

Pebble Bed Modular Reactor Program Overview

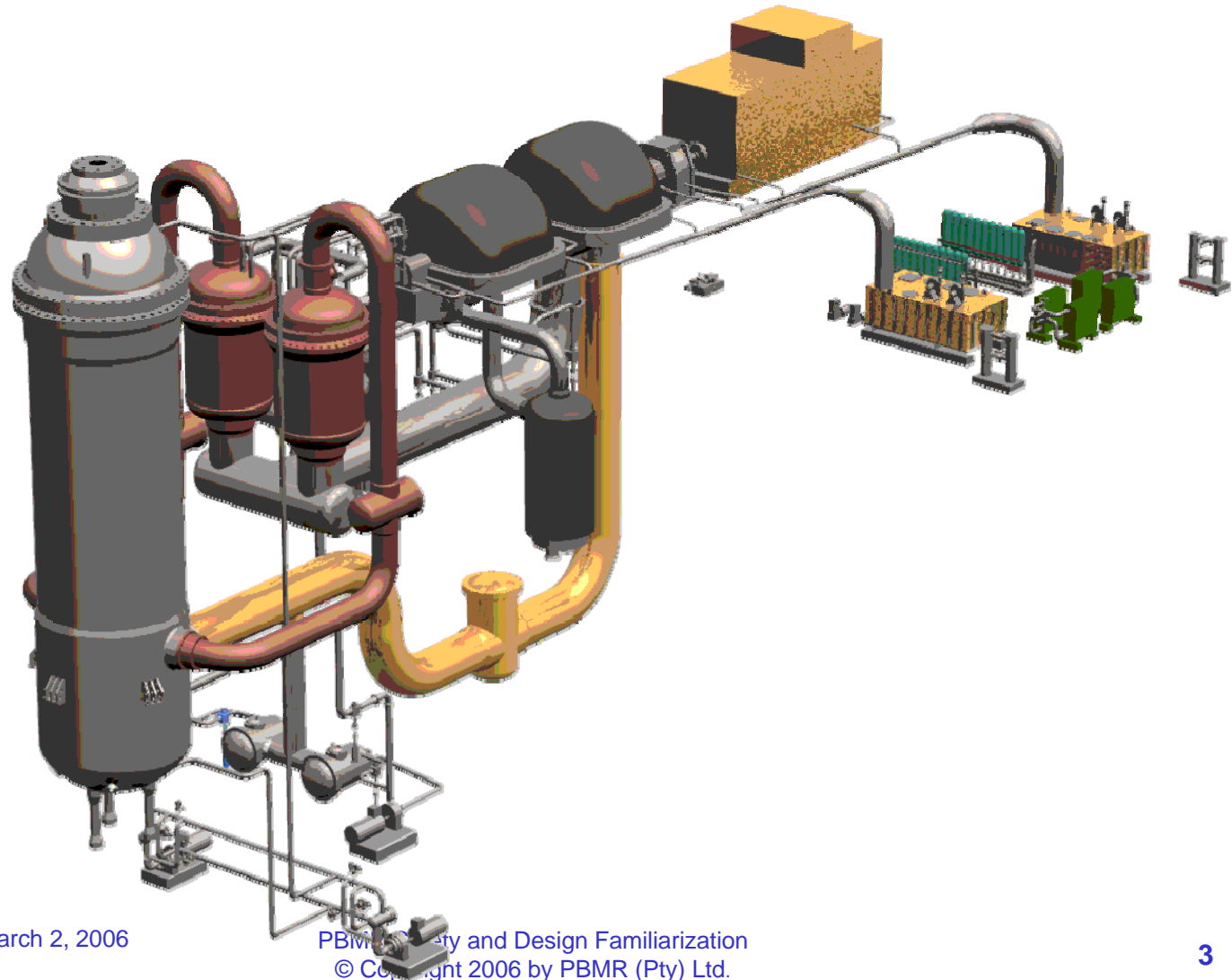
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Program Overview

- **Project Elements and Schedule**
- **Koeberg Site Plant Location**
- **PBMR Test and Development Facilities**
- **PBMR Distinguishing Characteristics**
- **Pilot Fuel Plant**
- **Multi-Module Power Plant**

The Demonstration Power Plant





Electricity Demonstration Project Has Been Launched

- **Currently over 700 equivalent full-time staff working on project at PBMR and at strategic suppliers**
- **Basic design being completed and detailed design started**
- **Revised Environmental Impact Assessment (EIA) submitted and updated Safety Analysis Report (SAR) nearing completion**
- **Helium Test Facility (HTF) and Heat Transfer Test Facility (HTTF) under construction**
- **Construction Manager mobilized**
- **Contracts with key suppliers for critical components being placed now**
- **Firm construction schedule established at Koeberg-South Africa**
 - **Site Access** 1 Qtr 2007
 - **Construction Excavation Starts** 3 Qtr 2007
 - **Fuel Load** 3 Qtr 2010
 - **Plant Turnover to Client** 3 Qtr 2011



Eskom – The Host Utility

- Eskom is host utility for Demonstration Plant at existing site next to Koeberg Nuclear Power Station (KNPS) within the security area on the South African West Coast near Cape Town.
- Active client office that is responsible for EIA and SAR.
- Launch customer for follow-on commercial plants (Letter of Intent)

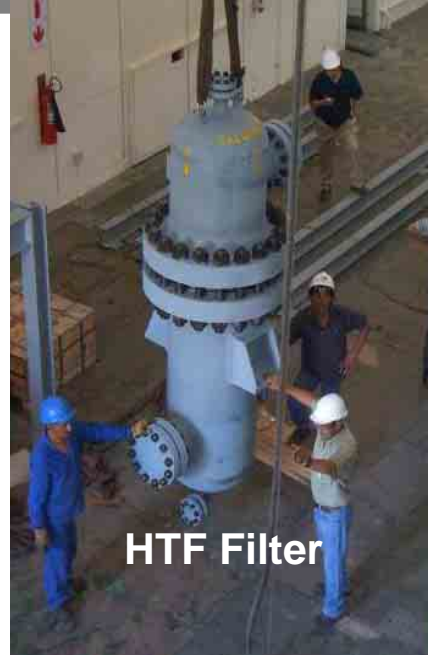


REACTOR / GENERATOR BUILDING



Comprehensive Test Program Established / Underway

- **ASTRA Critical Facility** benchmarked core physics/neutronics codes.
- **Micro-Model** demonstrated operation of closed cycle recuperative Brayton Cycle.
- **Helium Test Facility (HTF)** to verify codes and equipment reliability
- **Heat Transfer Test Facility (HTTF)** to validate thermo-hydraulic properties of pebble bed (2 loops)
- **IVV-2M Test Reactor** (plus others) to obtain confirmation of fuel performance
- **Plate Out Test Facility (POTF)** to confirm fission product transport in helium systems
- **NACOK facility** investigating oxidation of graphite during postulated air Ingress





Pebble Bed Reactor Designs

Reactor	Reactor Power	Status
HTR-10 (China)	10 MW	Built and running
AVR (Germany)	46 MW	Built, run and decommissioned
HTR Modul (Germany)	200 MW	Designed, licensability review completed, not built
HTR 100 (Germany)	250 MW	Designed
PBMR (South Africa)	400 MW	In Design / Pre-construction
THTR 300 (Germany)	750 MW	Built, run and decommissioned
HTR 500 (Germany)	1390 MW	Designed



Different Design Approaches for Modular HTRs

- **Direct vs. Indirect Cycles**

- **Direct Brayton Cycle**

- *Helium reactor coolant drives Brayton power conversion cycle*
 - Intercooled cycles
 - Non-intercooled cycles

- **Indirect Cycles**

- *Indirect Brayton Cycle*
 - Helium to helium IHX driving Brayton cycle power conversion cycle
- *Indirect Steam Cycle*
 - Helium to water IHX driving conventional steam power conversion cycle
- *Indirect / Indirect Combined Cycle*
 - Helium to Gas (Helium/Nitrogen) IHX with direct Brayton Topping cycle and Gas to Water IHX driving conventional steam bottoming cycle (combined cycle)



Different Design Approaches for Modular HTRs

- **Basic Issues driving design approaches**
 - Simplicity
 - Efficiency
 - Safety
 - Economics
 - Local Industrial Capacity
 - Schedule
 - Evaluated Risks
 - Development Costs
 - Co-product Applications
- **Different designs emphasize different combinations of drivers.**
- **All designs based on inherent, passive safety principles and TRISO fuel coated particle design concept**



Definition of Inherent

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



Definition of Passive Design Features

- **Design features engineered to meet their functional requirements *without***
 - Needing successful operation of systems with mechanical actions such as pumps, blowers, HVAC, sprays
 - Depending on availability of electric power
 - Relying on operator actions
- **PBMR passive design features utilize inherent characteristics.**



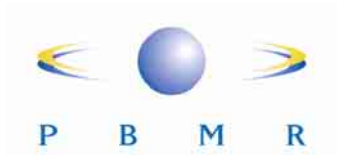
Important Paradigm Shifts

- The fuel, helium coolant, and graphite moderator are chemically compatible under all conditions.
- The fuel has very large temperature margins in normal and accident conditions.
- The safety of the PBMR core is not dependent on the presence of the helium coolant.
- The response times of the reactor are very long (days as opposed to seconds or minutes).
- There is no inherent mechanism for runaway reactivity excursions or power excursions.
- The PBMR has three concentric radionuclide barriers.
- Accident phenomena can be modeled mechanistically.
- An LWR-type containment is not advantageous or necessarily conservative.



Basic Technology Differences

- **Fuel Form**
- **Fuel Performance Record**
- **Core Design Simplicity**
- **Inherent Passive Safety & Safety Margins**
- **Relative Design Simplicity**
- **On-line Fueling**
- **Component Designs Within Known Industrial Capabilities**
- **Direct Cycle vs. Indirect Cycle**
- **Non-proliferation**
- **Waste Disposal / Spent Fuel**
- **Process Heat Potential**



Pilot Fuel Plant

- **Production scale facility to verify manufactured fuel is of requisite quality and performance**
 - Planned capacity ~ 270,000 spheres / year
- **Building refurbishment underway**
 - Operational – 2008

Concept of Multi-Module Power Plant

