Future Directions: Toward Higher-Temperature Reactors

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OAK RIDGE NATIONAL LABORATORY

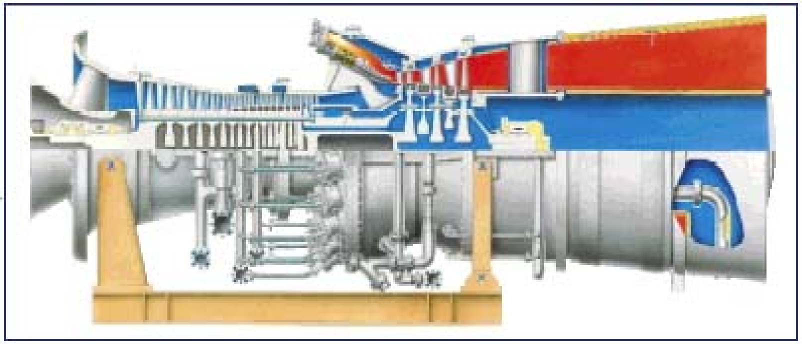
Thesis

New Technologies and New Needs Are Driving the Interest in Higher-Temperature Reactors

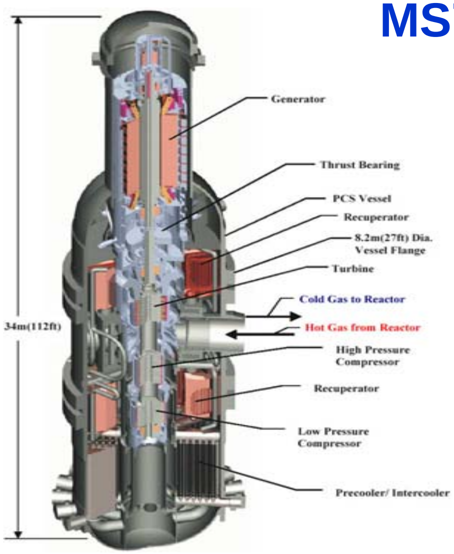
High-Temperature Reactors Drive the Need for Innovative Fuels

Brayton Cycles Enable Cost-Effective High-Temperature Reactors

- **Steam turbines (with a 550ºC peak temperature) have been the only <u>efficient, industrial method</u> to convert heat to electricity**
- **High-temperature reactors have been non-competitive, partly because there was no efficient method to convert high-temperature heat to electricity**
- **Development of large efficient high-temperature Brayton cycles <u>*in the last decade* makes possible economic higher-temperature reactors</u>**

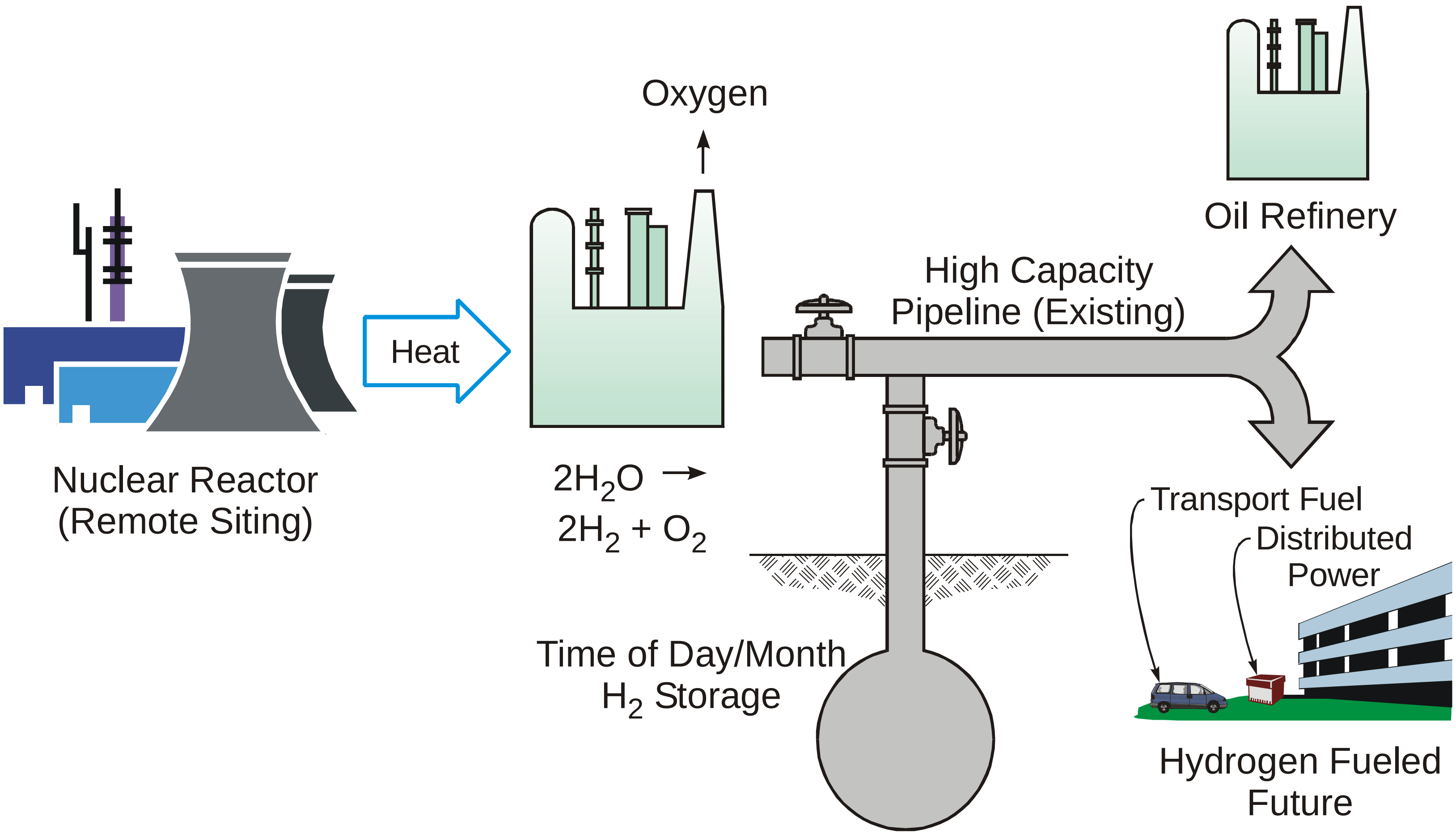


GE Power Systems MS7001FB



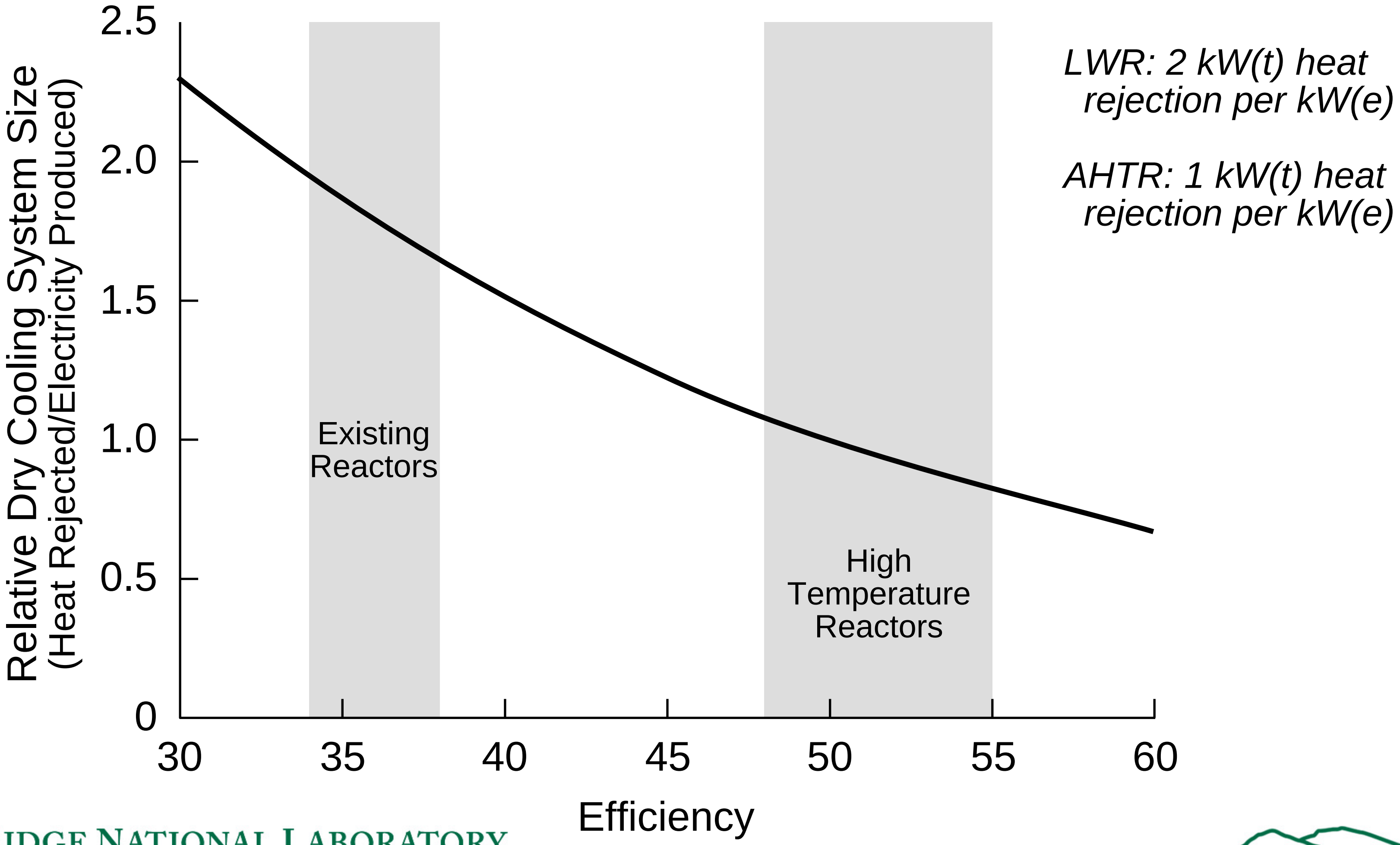
General Atomics GT-MHR Power Conversion Unit (Russian Design)

Hydrogen Production Requires High-Temperature Heat (700-850ºC)

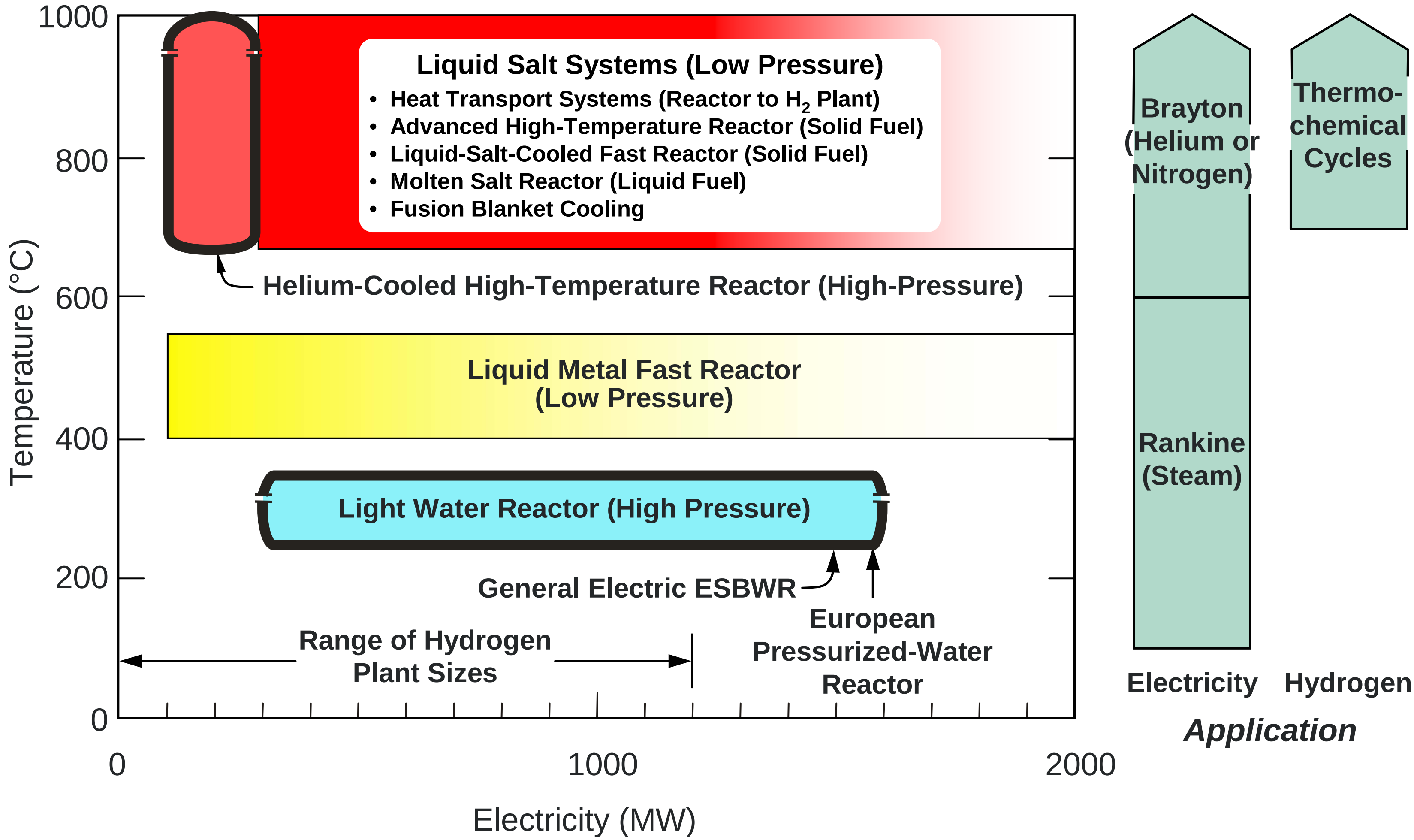


Water and Energy Conflicts Abound

Higher-Temperature Reactors Enable Dry Cooling and Open Up Power Plant Siting

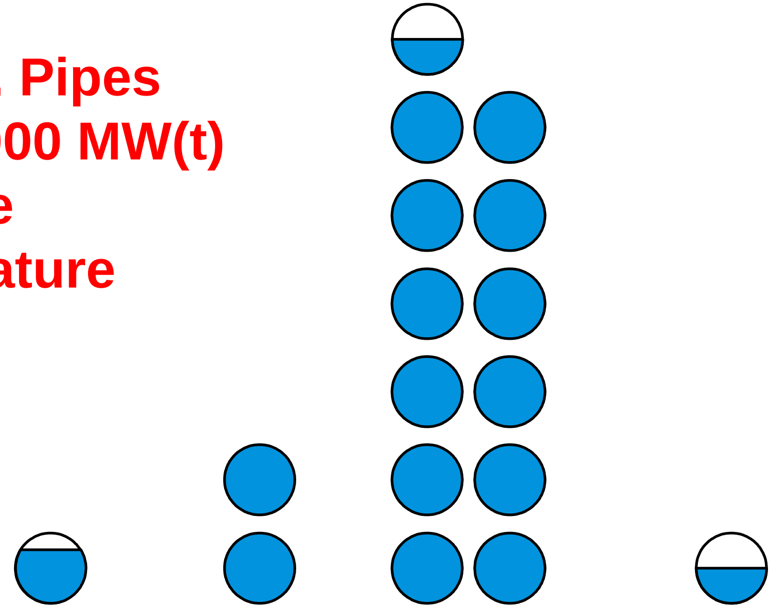


Schematic of Reactor Options By Coolant Temperatures and Reactor Size



Properties of Gases Support Use in Smaller Modular Reactors; Properties of Liquids Support Use in Large Reactors

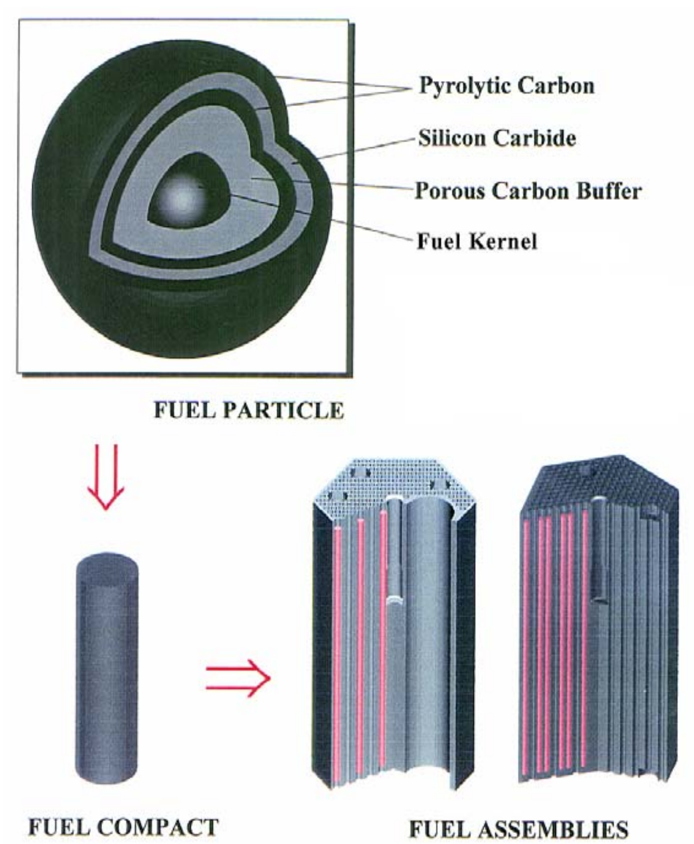
Number of 1-m-diam. Pipes Needed to Transport 1000 MW(t) with 100ºC Rise in Coolant Temperature



	Water (PWR)	Sodium (LMR)	Helium	Liquid Salt
Pressure (MPa)	15.5	0.69	7.07	0.69
Outlet Temp (ºC)	320	540	1000	1000
Coolant Velocity (m/s)	6	6	75	6

Very High-Temperature Reactors

One Fuel Option



Two Coolant Options

Helium

High-Pressure

Transparent

Liquid Fluoride Salts

Low Pressure,

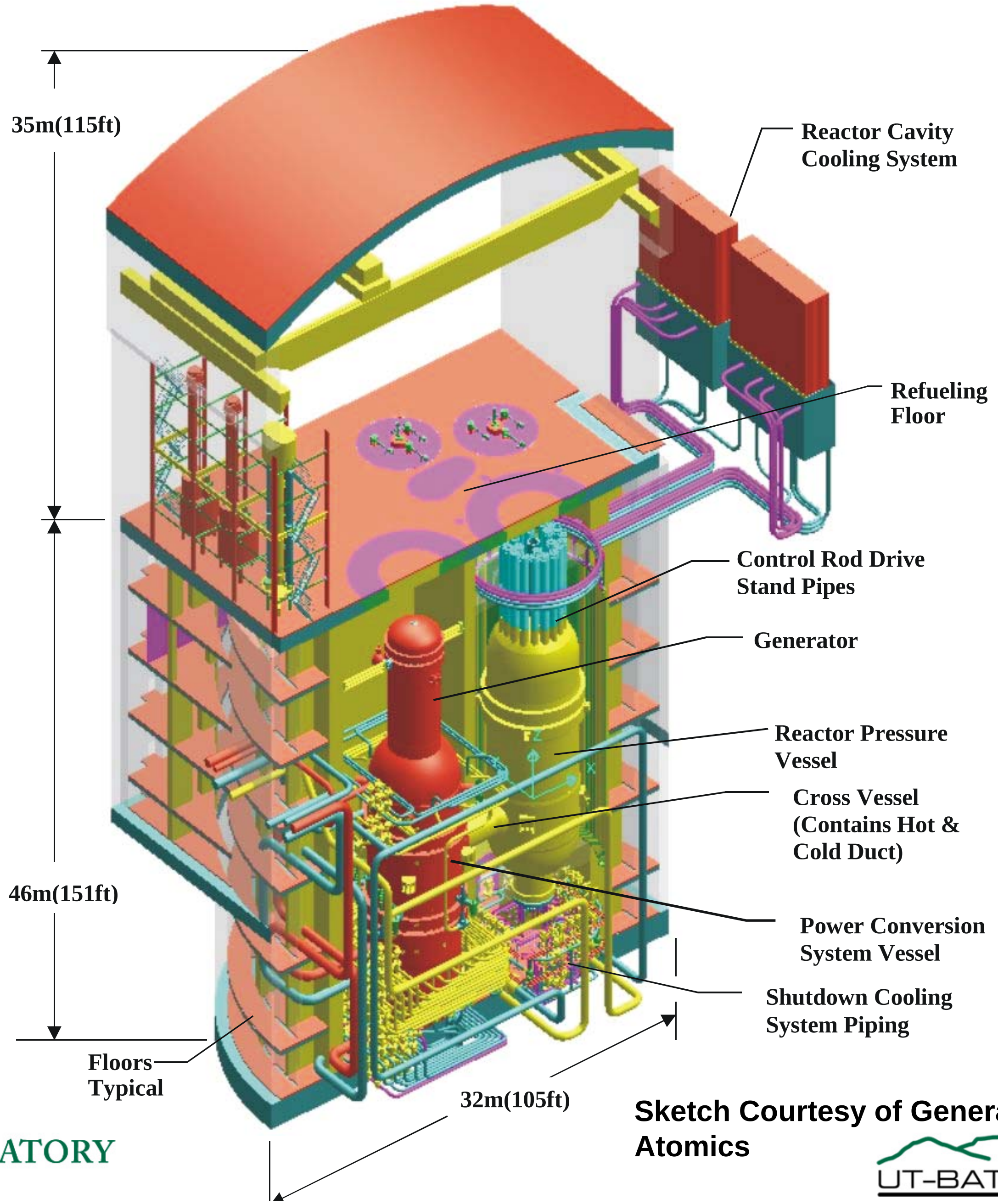
Transparent

Gas-Turbine Modular Helium Reactor

Graphite-Matrix Fuel

Helium Coolant

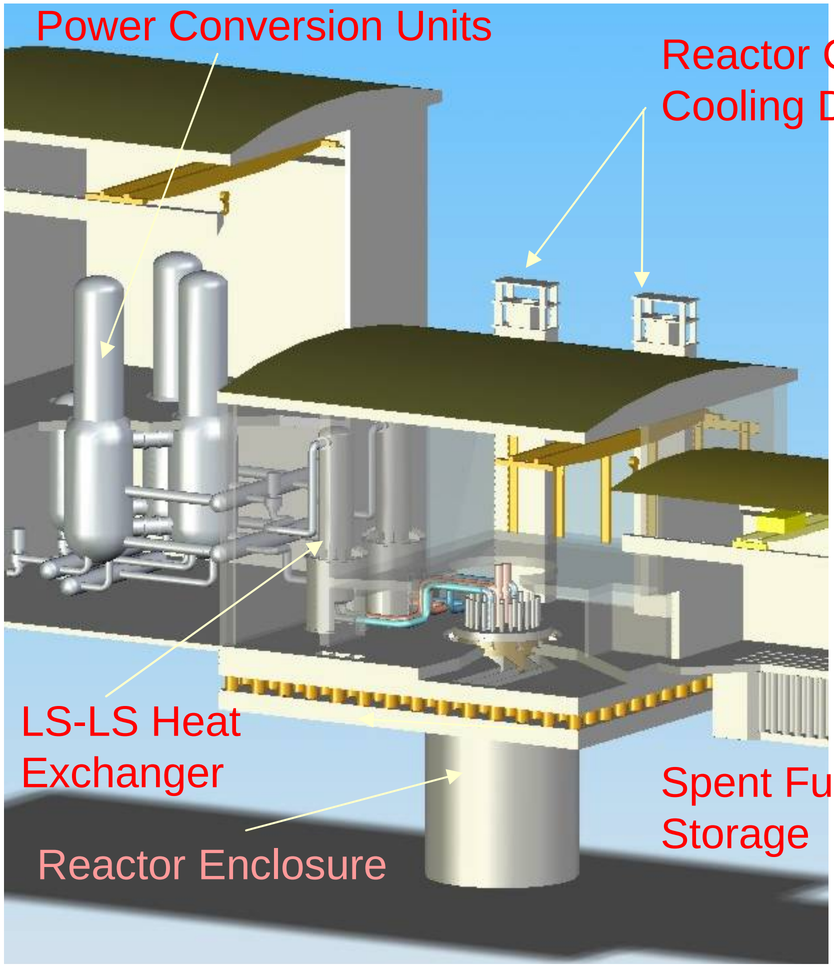
600 MW(t)

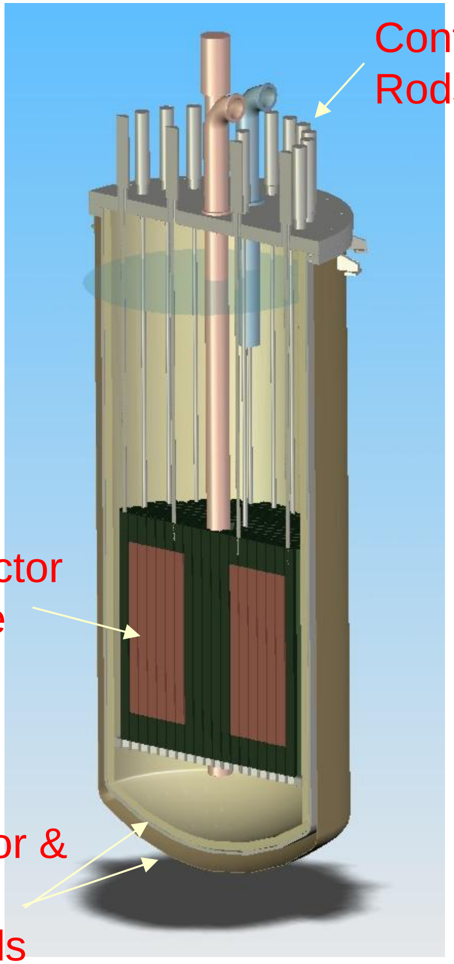


Sketch Courtesy of General Atomics

Advanced High Temperature Reactor

Graphite-Matrix Fuel, Liquid Salt Coolant



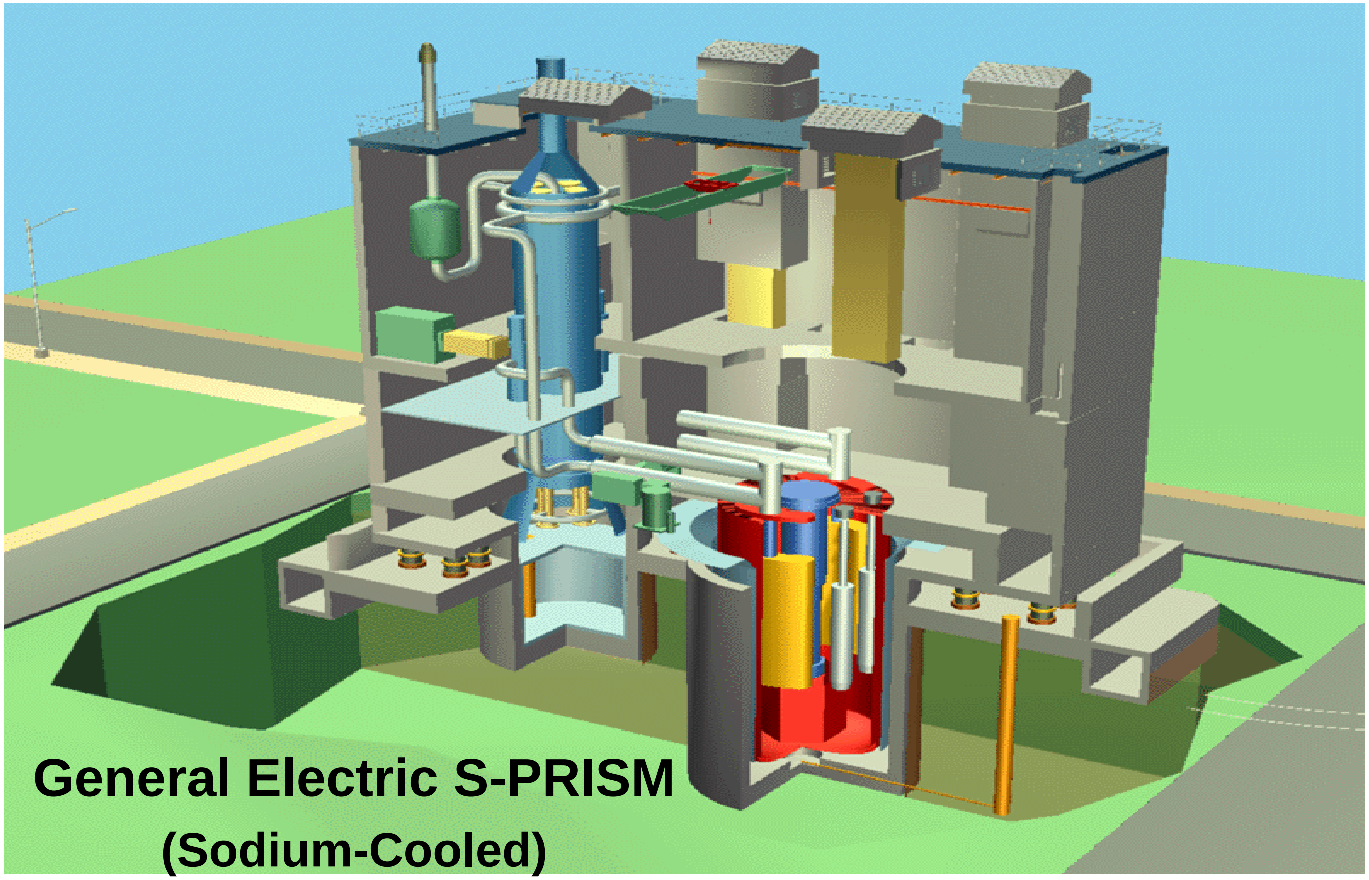


Output: 2400 MW(t)

High-Temperature Fast Reactor Options

Liquid-Salt-Cooled and Lead-Cooled

(Boiling point must exceed 1000ºC)



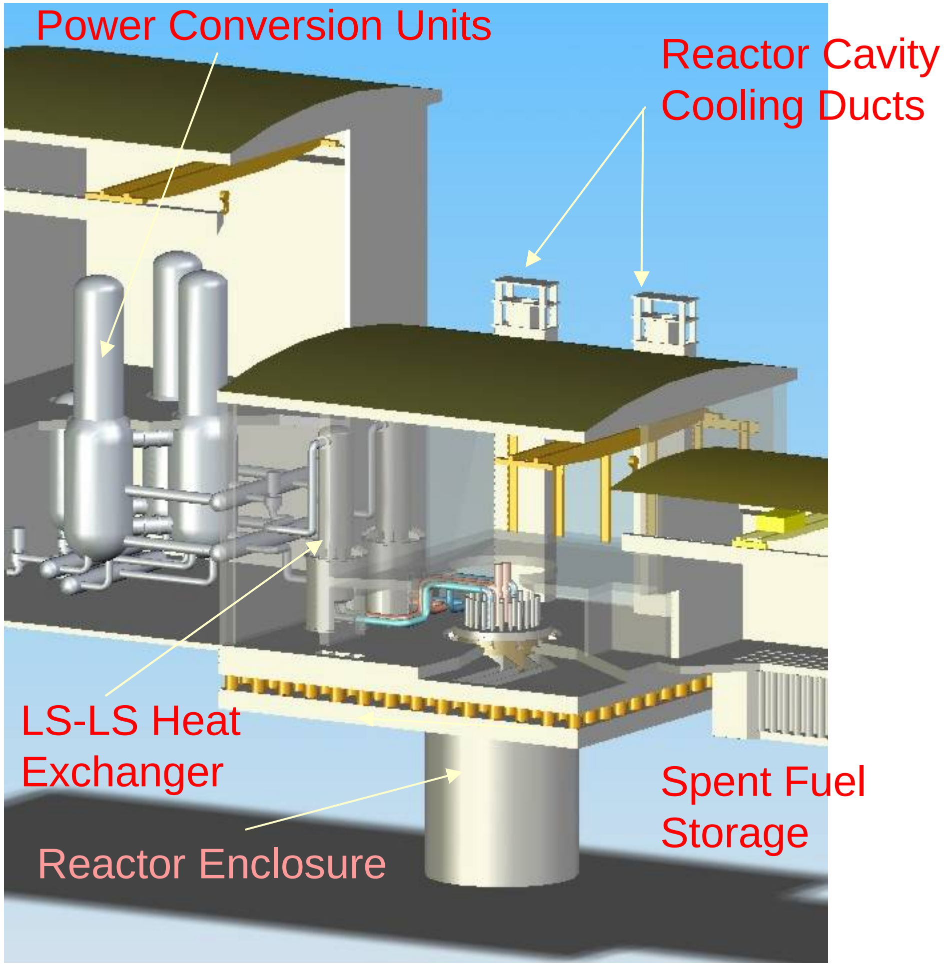
General Electric S-PRISM

(Sodium-Cooled)

Observations I

- **Strong drivers for higher-temperature reactors**
  - **Recent development of efficient Brayton cycles to convert heat to electricity**
  - **Need for hydrogen production**
  - **Need for dry cooling to avoid water shortages and siting constraints**
- **Options**
  - **Helium-cooled high-temperature reactor**
  - **Advanced High-temperature reactor**
  - **Lead-cooled fast reactor**
  - **Liquid-salt-cooled fast reactor**
  - **Fast-gas-cooled reactor**
- **Need for advanced reactors with innovative fuels**

Observations II: Strong Incentives for International Cooperation



- **Development of advanced reactors is a major undertaking**
  - **Time**
  - **Resources**
  - **Facilities**
- **Commercial reactor development is an international effort**
- **Similar approach applicable for pre-commercial development of new reactor concepts (through first test reactor)**