Nuclear & Hydrogen: Teaming Up

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Tulane Engineering Forum

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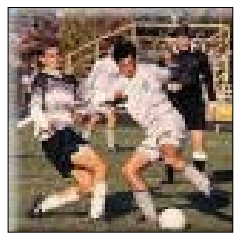
Entergy

Earth At Night *NASA*

A Unique Perspective

Our Planet Today



Millions Enjoy Unprecedented Standard of Living

Our Planet Today

A World of Need

Our Planet Today

To Stabilize GHGs → 50% - 75% Reduction in Global Emissions

Our Next Century

By 2050 Global Energy Consumption Will Double

The Global Challenge

Our Challenge - To Produce Clean Energy On A Global Scale.

The Energy Picture

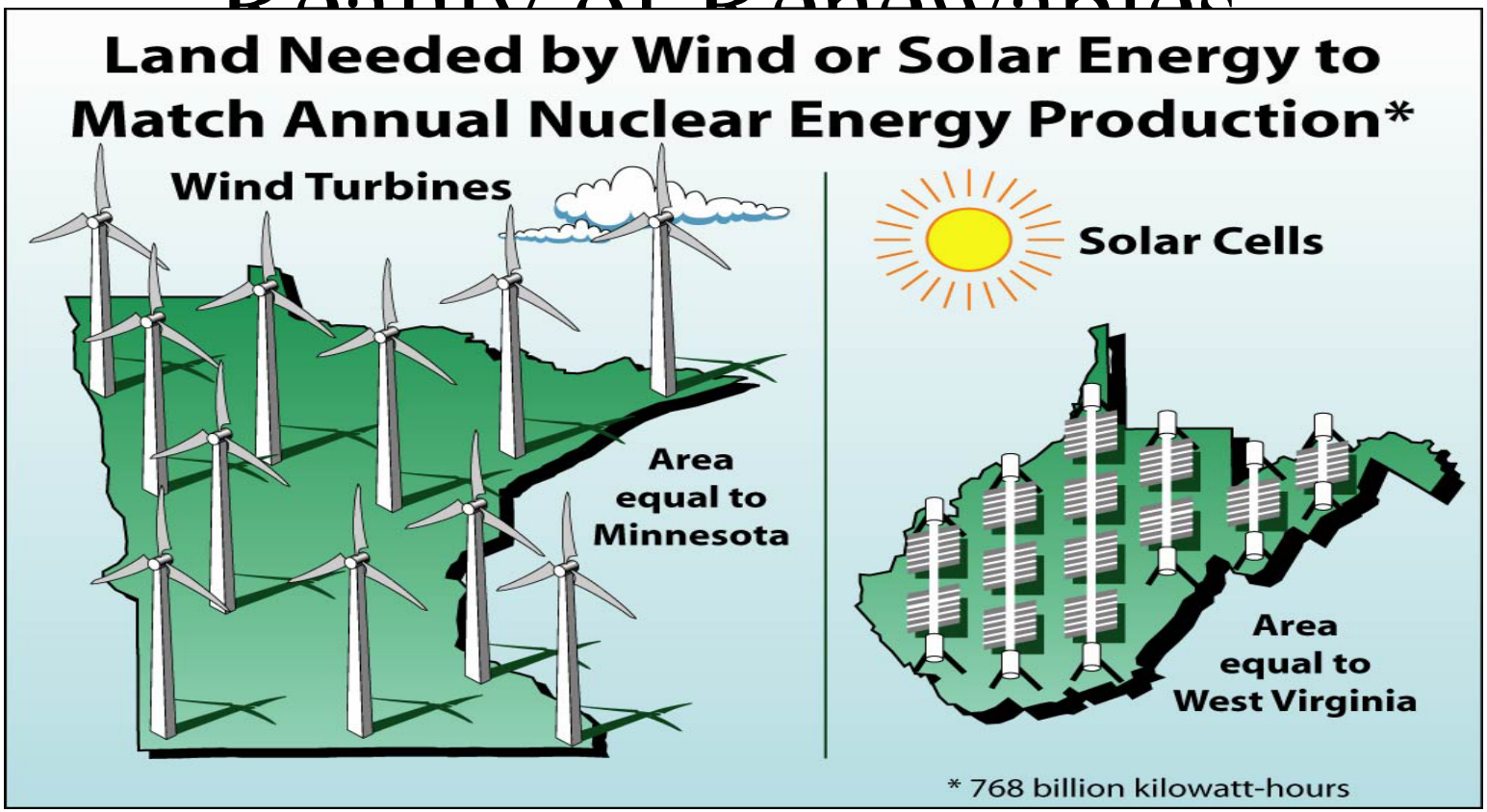
. . . . And A Move Away From The Predominate Use Of Fossil Fuels

“Renewables”

Renewable
Development Must Be
Strongly Supported

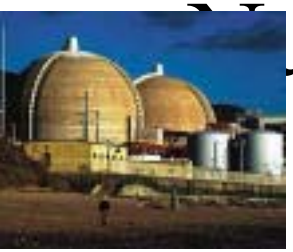
<u>Realistic Perspective</u> – Collective impact will be quite limited – for decades to come. OECD projects less than 3% of world electricity demand.

Reality of Renewables

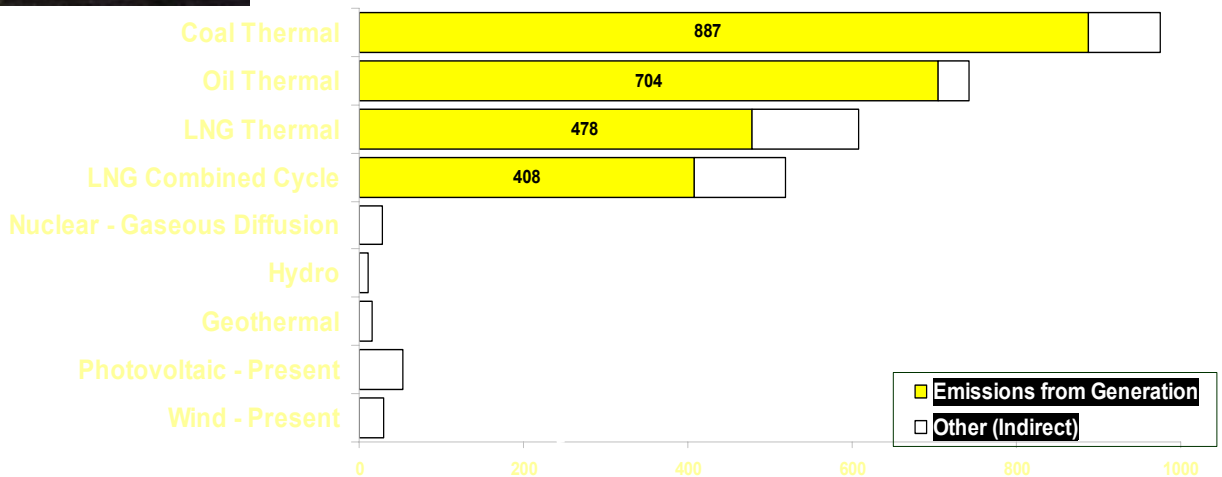


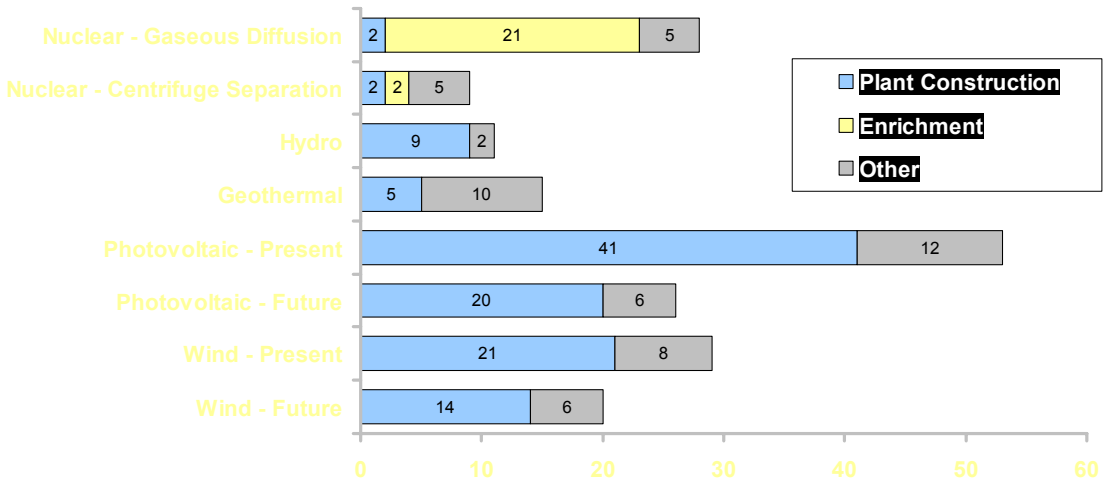
Want H_2 from renewables?
Add more states!

Nuclear – A Viable "Clean Energy"



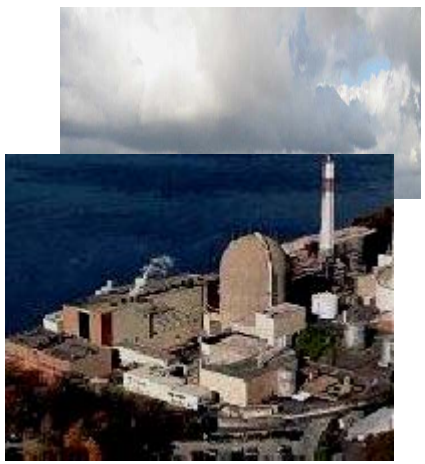
CO_2 Emissions Comparison (Grams/kW-hr)





Nuclear on Par with Renewables

Nuclear Today



2/3 of Global Population ⇒ Nuclear Power

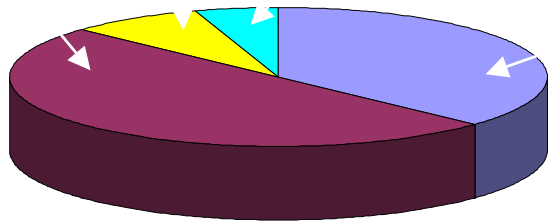
~ 440 Nuclear Power Plants

Poised to realize its full potential - - - - - -

Hydrogen - Today

World Consumption → 45 MM Tons/yr

Source: Salomon Smith Barney, EIA, EPRI



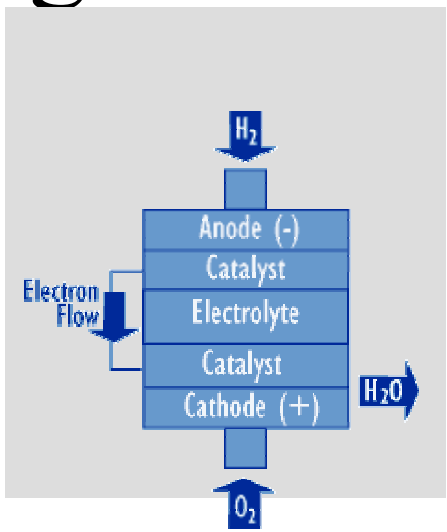
Liquid Fuel Production is Rapidly Becoming Major Mar

10% Annual Growth

A "Bridging" Market For Deployment of Nuclear –

Hydrogen's Promise

A Clean "Abundant" Fuel



Stationary Applications In Home & Industry

Clean Transportation

"Micro" Applications

. . . Store Enormous Quantities Of "Electricity"

H_2 Versatil

Multiple Sources & Applications

Biomass

Hydro
Wind
Solar

Nuclear

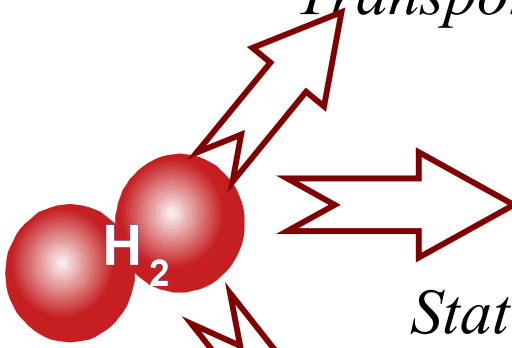
Oil

Coal

Natural Gas

Sequestration

Transportatio



Stationary

-

Commercia

Micro
Apps

ial

Makes Sense Only If Hydrogen Is Produced With Non-GHG Emitting Processes

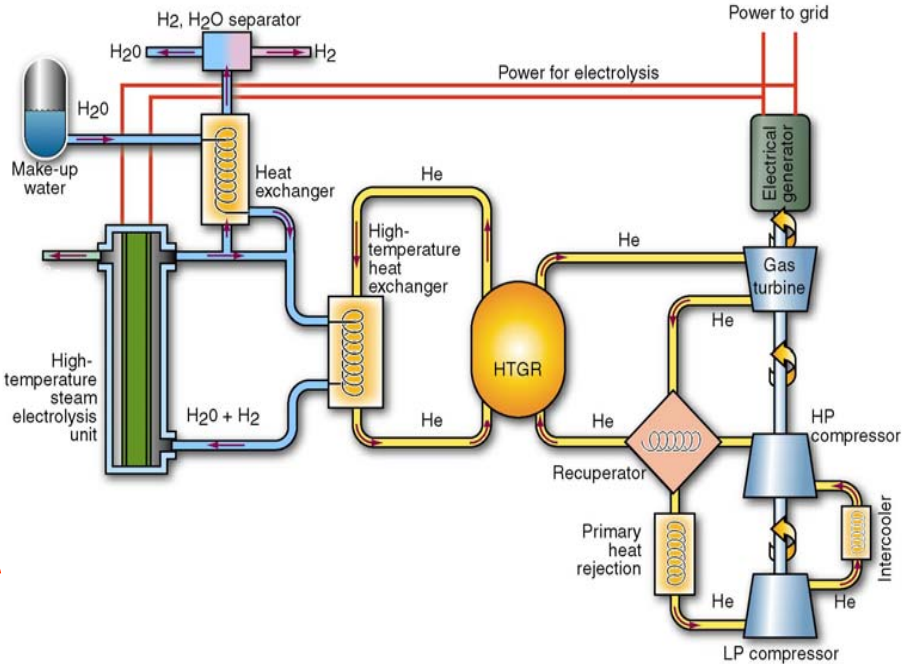
Getting Hydrogen From Nuclear

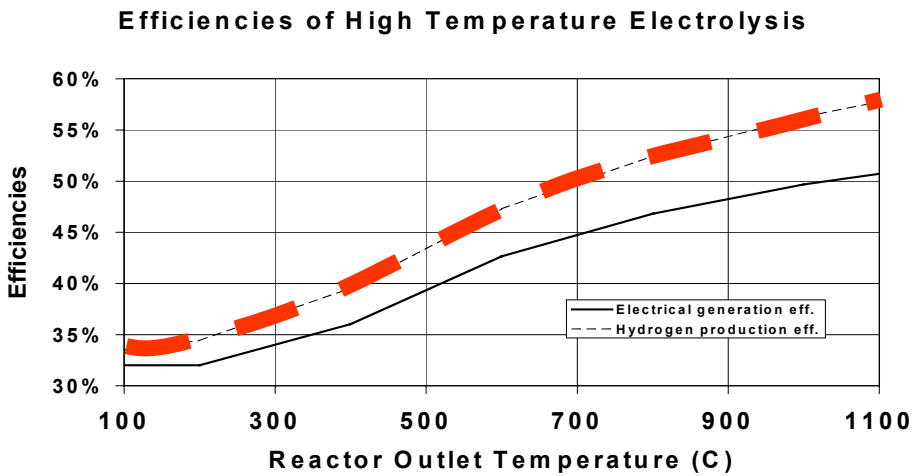
- Conventional Electrolysis (A Proven Technology)
  - Overall Efficiency ~24% (LWR), ~ 36% (HTGR)
- High Temperature Electrolysis (HTE)
  - > 50% Efficiency
- Thermo-Chemical Water-Splitting ⇒ *Developing Technologies*
  - Set Of Chemical Reactions That Use Heat To Decompose Water Into H_2 & O_2
  - Overall Efficiency ~ 50%
  - Requires Generation IV Or High Temperature Gas Reactors
  - Several Cycles under Consideration – Sulfur Iodine, Calcium

High Temperature Electrolysis

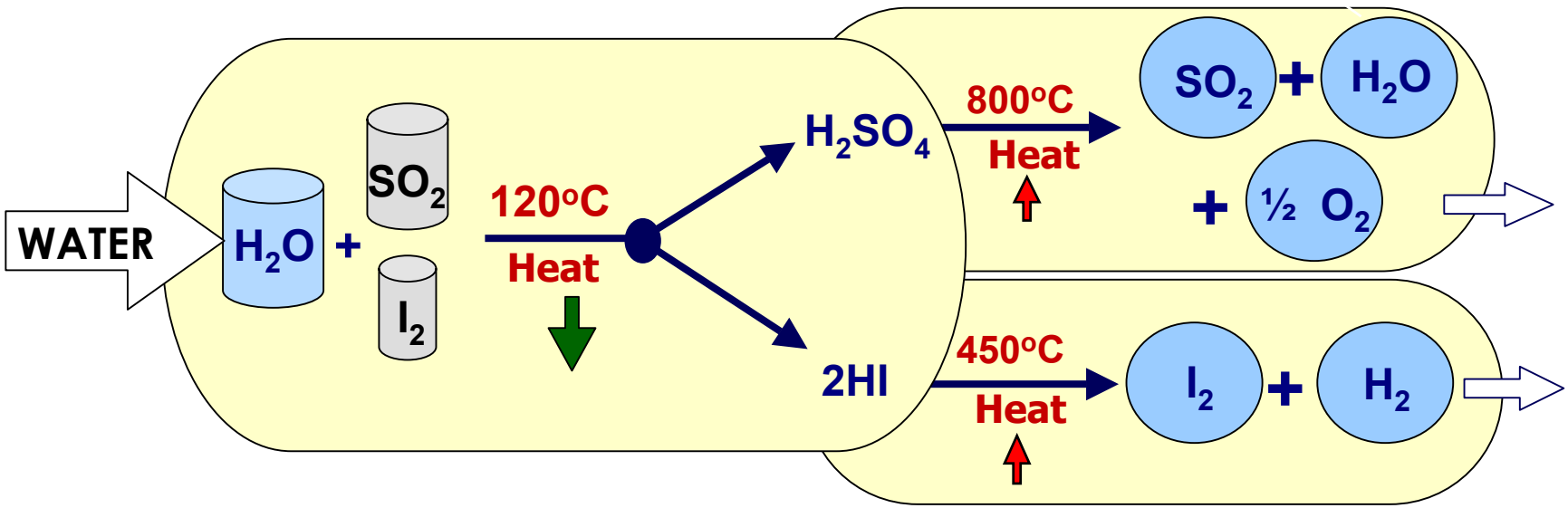
Uses thermal energy to reduce

electrical energy requirements





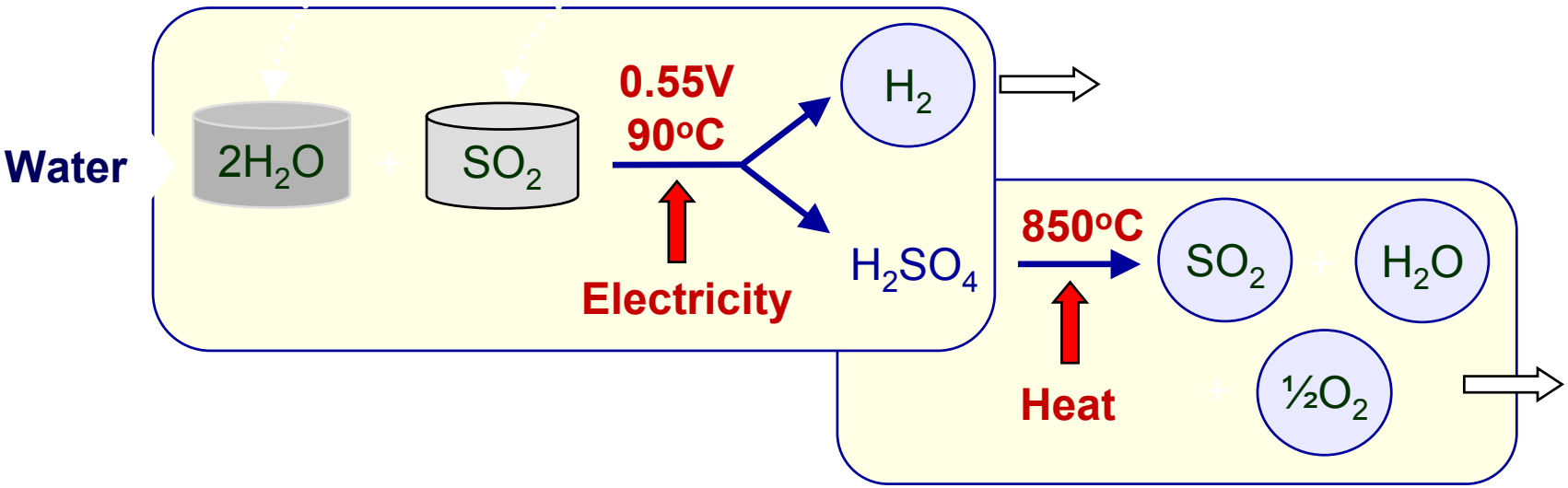
ThermoChemical Water Splitting



Efficiencies 47%- 53%
600 MWTh Module ⇒ ~200 Tons / Day

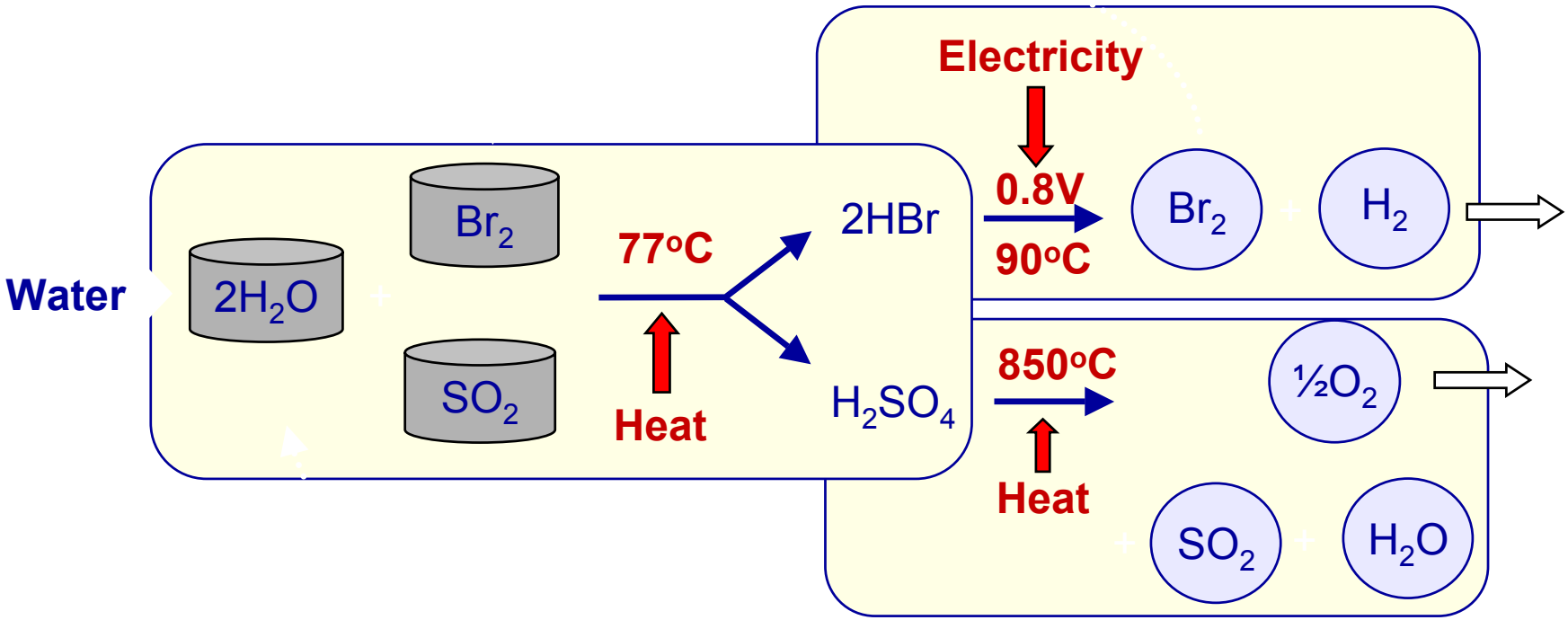
ThermoChemical Water Splitting

Westinghouse – Hybrid Process



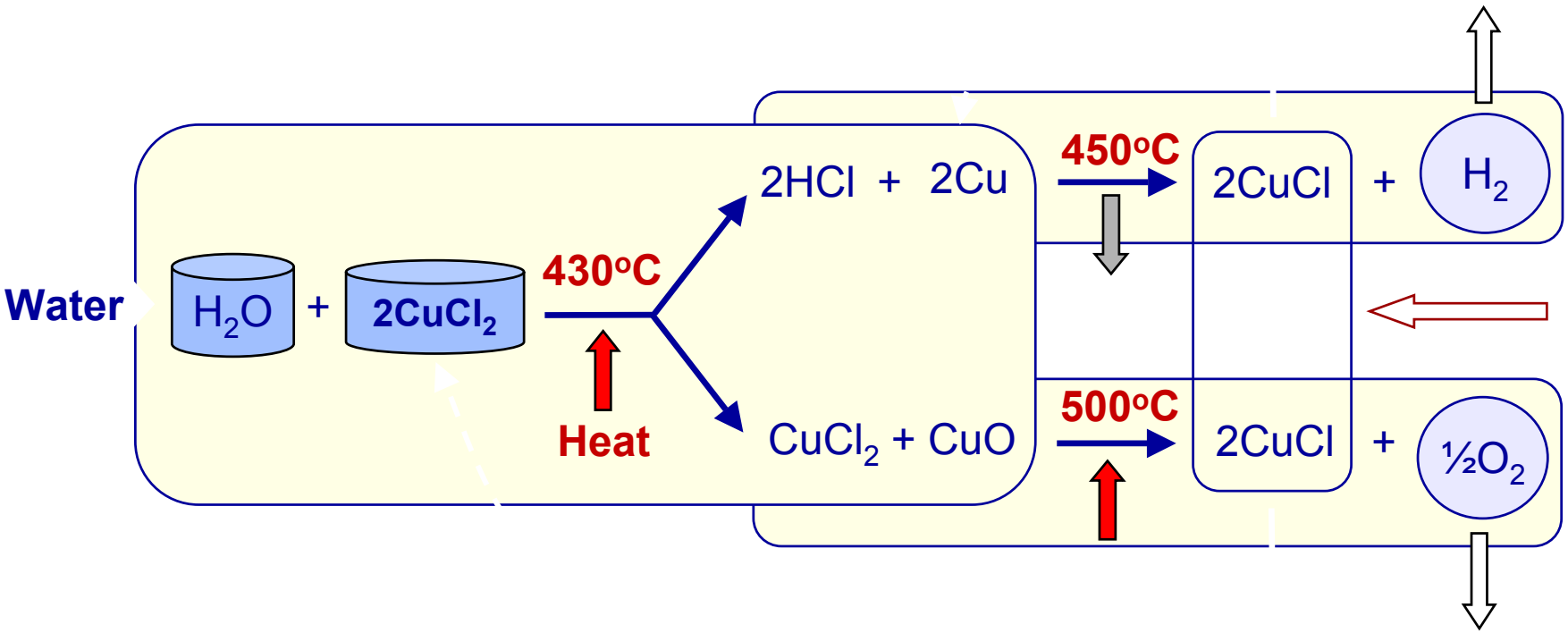
ThermoChemical Water Splitting

Sulfur-Bromine "S-Br" Process



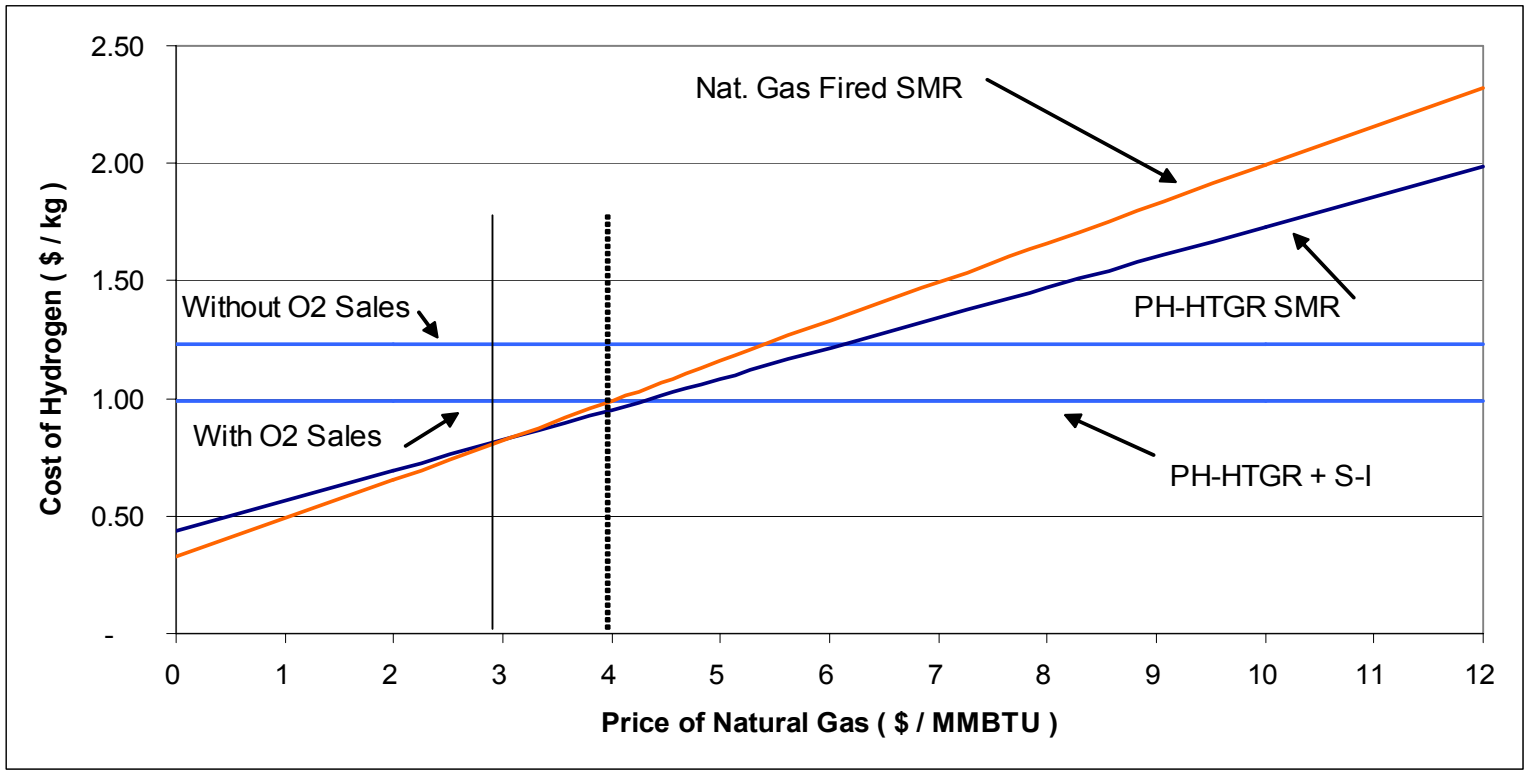
Thermochemical Water Splitting

Copper Chlorine – Cu-Cl – Indirect (Argonne Low Temperature Cycle - 3)



Nuclear H_2 – Commercially Viable ?

Preliminary Economics "SI" Process – Based on Best Available Industry Data



Nuclear Appears To Be Commercially Competitive in H_2 Production On A Large Scale

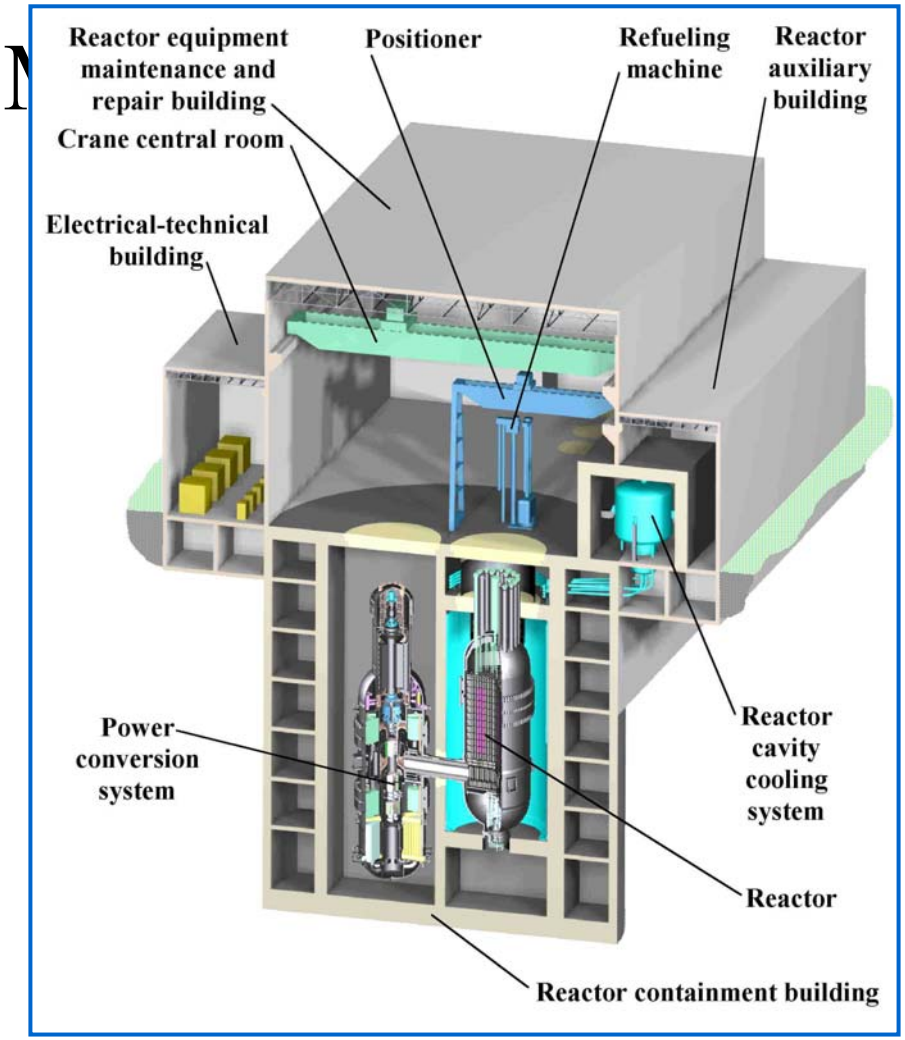
Gas Turbine – Modular Helium Reactor (GT-M

Modular Construction

Low Cost

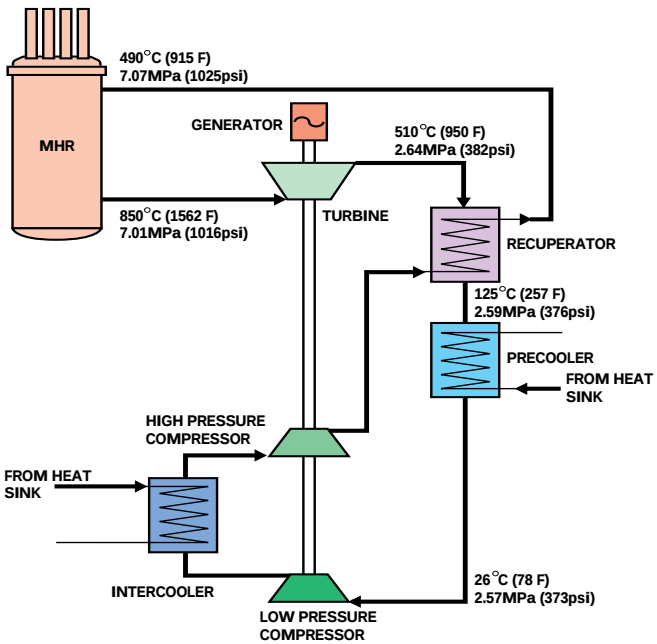
Technology Base

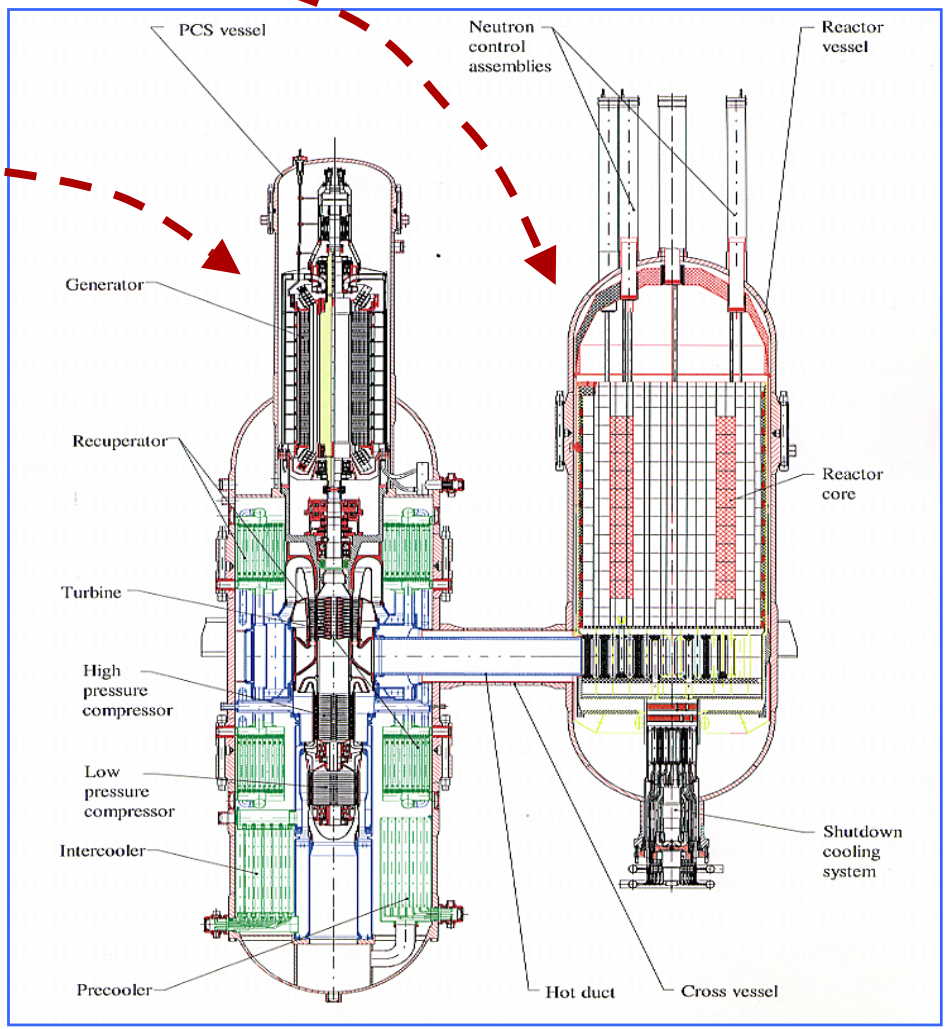
Fort St. Vrain, Peach Bottom, International



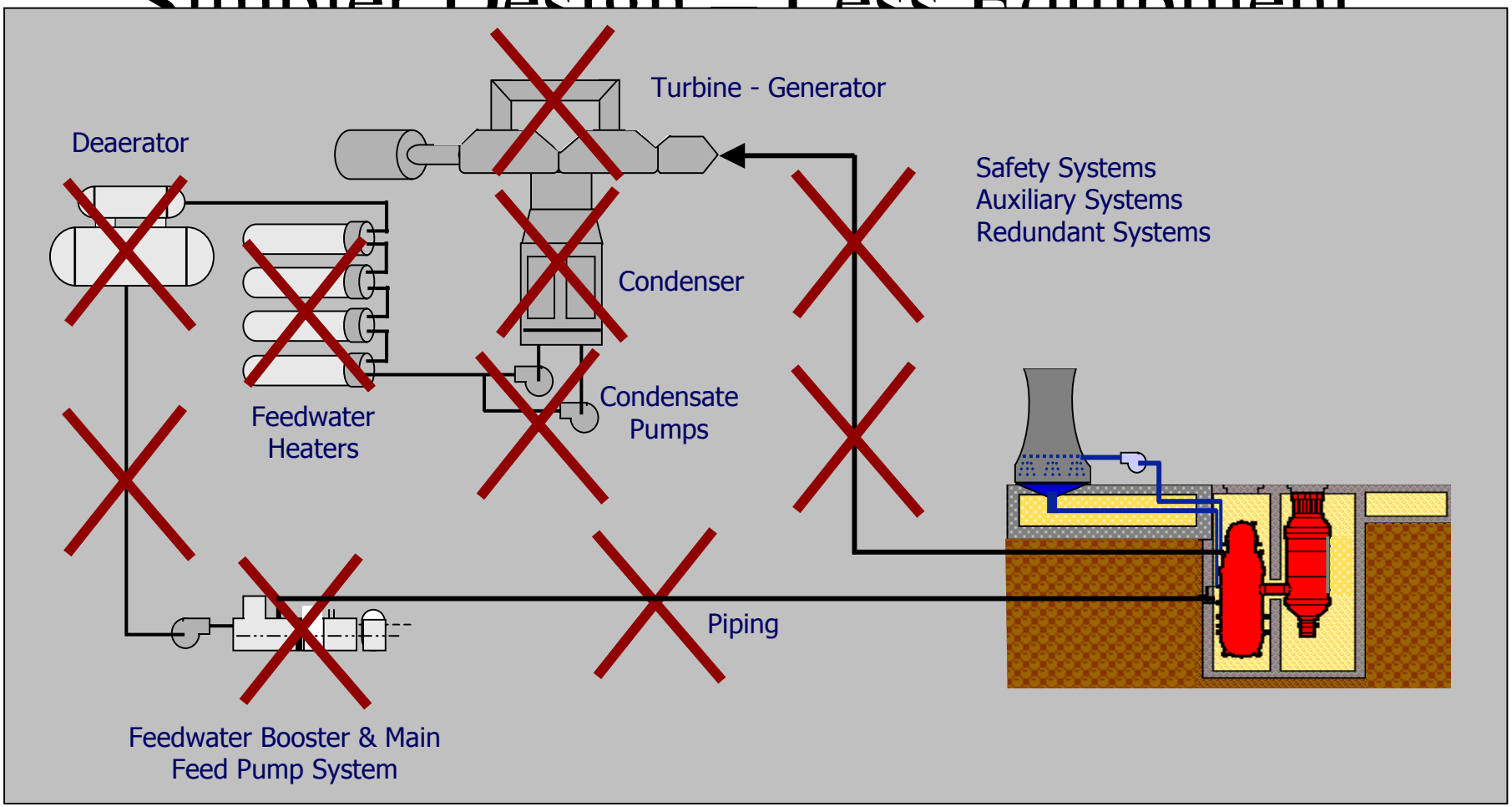
A Closer Look

- Reactor
- Power Conversion System



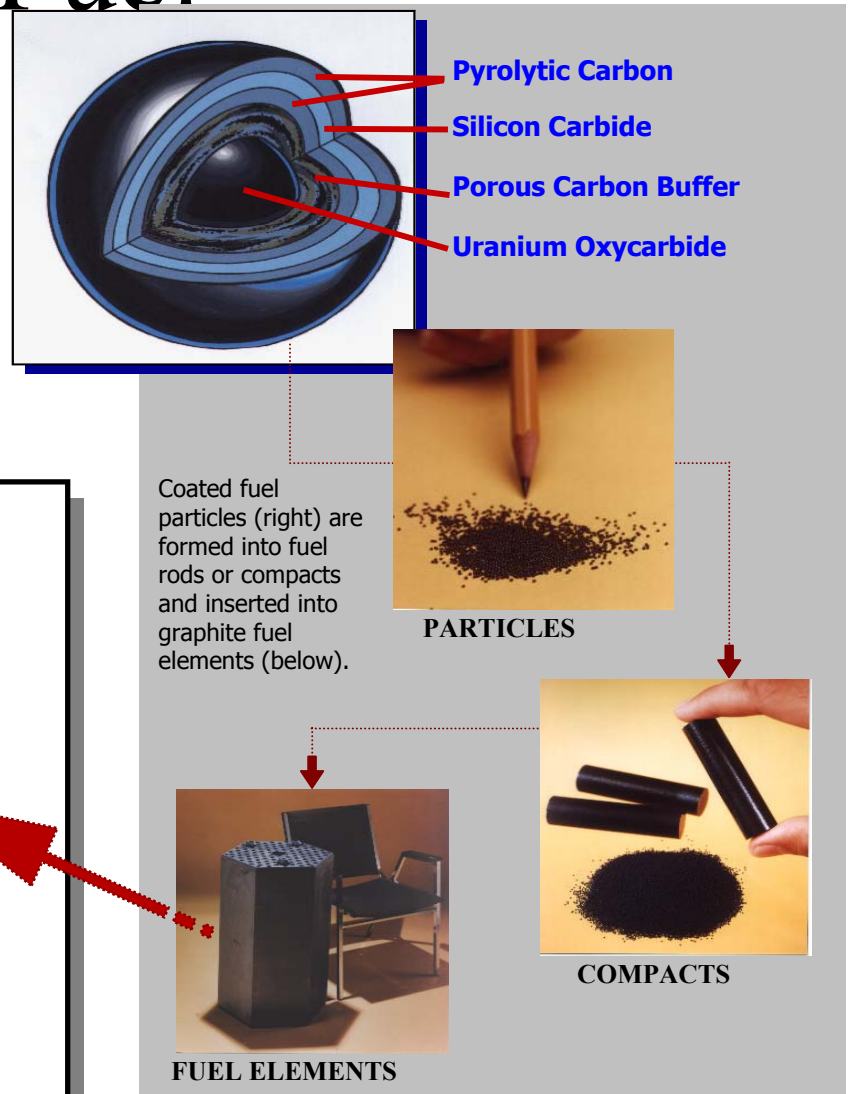


Simpler Design – Less Equipment



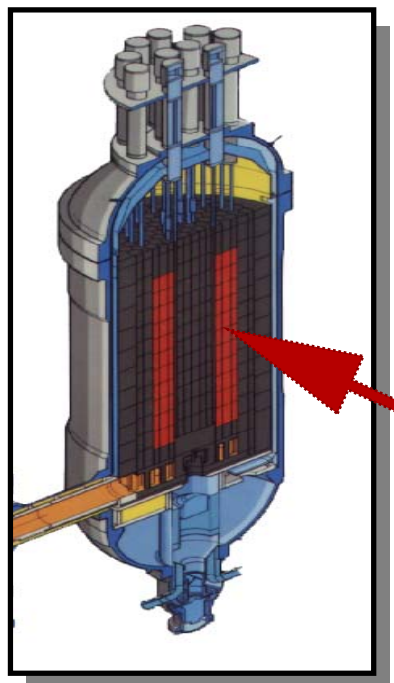
Particle Fuel

- Ceramic Fuel Particles



–High Fuel Burn-up Capability
–Low Fissile Fuel Volume Fraction

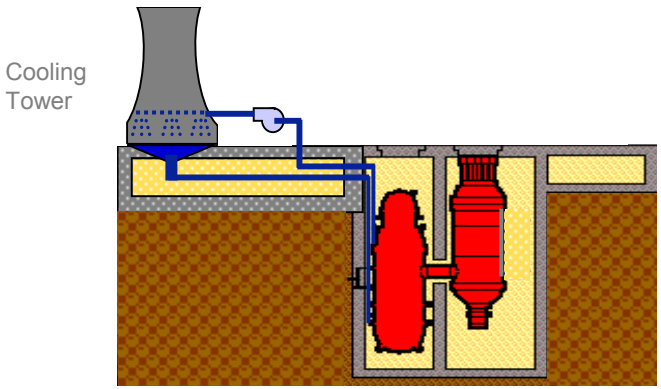
Meltdown Proof



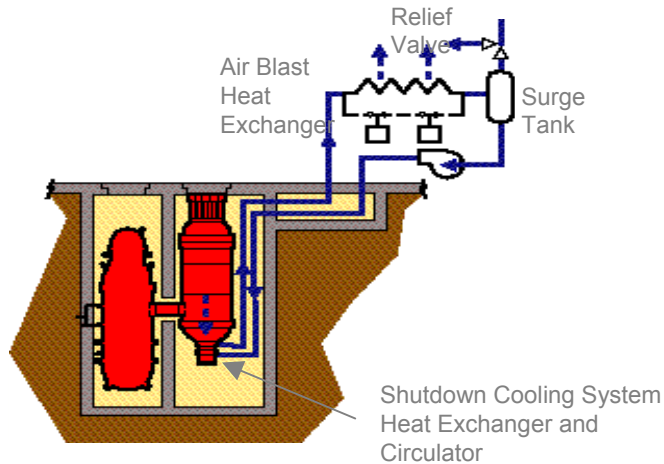
Passive Safety

Heat Removal Paths

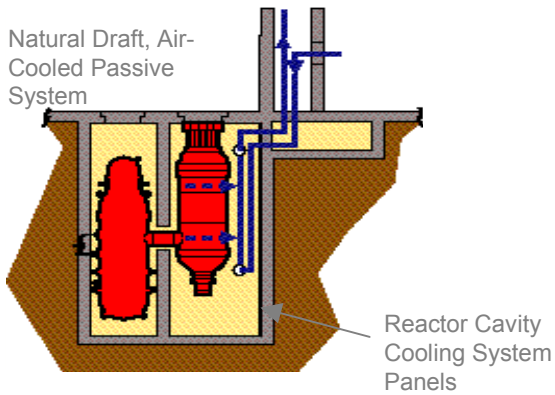
A. Normal - Using Power Conversion System



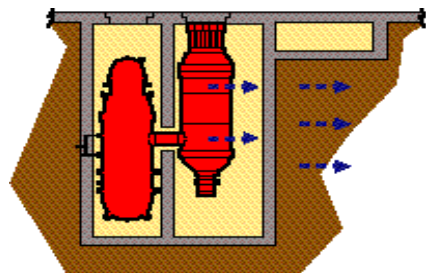
B. Active Shutdown Cooling System



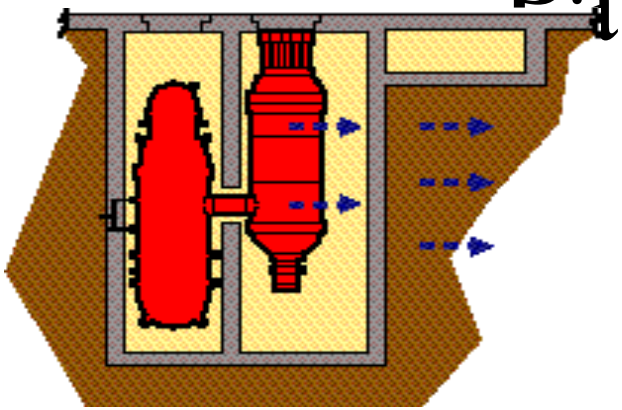
C. Passive Reactor Cavity Cooling System

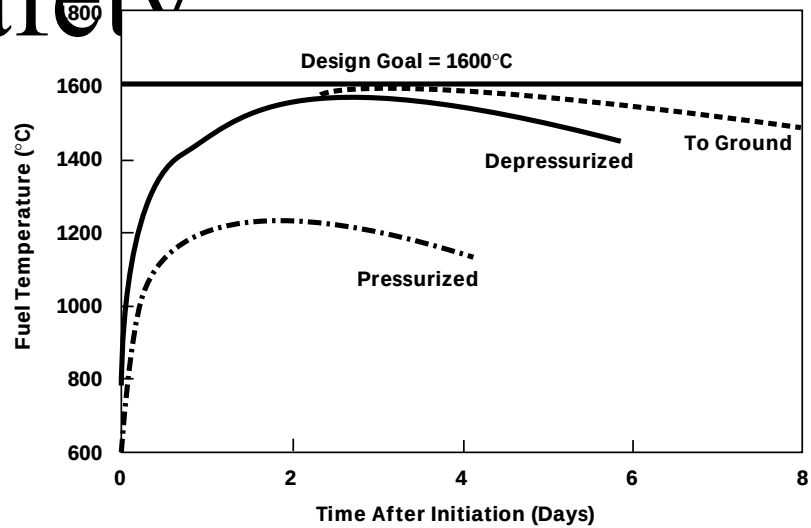


D. Passive Radiation & Conductive Cooling



Passive Safety





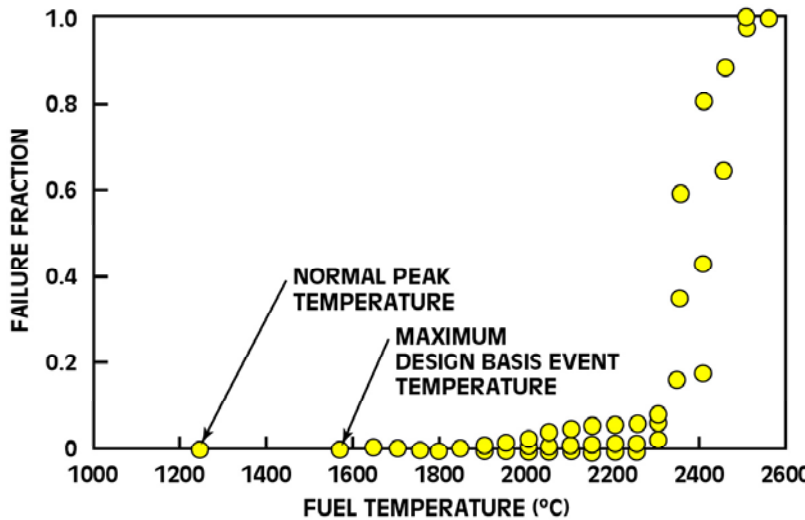
"Safe"- in Worst Case Conditions

- Temperature Remains < 1600 °C
- Fuel Integrity Maintained
- Prevents [illegible] ctivity

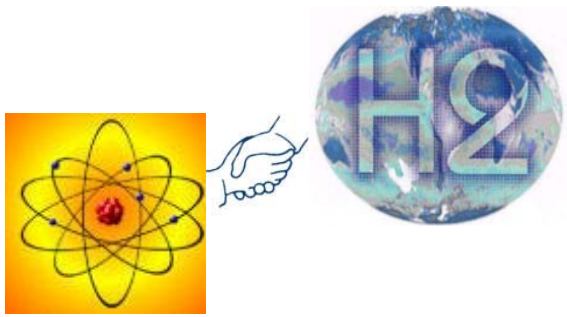
No Need For

Active Safety Systems

Offsite Emergency Response



Our Future



A "Bridge" – From Electric Energy Sector To The Larger Spectrum of Energy Use

1 **Public Awareness – Recognize Nuclear Power As A Safe, Large Scale Source of Climate Friendly Energy**

2 **Collaborative Efforts – Support International Efforts to Fully Develop Nuclear-Hydrogen Technologies**

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