Recycling Reactor: PRISM

✓ Advanced Conceptual Design
  • Already paid for by USG
  • Available today

✓ NRC “…no obvious impediments to licensing…”
  • Prudent starting point

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1981-1984
GE Program
• GE funded
• Innovative design approaches

1985-1987
PRISM
• DOE funded $30M
• Competitive LMR concepts

1988
PRDA
• DOE funded $5M
• Continuing trade studies

1989-1995
ALMR
• DOE funded $42M
• Preliminary design
• Regulatory review
• Economics
• Utility advisory board
• Commercialization
• Tech development ($107M additional)

1995-2002
S-PRISM
• GE Funded
• Improved economics
• Actinide burning scenarios

2007-2009
GNEP
• Demo reactor
• Actinide burning
• Commercial
• Best practices
• Advanced power conversion cycle
What it is?
PRISM power block is . . .

- Two reactors
- Drives one turbine
- 622 MWe output
Power Reactor Innovative Small Module (PRISM)

- Modular nuclear reactor that uses nuclear waste as fuel
- 311 MWe (840 MWth) per reactor
  - Two reactors per turbine-generator
  - 6 reactors/site - 1866 MWe
- Fuel for PRISM fabricated on-site in NFRC
- Features advanced safety and digital control systems
- Modular components allow for factory fabrication
How it works?
Reactors: sodium and water cooled

PRISM

- Consume “waste”
- Consume U235
- 400 w/cm³
- 300 w/cm

BWR

- Produce “waste”
- Consume U235
- 60 w/cm³
- 200 w/cm

Should not be an “either/or”

Two reactor system affords better resource utilization: uranium reuse and waste-to-watts
Neutron flux

Neutrons are born at the same energies in both systems... in a fast reactor they stay at those energies.

Courtesy W. Yang, ANL
Transuranics will fission more often than capture at fast energies.
Burners versus Breeder

Breeder

1.3

Blankets

Active Core
840 MWt

Breakeven

1.0

Active Core
840 MWt
$\Delta k_c = 0.5$

Burner

0.7

Active Core
840 MWt
$\Delta k_c = 9.0$

As core height decreases:

• Breed ratio 32%*
• Linear heat ratio 13%*
• Reactivity swing 1,698%*

* Between breakeven and a breeding ratio of 0.7
Reactivity swing

Sign varies with conversion ratio
- $\Delta k$ negative for actinide burning
- $\Delta k$ positive or approx. 0 for breeding
391 Hexagonal Ducts Make a PRISM Core

- Fuel assemblies DO NOT move
- Blanket assemblies are shuffled
- Reflectors: rotated every cycle (removed after 10 cycles)
- Control Rods
- GEM’s
- Ultimate Shutdown
- Shield assemblies: rotated every cycle (removed after 6 rotations)
Methods

Whole-core neutronics

Relative fast reactor flux profile

Total Flux

Shield | Reflector | Core
The pool reactor: GDC 35 does not apply
Passive Systems versus Active Systems

Reactor Vessel Auxiliary Cooling System (RVACS)
PRISM power extraction cycle
Steam generators
Basic design features of reactor and balance-of-plant

Simple Conservative Design
- Passive decay heat removal
- Passive accommodation of ATWS events
- Automated safety grade actions

Simplified O&M
- Safety grade envelope confined to NSSS
- Simple compact primary system boundary
- Low personnel radiation exposure levels

Reduced Capital and Investment Risk
- Factory fabrication of standard certified design
- Modular construction and seismic isolation

Minimized Required R&D
- Low temperature
- Small and simple system configuration
To build PRISM means to license PRISM

3 Paths
Working Together

Engineering Design
Status: 30%
Design: Hybrid
✓ PRISM based design
✓ S-PRISM adv. features
   - Seismic isolation
   - Containment
   - HCSG Relief System

Path 1
Licensing
- Update Licensing Strategy
- Start Pre-Application Meetings
- Submit a PSER or DCD

Path 2
Simulation
- Build Analytical Simulator
- Start Design Optimization
- Select Component Scale Model
- Testing

Path 3
Component Testing
- Fabricate Select Components
  - Reactor Vessel (USA Built!)
  - Fuel Handling Equipment
  - EM Pump
- Test Components

Recycling Reactor Deployment
- Integrate simulation into design process
- Optimize, validate, and iterate prior to construction

Benefits:
- Reduced time to deploy prototype
- Take advantage of existing LWR processes
- Optimize design through iteration