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# ***PBMR Safety Design***

**Edward Wallace**

**Sept 21, 2005**



## ***ESKOM Selection Criteria 1995***

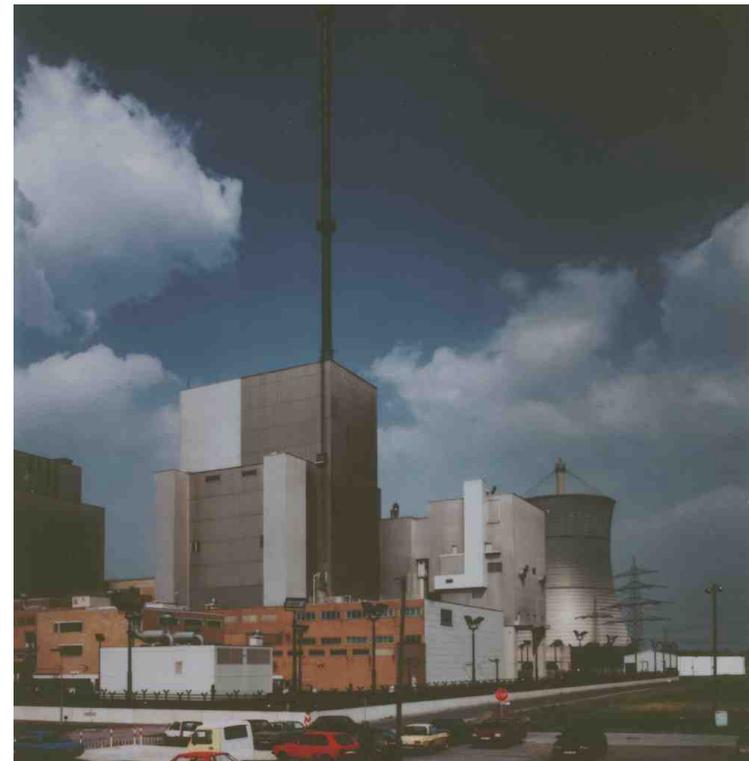
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- **Competitive Economics** (with CCGT/Eskom coal)
- **Distributed Generation** (close to load centers)
- **Short Lead Times** (reduce risk of capacity mismatch)
- **Load Following** (increased commercial pressures)
- **Reduced Environmental Impact** (no emissions)

## Germany



**AVR (1967-88)  
15 MWe**



**THTR (1985-89)  
300 MWe**



# ***Application of German Technology Base to PBMR Design***

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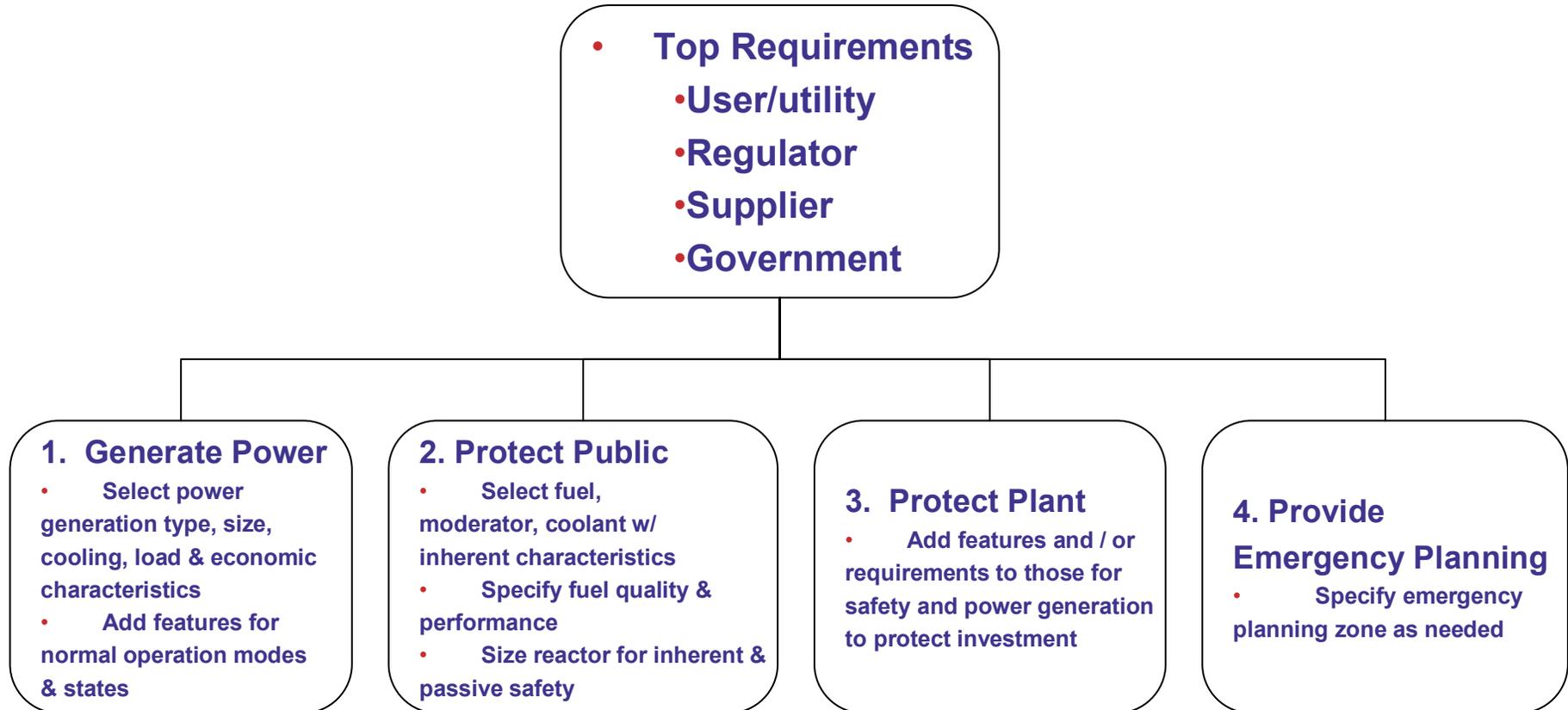
- **AVR (15 MWe)**
  - Pebble Bed core configuration
  - Pebble Fuel
  
- **THTR (300 MWe)**
  - Reactor and Auxiliary component design rules
  - Proven component designs
  
- **HTR-Module Concept (80 MWe)**
  - Inherent safety concept certification
  - Steel reactor vessel instead of RCPV



## ***Plant Target Specifications***

- **Rated Power per Module** 165 MW(e)
- **Net Efficiency** > 41%
- **Four-pack Power Plant** 660 MW(e)
- **Continuous Power Range** 20-100%
- **Module Construction Schedule** 24 months (1st)
- **Planned Outages** 30 days per 6 years
- **Seismic** 0.4g
- **Aircraft (Calculations to survive)** 747 / 777
- **Overnight Construction Cost** < \$1500/kWe
- **Fuel & O&M Costs** < 15 mills/kWh
- **Emergency Planning Zone** < 400 m
- **Availability** > 95%

# PBMR NPP Design Process



## ***Definitions***

### ***Inherent:***

- *“Existing in something as a permanent or essential attribute”*

*Concise Oxford English Dictionary 11th Edition 2004*

- *“Existing in someone or something as a permanent and inseparable element, quality or attribute”*

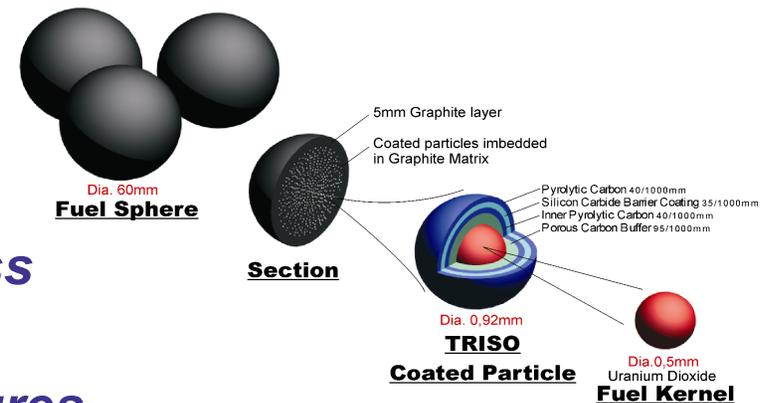
*Random House Unabridged Dictionary 1997*

### ***Permanent:***

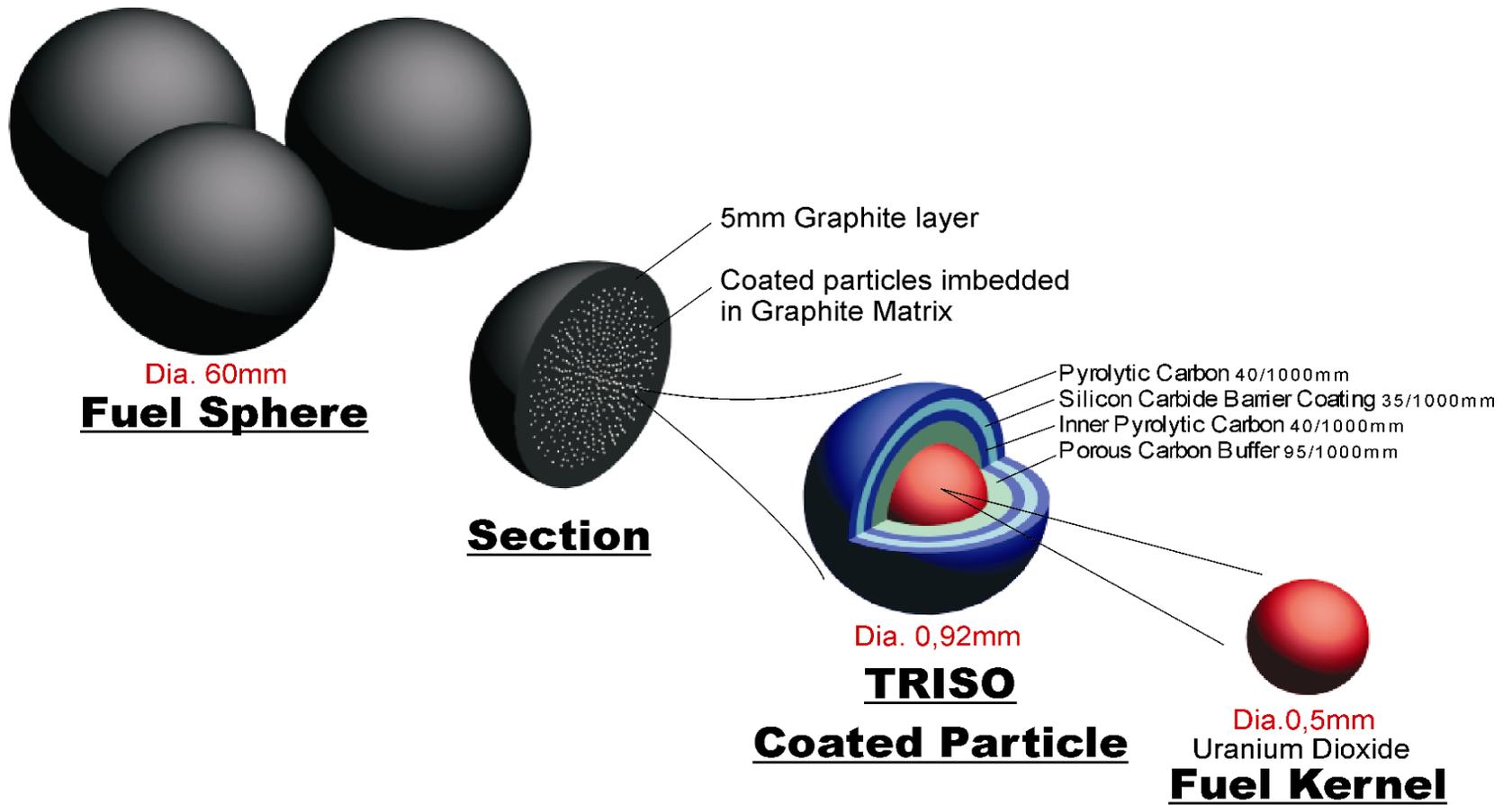
- *“Lasting or remaining unchanged indefinitely, or intended to be so”*

*Concise Oxford English Dictionary 11th Edition 2004*

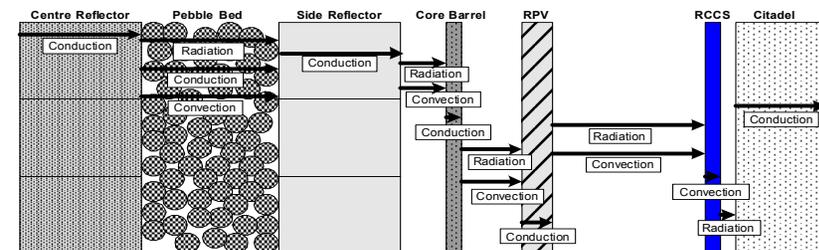
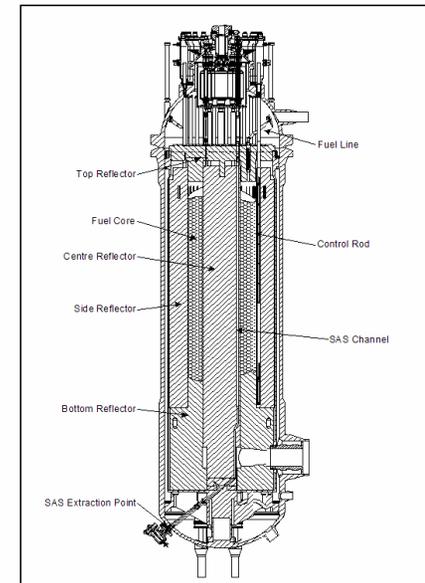
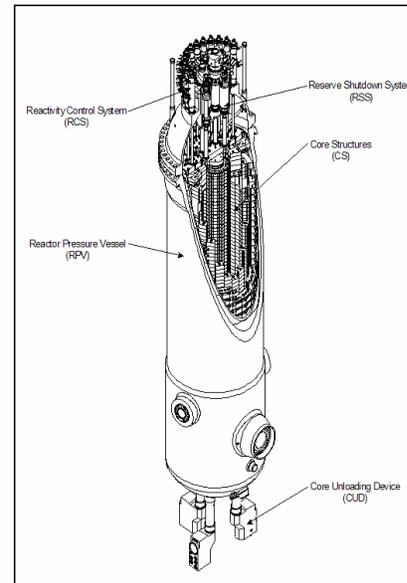
- *Fuel developed to provide fission product retention at relatively high surface temperatures*
- *Fuel is melt-down proof*
- *Spherical form offering the ideal geometry for heat removal and stress distribution*
- *Physically strong matrix which ensures low damage potential during handling operations*
- *Fuel good for storage in tanks during operation or during long term storage following final shutdown*
- *Provide for uncomplicated on-line fuel integrity and burn-up checking*



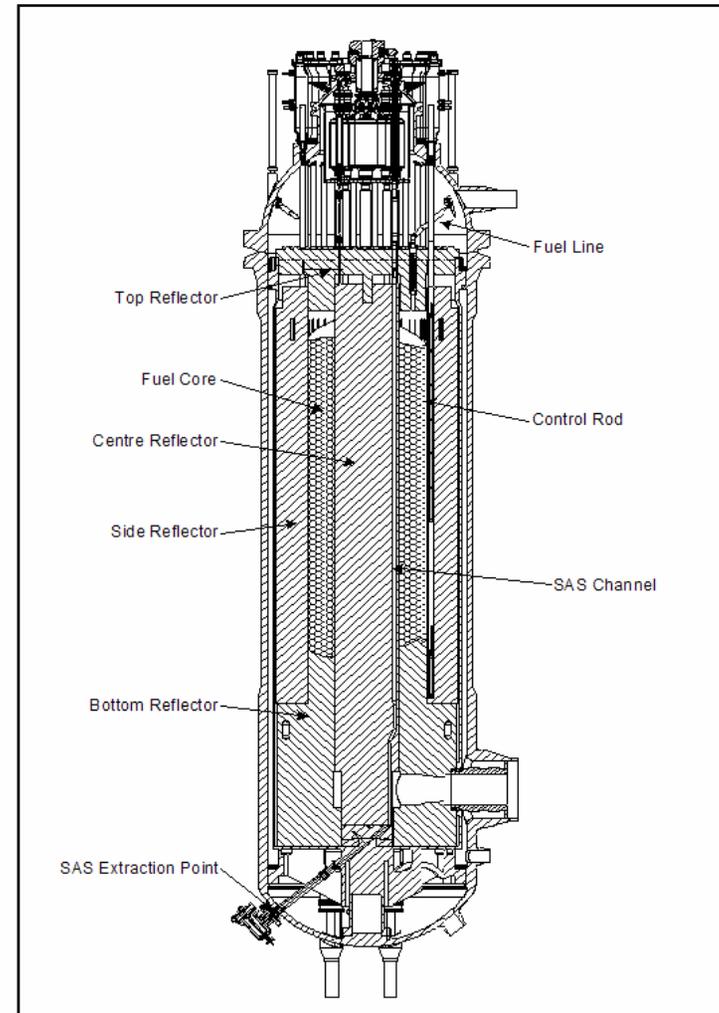
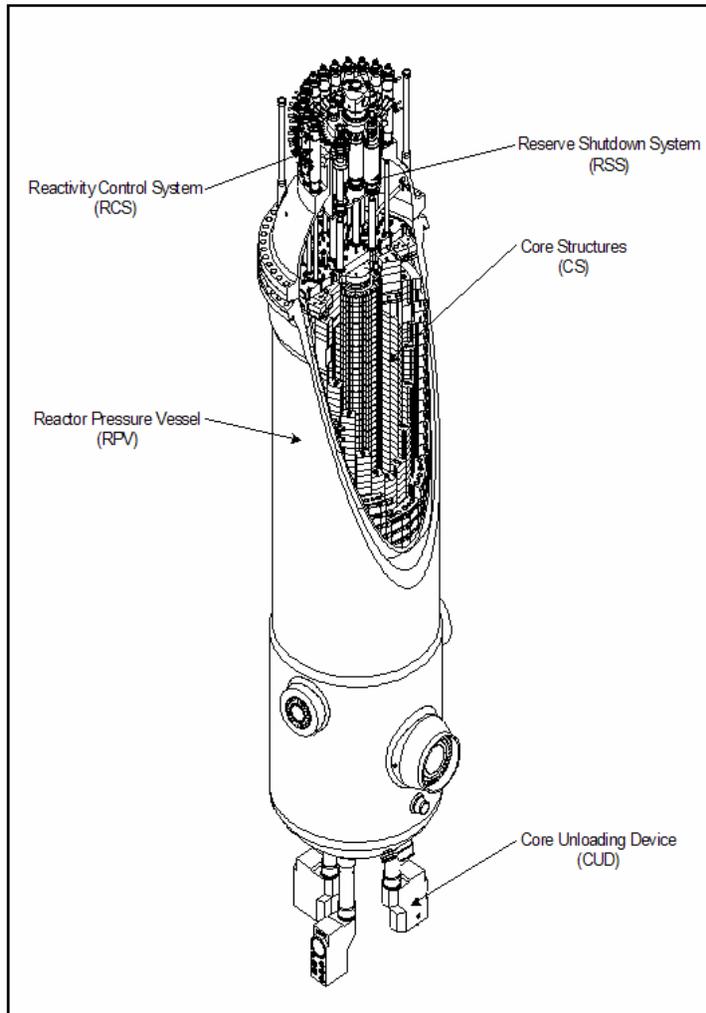
# Fuel Quality and Form



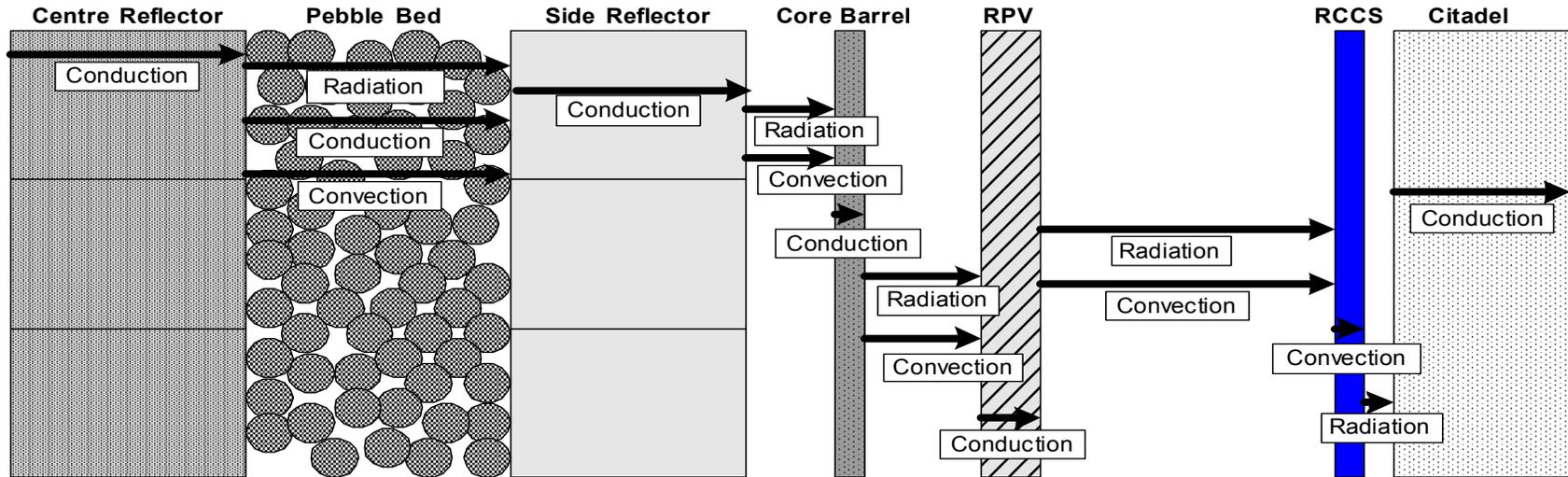
- **All ceramic core**
- **Low power density in core**
- **Large thermal capacity of core**
- **Annular core geometry provides for short heat transfer path to the outside of RPV resulting in lowering of maximum fuel temperature during a loss of cooling event**
- **No coolant phase changes**
- **Prompt negative temperature co-efficient of reactivity**
- **Low excess reactivity**
- **Ingress of water into core eliminated by design**



# Low Power Density Core Design

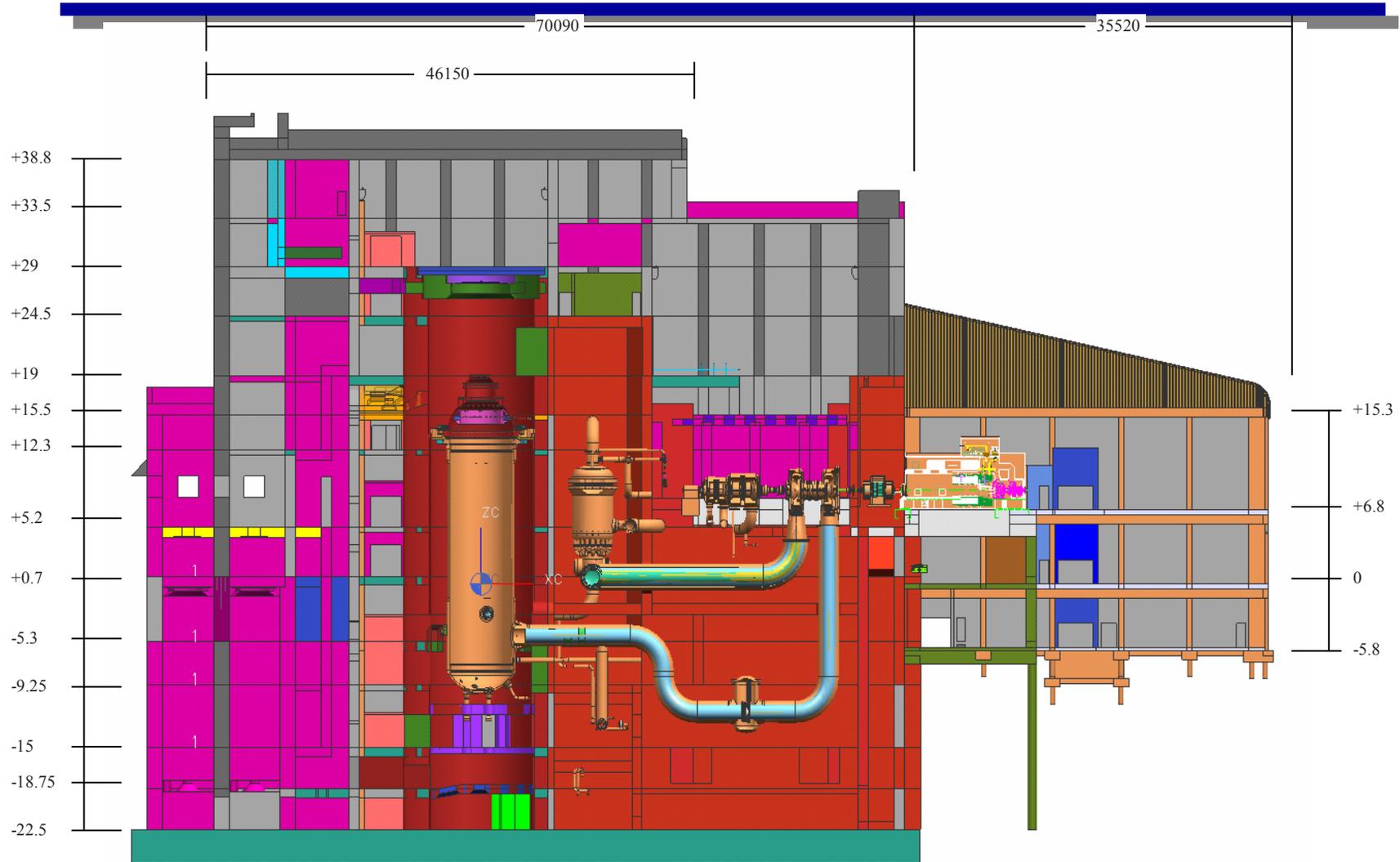


# Core Design for Passive Heat Removal





# Module Dimensions

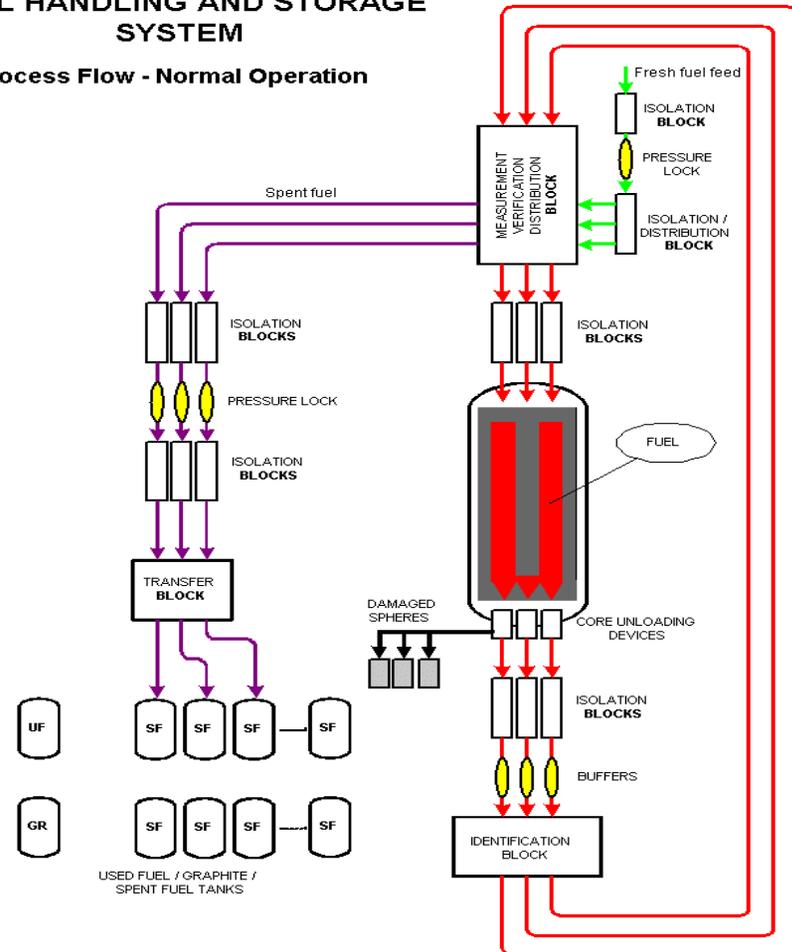


Seq | 6.5

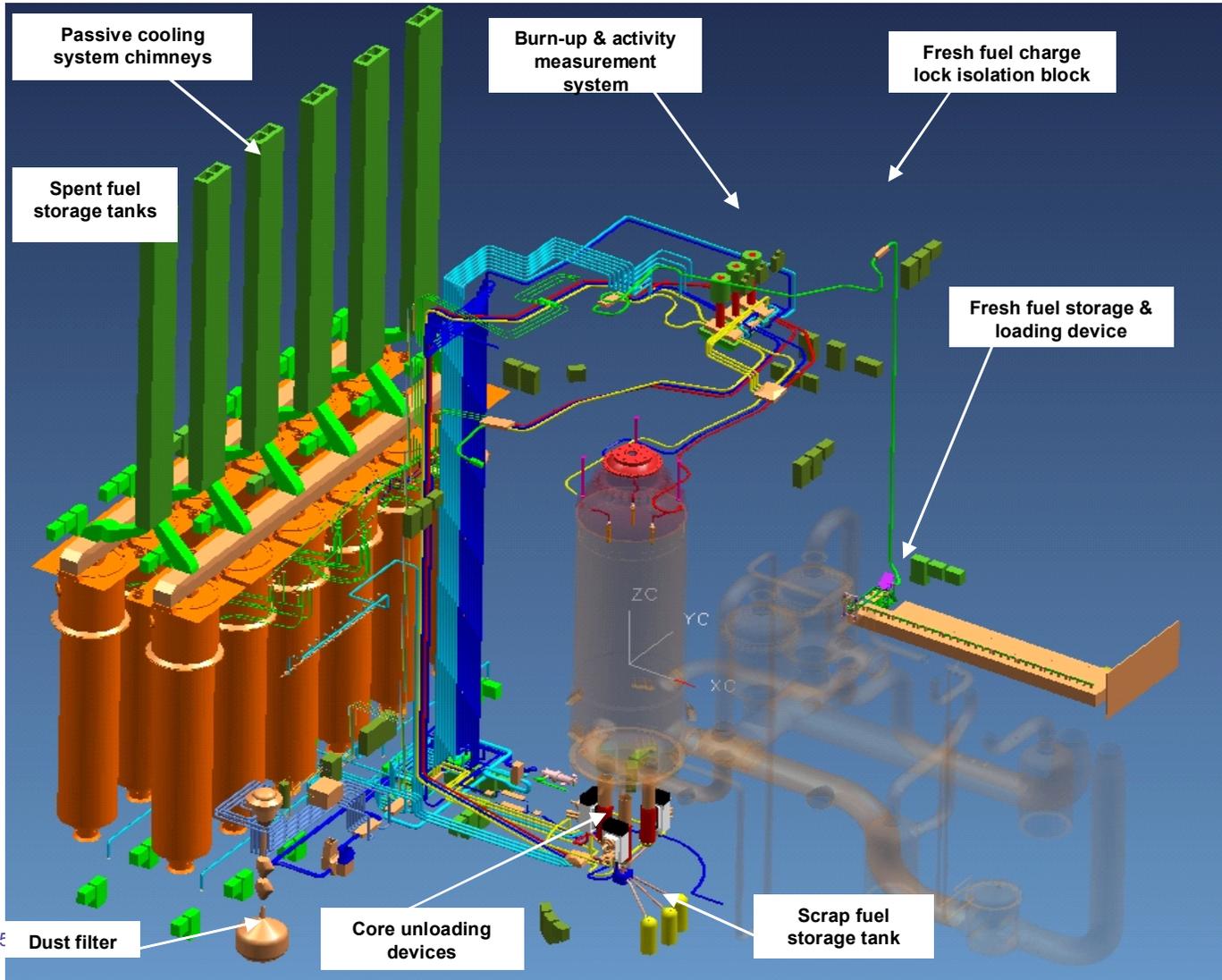
- *Reduction of required excess reactivity*
- *Dynamic core movement ensures that temperature profile through fuel spheres changes continually*
- *Fuel form and closed system provides substantial non-proliferation assurance*

## FUEL HANDLING AND STORAGE SYSTEM

### Process Flow - Normal Operation



# Fuel Handling and Storage System



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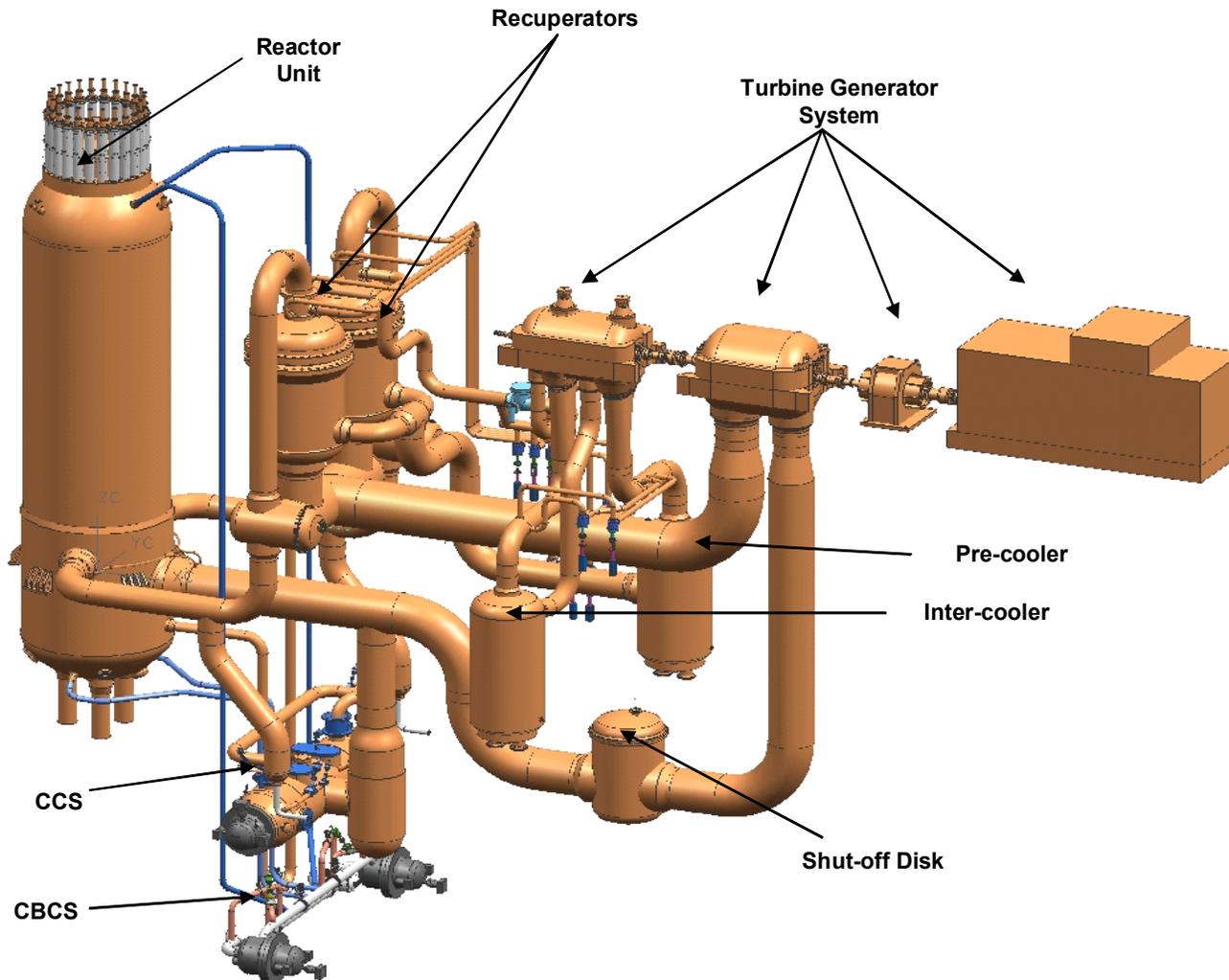


## ***Inherent High Availability Characteristics***

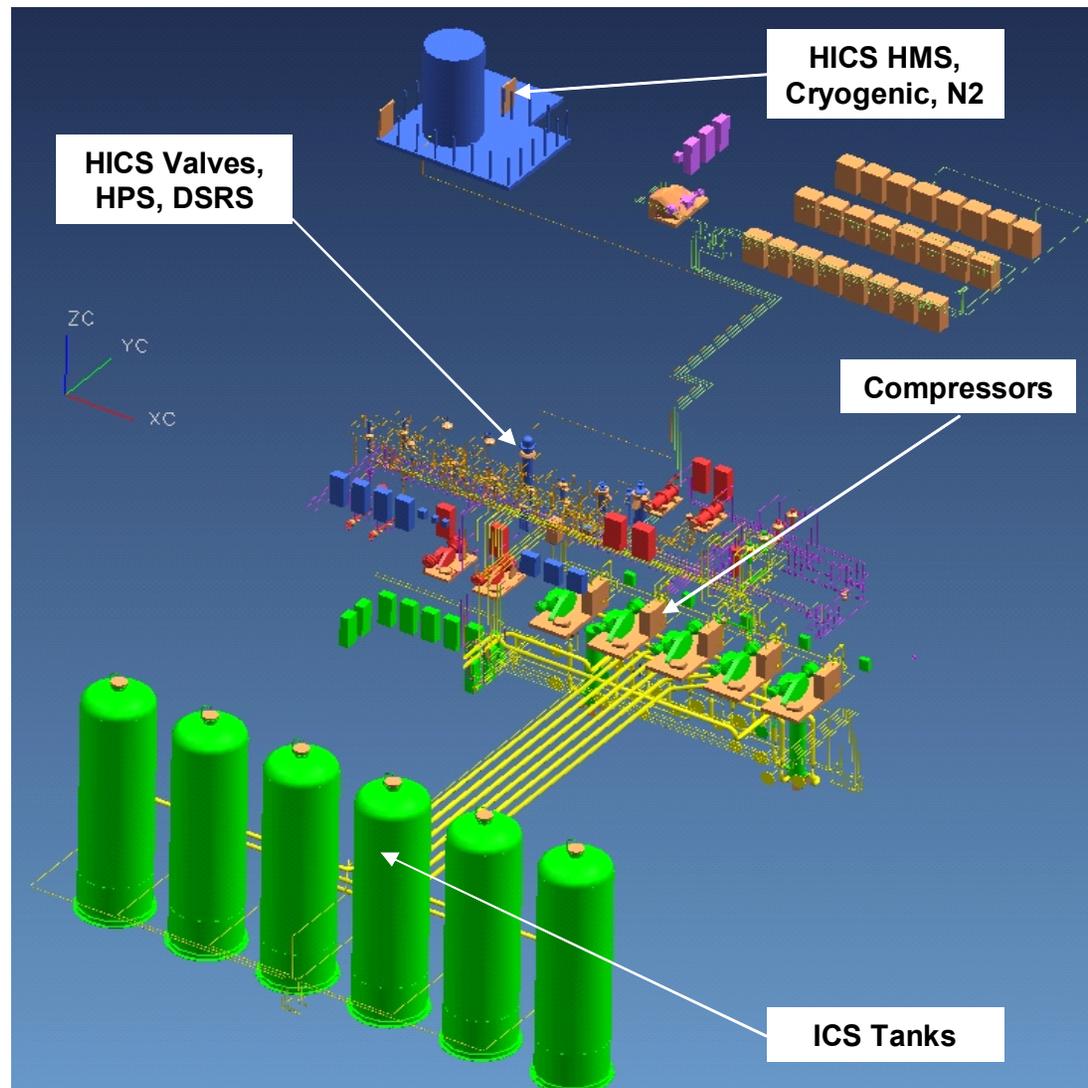
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- ***On-line fueling avoids frequent refueling outages***
- ***Turbo machines and other critical components designed for 6 year inspection cycles***
- ***Designed for replacement of complete units during scheduled maintenance***
- ***Large thermal inertial creates slow thermal transients***
- ***Relatively simple design with fewer operationally significant components***

# Main Power System



# Helium Inventory Control System



## Site Buildings (Demonstration Plant)

