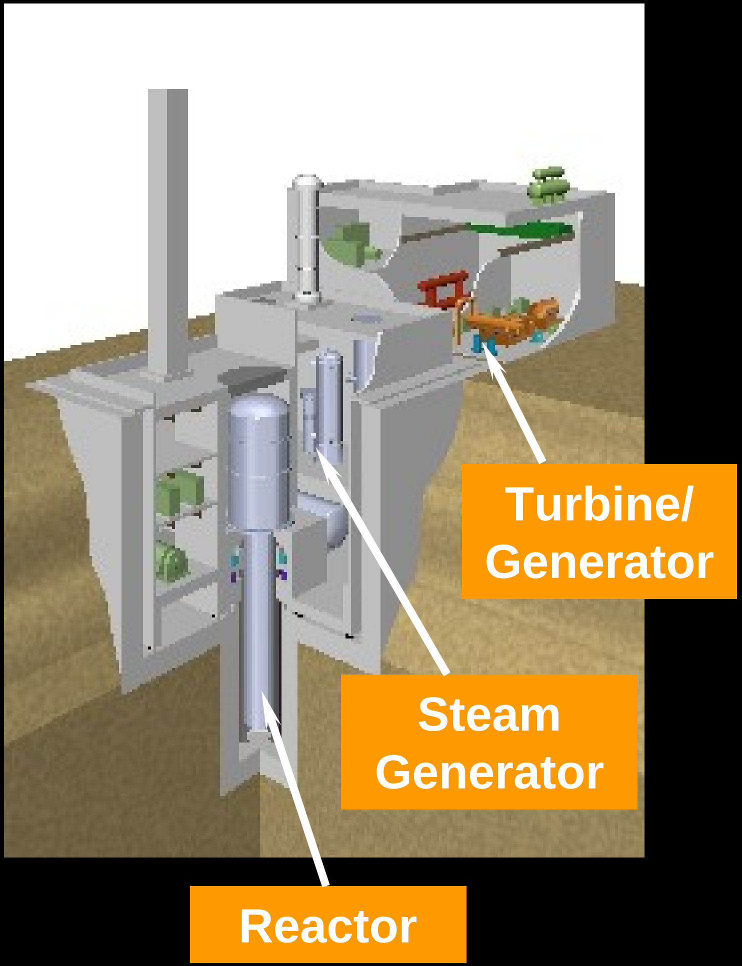
Plant Description

- **Reactor**
  - Core
    Metallic fuel core (U-10%Zr)
  - Reactivity control
    Movable reflectors
  - Shutdown system
    Shutdown rod and reflectors
  - Primary heat transport system
    - Pumps: Annular type
      Electro-magnetic (EM) pumps
    - IHX: Annular type
      intermediate heat exchanger



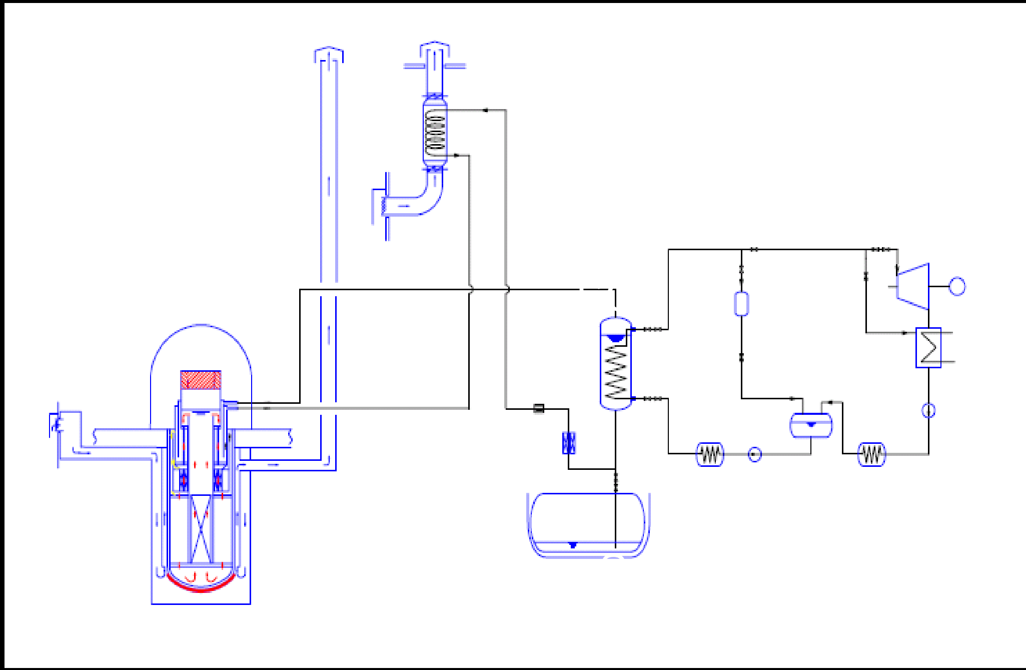
Overview

- **Sodium cooled fast reactor**
- **30 MWt (10MWe)**
- **Application**
  - Remote areas of small power demand (e.g., Galena Alaska)
  - Considered a candidate for GNEP grid-appropriate small and medium reactor design
- **Main features**
  - Passive safety
  - No onsite refueling for 30 years
  - Low maintenance requirement
  - High inherent security



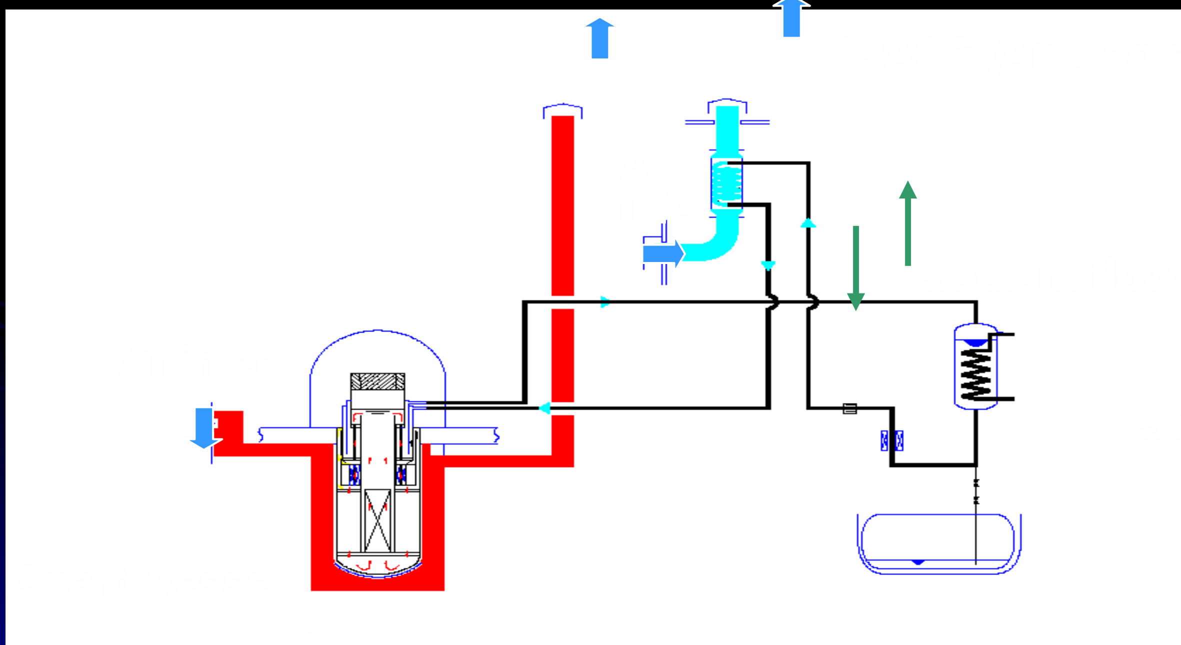
Plant Description

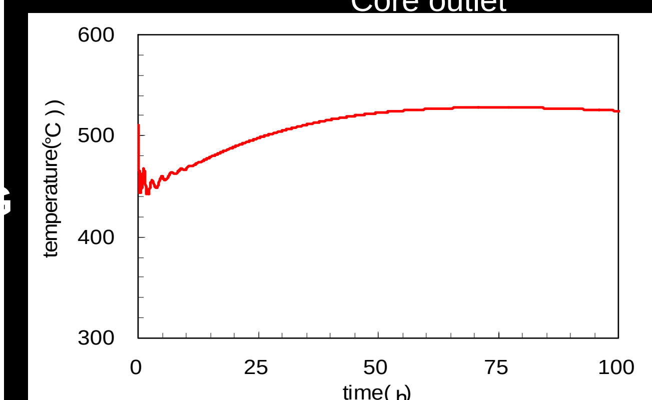
- **Heat transport systems**
  - Primary heat transport system: Inside the reactor
  - Intermediate heat transport system
    - Steam generator
    - EM pump
    - Air cooler
    - Dump tank
  - Water & steam system
    - Turbine Generator



Passive Decay Heat Removal

- **Heat removal by natural circulation & natural air draft**
  - RVACS: Natural air draft outside the guard vessel
    - Sufficient cooling capacity by only RVACS
  - IRACS: Natural circulation of sodium and air draft of air cooler

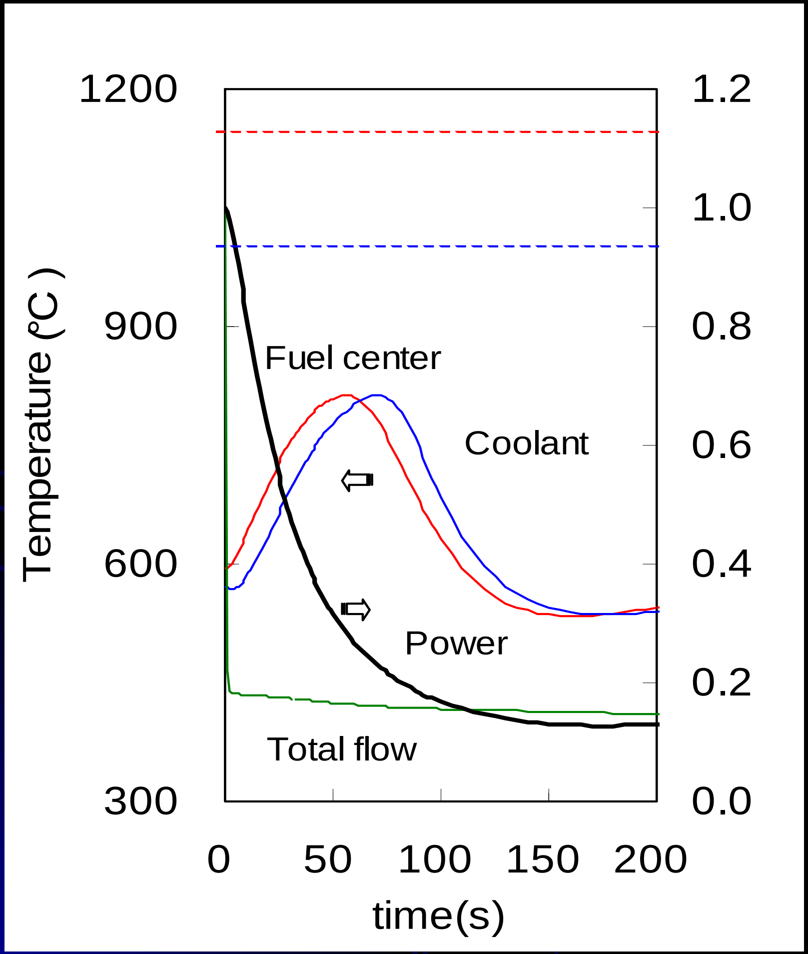


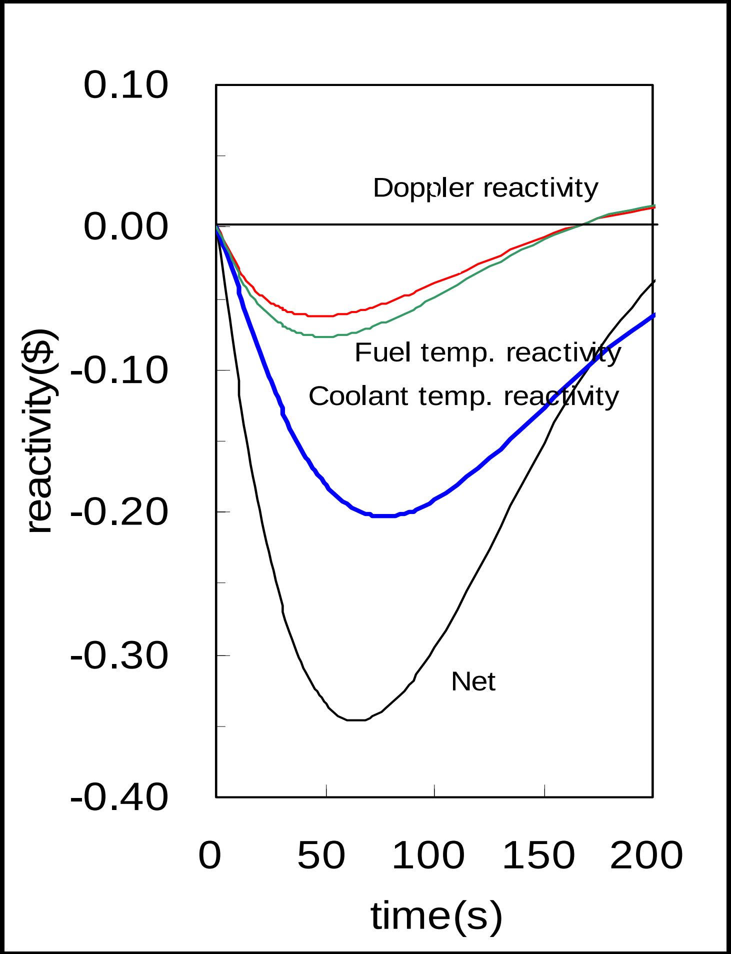


Loss of offsite power
Assumption : Heat removal by only RVACS

Passive Shutdown for Unprotected Events

- Safety Analysis of Unprotected sudden loss of flow
  Large margin to coolant boiling and fuel melting





Main Design Features

- Safety Features
- Key Features of 4S
  - Passive safety
  - No onsite refueling for 30 years
  - Low maintenance requirement
  - High inherent security

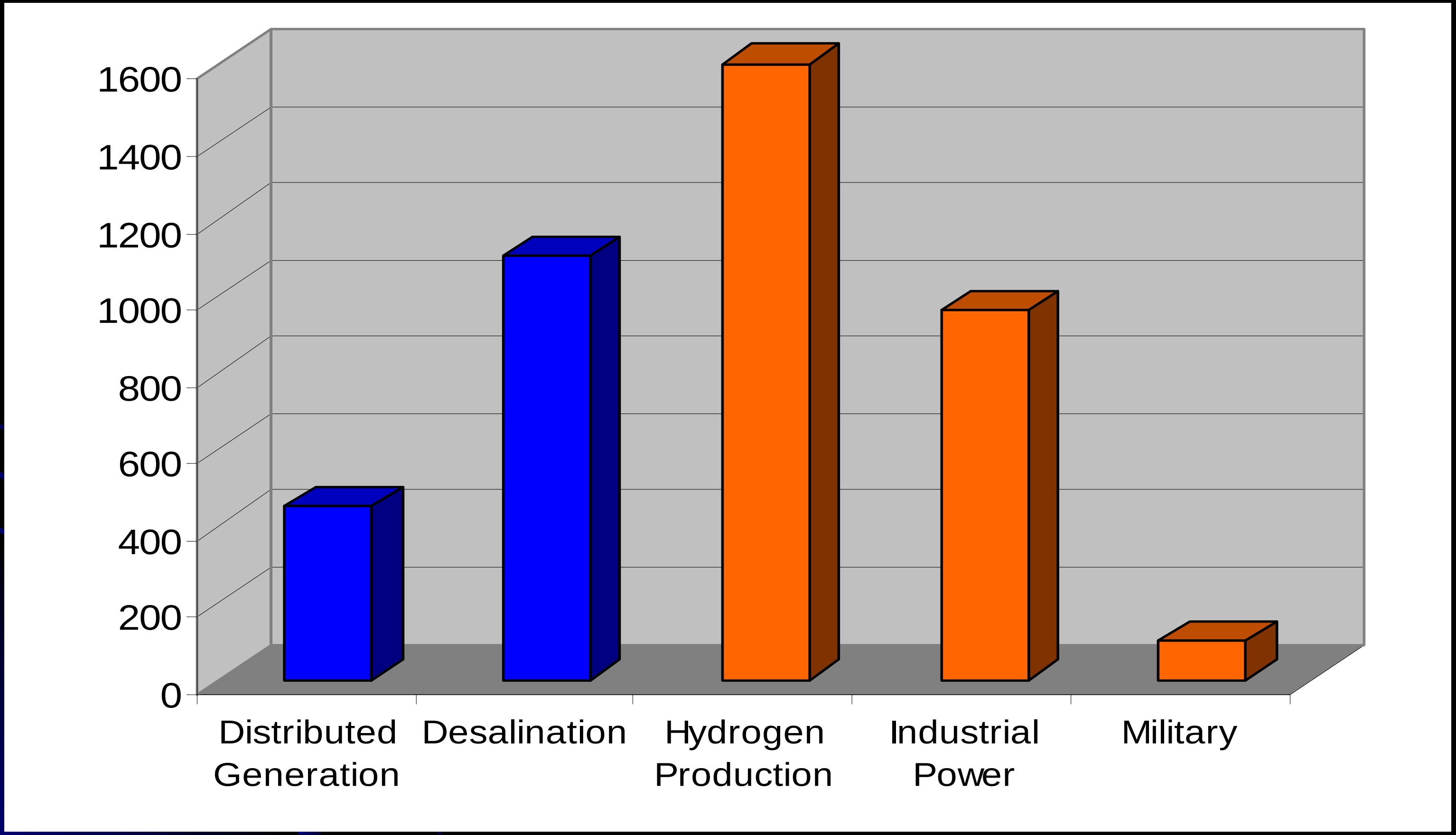
Safety Features

- Low pressure system with pool design and guard vessel
- Negative coolant temperature coefficient promotes safe, stable operation.
- Large margin to coolant boiling or cladding failure
- Reliable, redundant and diverse scram systems
- Smaller excess reactivity with metallic fuel core design – limited potential for reactivity insertion accident
- Passive, reliable, and diverse shutdown heat removal systems

Tests to Support 4S Design

Design Feature	Verification Item	Required Testing	Status
Long cylindrical core with small diameter	Nuclear design method of reflector control core with metallic fuel	Critical experiment	**Done**
Reflector controlled core			
High volume fraction metallic fuel core	Confirmation of pressure drop in fuel subassembly	Fuel hydraulic test	**Done**
Reflector	Reflector drive mechanism with fine movement	Test of reflector drive mechanism	**Done**
RVACS	Heat transfer characteristic between vessel and air	Heat transfer test of RVACS	**Done**
EM pump	Structural integrity Stable characteristics	Sodium test of EM pump	**Done and Planned**
Steam generator (Double wall tubes)	Structural integrity Heat transfer characteristic Leak detection	Sodium test of steam generator Leak detection test	**Done and Planned**
Seismic isolation	Applicability to nuclear plant	Test of seismic isolator	**Done**

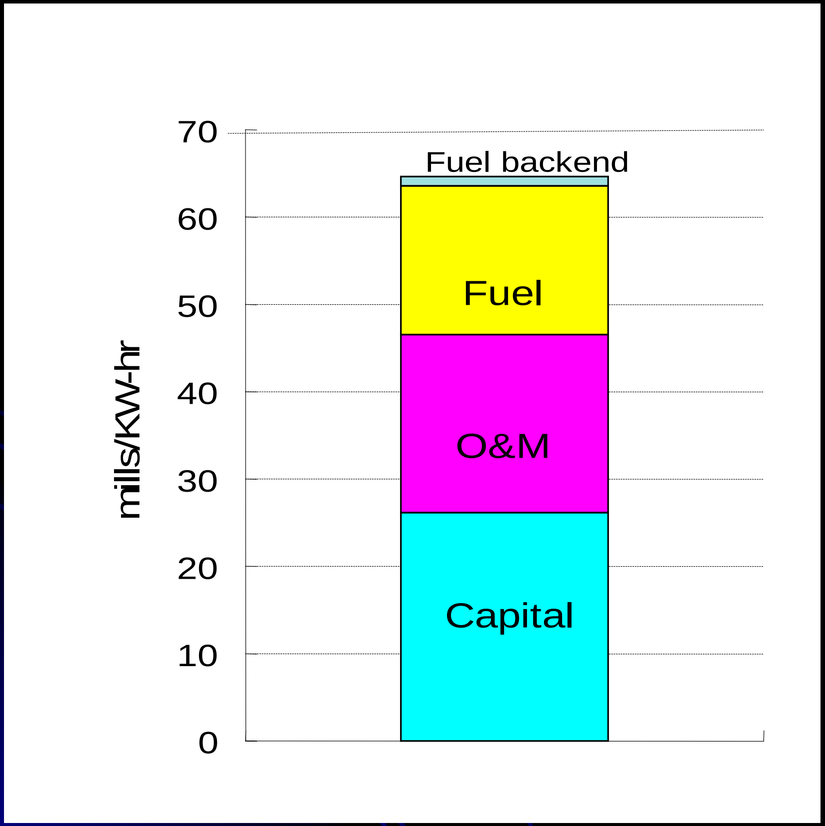
Small Reactor Market Niche Program Plan



Sample Commodity Costs – 10 Megawatts of Electricity Equivalent

Commodity	Production Rate	10 MWe Yields:	Comments
Electricity	10 MW	240,000 KW/day	
Oxygen	567 scf/min	817,071 scf/day	Assume electrolysis process using Teledyne Titan HP generator
Hydrogen	1134 scf/min	1,634,143 scf/day	Assumes electrolysis process using Teledyne Titan HP generator
Desalinated Water	6,381 gpm	9,188,522 gpd	Assumes Salt Water Reverse Osmosis process with 35,000 ppm TDS input and producing 350 ppm TDS output

4S Preliminary Cost Estimate



- 50MWe (135MWt) :
  10 MWE variant
- Commercial_plant
  (mass production phase)
- Plant Construction:
  $ 2,500 $3,000/KWe
  Busbar Cost:
  $.065 mills-$.070 /KW-hr*

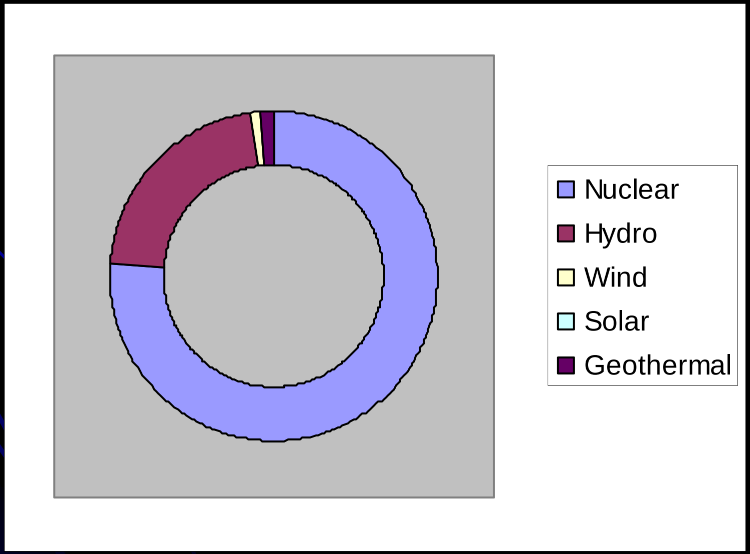
Mohamed ElBaradei

One potential strategy is to construct hundreds of mini-nuclear power plants that would each serve a single village, said ElBaradei. These plants would be less expensive than their full-size counterparts and could be set up without a need for an extensive power grid. In addition, the small-scale plants could be made with sufficient safety features to prevent meltdown and theft. This includes a passive cooling system that works even if power is shut down, said researchers this summer at Argonne National Laboratory. The reactors could also run for 30 years without the need to refuel, and any theft would require the use of large and conspicuous gear that could be visible by satellite, according to Argonne's senor technical advisor David Wade.

Nobel laureate Mohamed ElBaradei, director general of the International Atomic Energy Agency, gave this year's David J. Rose Lecture on "Nuclear Technology in a Changing World: Have We Reached a Turning Point?" Photo / Donna Coveney

Emission Free Energy in the United States

Nuclear	Hydro	Wind	Solar	Geothermal
76.20%	21.60%	0.70%	0.10%	1.40%



Vision for the Future

- The natural gas pipeline,
- Geothermal development at Mt Spurr,
- Hydroelectric projects,
- Wind projects,
- Nuclear power
- Coal to liquid project

Toshiba 4S Project

☺Thank You

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