22.033 Core Group- Reactor Concept and Decision Making Process

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Overview

- Final Decision
- Reactor Concepts
- Choice Justification
- Moving Forward

Final Decision

- Lead Cooled Fast Reactor
- Supercritical CO2 Secondary Loop
- Looking at range of sizes >500 MWe (designed to diminishing returns to scale)

Reactor Concepts

- Supercritical Water/CO2
- Travelling Wave
- Molten Salt
- CANDU
- Very High Temperature Reactor (VHTR)
- Sodium Fast Reactor (SFR)
- Lead Fast Reactor (SFR)

Supercritical Coolant Reactor

- Supercritical Water Reactor
  - One of the Gen IV reactor designs
  - Excellent heat transfer, no boiling in core
  - 20 MPa, 550^{o}C
  - High Thermal to Electric Efficiency (~45%)
  - Very simple BWR-esque design
  - Materials concerns
  - Supercritical CO_2 Options

Travelling Wave Reactor

- Breed and Burn concept
  - Start with some enriched Uranium to get core critical at some location
  - Then through neutron absorption U-238 becomes Pu-239 which then fissions causing the same thing to more U-238
- Long life, on-line refueling
- Potential to use “unwanted” fuel
- Proliferation concern
- Not the temperatures we were looking for

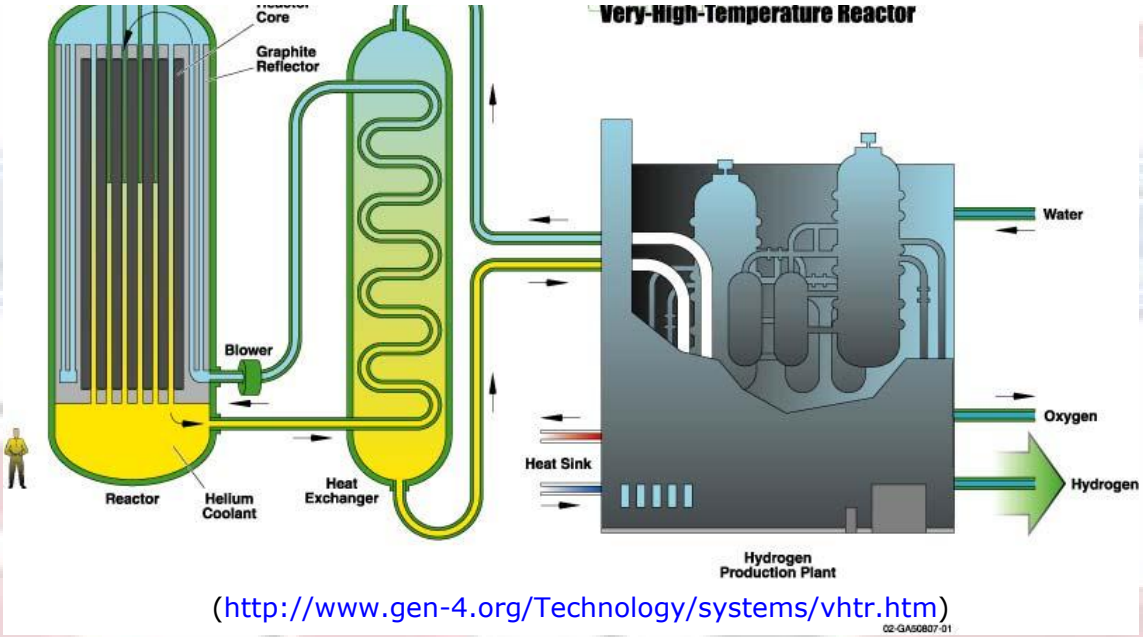
Molten Salt

- Able to scale to many desired power levels
- No high pressure – eliminates need for a pressurizer
- Extremely high negative temperature coefficient
- Breeder Reactor with Thorium would be extremely cost effective
- Many hazardous materials such as HF and Be

CANDU

- Able to use various plentiful sources of fuel
- Heavy Water Moderator is an expensive capital cost
- Moderator is unpressurized, thinner fuel bundle tubes
- Already operational in several nations
- Temperature Requirements for this project were too high for CANDU

Very High Temperature Reactor (VHTR)



(http://www.gen-4.org/Technology/systems/vhtr.htm)

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Quick Facts:

- Primary Coolant: Helium
- Moderator: Graphite
- Neutron Spectrum: Thermal
- Outlet Temperatures: up to 1000˚C
- Neutron Spectrum: Thermal
- Efficiency: >50%
- Fuel Options: Spherical or Prismatic

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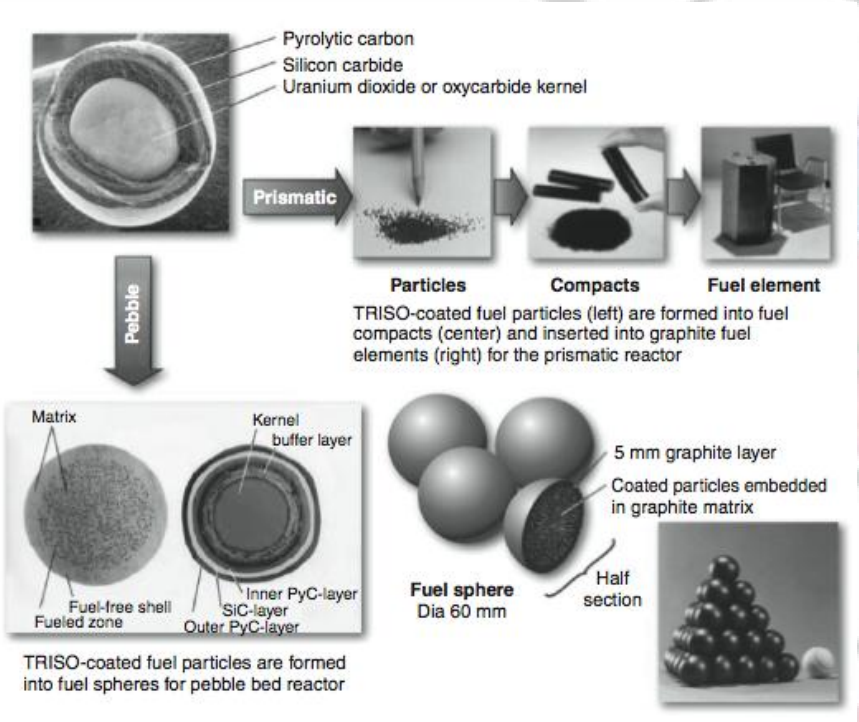

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Notable Features:

- Coated Fuel Particles
- Passive Safety Features
- Very High Temperatures

SFR and LFR Designs

- General
  - Fast spectrum – possible intergration into closed fuel cycle
  - Excellent thermal properties
  - Large heat sink, easier cooling, small footprint,
  - Low pressure
  - Passive safety

SFR

- Minimal moderation
- Low melting point
- Operational experience
- Volatile material
- Some activation

LFR

- Minimal moderation
- High boiling point
- Range of scales
- Higher temp. possible
- Difficult start-up
- Some activation
- Minimal US experience

Comparison

Neutronics

Both very good

Minimal moderation and voiding, burn actinides

Could have positive breeding ratio

Na and LBE both activate

Thermal

Sodium probably slightly better

Lead requires >328 °C start-up

Other

Lead isn't as volatile

No intermediate loop required w/ lead

Lead can corrode steel

Reactor Design Choice Reasoning

- Compact Size/Small Footprint
- Safety Features
- Thermal Properties
- Variety of Power Levels
- Exotic Design- Questions to be answered/Interesting to work on
- Natural Circulation Possibilities

Looking Forward- Core

- Lead vs. Lead-Bismuth Coolant
- Begin Modeling Reactor in MCNP
- Reactor Power Decision
- Material Choices

Looking Forward- Plant

- Lead to CO2 Heat Exchanger
- Supercritical CO2 Viability
- Turbines
- Split point for Process Heat

QUESTIONS?

22.033 / 22.33 Nuclear Systems Design Project

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