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Industry Initiatives on New Reactor Design

PBMR DESIGN ACTIVITIES

Multinational Design Evaluation Programmes Conference, Paris, 11 Sept 2009

Dr Simanga Alex Tsela

GM: Nuclear Safety, Licensing & SHEQ

PRESENTATION

- Context: South Africa and PBMR
- Design Activities
- International Collaborations
- Cooperation with MDEP

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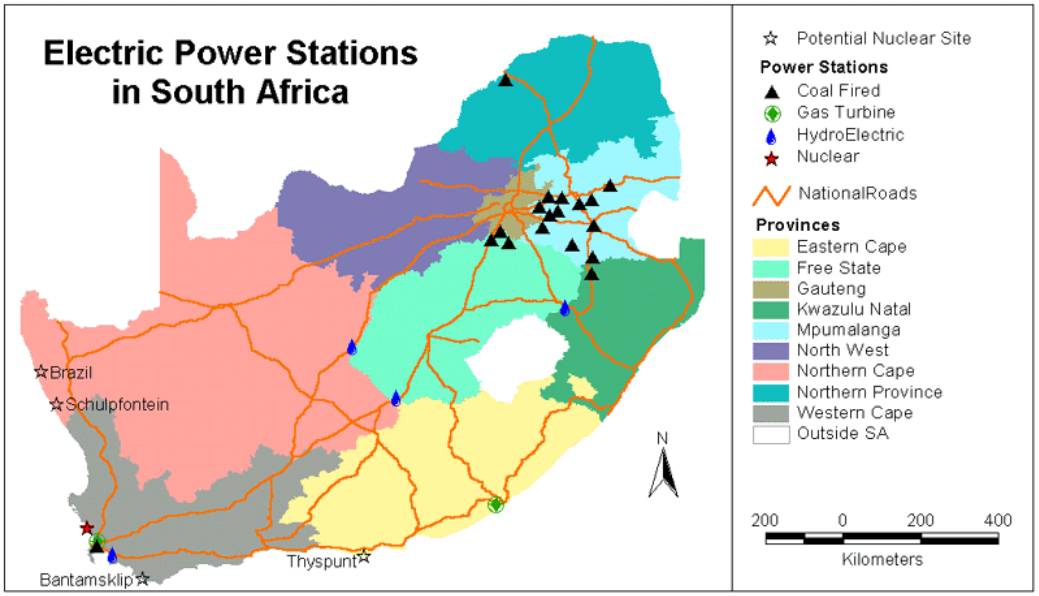
The historical SA Nuclear Industry & SA's nuclear capability

South Africa is committed to promoting sustainable development of human kind through implementing relevant policies & effectual measures



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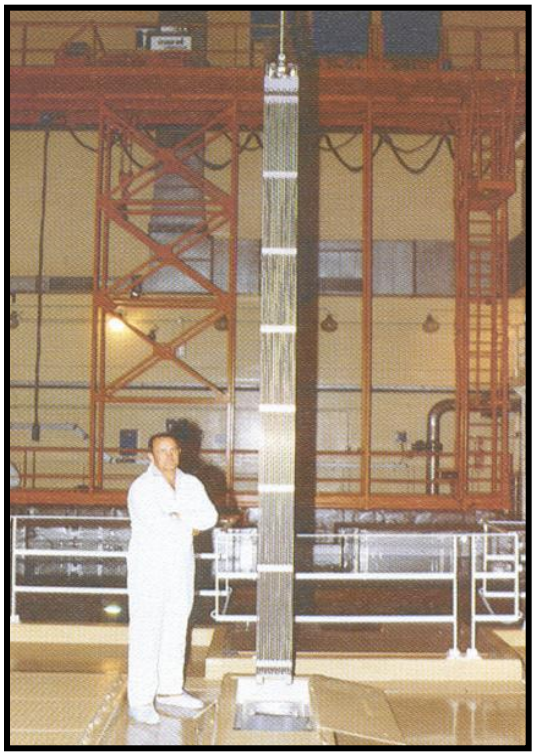
Development of strategic competence 1969 - 1989

Uranium Enrichment



Fuel fabrication

Weapons programme

PBMR

Two PWR Reactors at Koeberg, Cape Town

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VAALPUTS
Waste Disposal Site – Northern Cape

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VAALPUTS
Waste Disposal Site – Northern Cape

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PBMR Pty, Ltd

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Current PBMR Investors & Corporate Governance

- SA Government (grant)
- IDC
- Eskom
- Westinghouse
- Operate under a Co-operation agreement (shareholders agreement to be signed)
- PBMR Board and sub-committees maintain Corporate Governance

IDC
Industrial Development Corporation
Your partner in development finance

Eskom

Westinghouse

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Board of Directors

Dr Alistair Ruiters
PBMR
Chairman

Mr Jaco Kriek
PBMR
Chief Executive Officer

Mrs Lynette Milne
PBMR
Chief Financial Officer

Dr Alex Tsela
PBMR
GM: Nuclear Licensing, Safety & SHEQ

Dr Regis Matzie
Westinghouse
Senior Vice President & Chief Technology Officer

Mr Robert Pearce
Westinghouse
Director, Global Business Development Nuclear Power Plants

Ms Erica Johnson
Eskom
Managing Director System Operations & Planning Division

Mr Gert Gouws
IDC
Chief Financial Officer

Mr Setlakalane Molepo
IDC
Head: Metal, Transport and Machinery Products Strategic Business Unit

Dr Rob Adam
Necsa
Chief Executive Officer

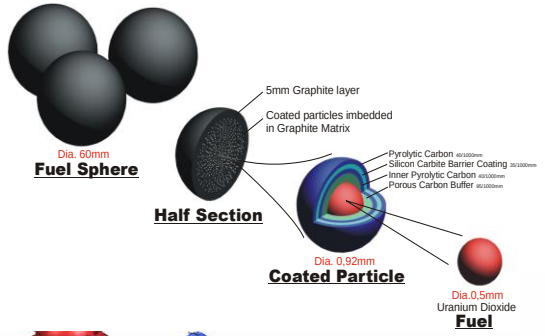
Mr Peter Readle
Consultant (Ex Director, Corporate Projects of BNFL)

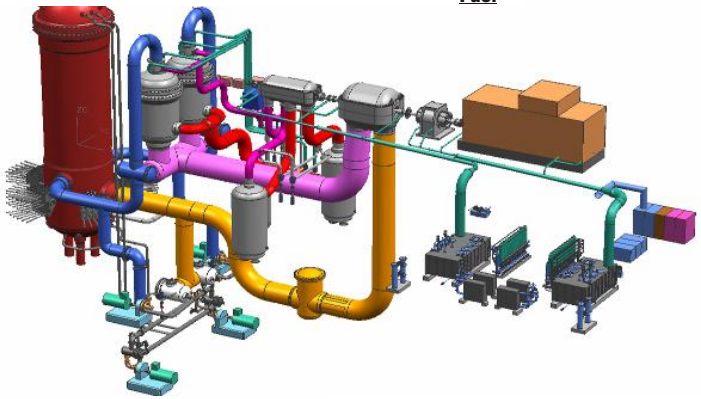
Mr Riaan Neethling
Eskom Nominee
(Ex: Senior General Manager: Resources & Strategy)

Dr Xolani Mkhwanazi
BHP Billiton
President: Energy Coal South African (BECSA)

PBMR DESIGN PRODUCTS

- Pebble Bed Fuel
- Pebble Bed Fuel Plant
- 400 MWt DPP reactor design, direct Brayton Cycle:
  - **Selection of Brayton Cycle** that favours high ROT, high RIT and high system pressure (for high power density)
- Small DPP reactor design, steam cycle :
  - Optimised for process heat, electricity or both





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DESIGN PROGRESS(1/2)

POWER PLANT :

- The conceptual design of the direct cycle power plant has been completed.
- Significant progress on equipment design, including:-
  - Conceptual design of all subsystems and equipment
  - Detail design of key equipment to the stage where procurement of long lead items could be initiated
- Design verification in progress.
- Analysis progressing for the completion of the Safety Case (SAR).

FUEL:

- Advance Fuel Design quality and safety specifications aligned with NNR regulations (LD-1096, RD-0034) to relate performance of the PBMR advance fuel to reference fuel (German fuel).
- PBMR Advance Fuel manufactured in the Fuel Development Laboratories (FDL) was transported on 6th September 2009 from RSA to INM (Russia) for testing.

DESIGN PROGRESS(2/2)

FUEL PLANT:

- A conceptual design based on the Hobeg plant has been completed.
- A basic design has been completed to a point where the following has been completed:
  - Process Flow and Piping and Instrumentation design to the point of completion of Hazop, Safety Assessment, Safety Instrumented Level analysis,
  - Establishment of design principles and approaches,
  - Completion of external hazard analysis including seismic, and
  - Completion of fire hazard assessment.

MANUFACTURING:

- Manufacturing and receiving inspection was successfully completed on the Top Plate Outer and the Top Flange Shell for the Core Barrel Assembly.
- Receiving inspection including additional Non Destructive Examinations were completed on half shell plates for the Reactor Pressure Vessel.
- Welding and NDE activities were completed on long welds joining 2 off half shell plates.

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CURRENT DESIGN ACTIVITIES(1/2)

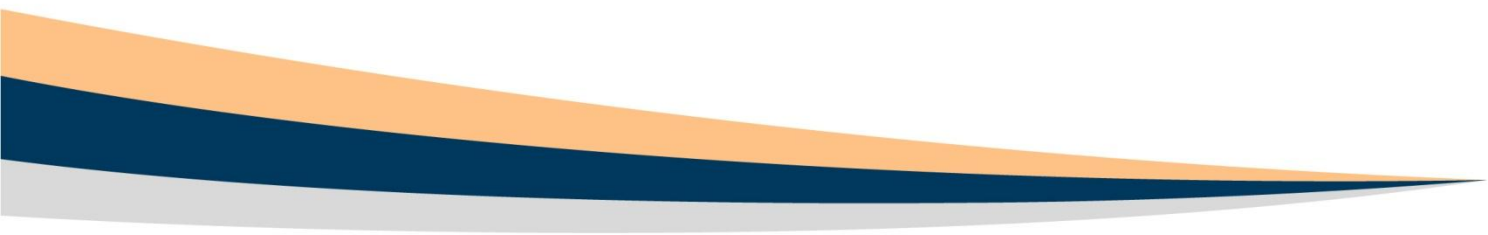
POWER PLANT:

- Recent market surveys have shown a **huge interest for PBMRs in the high-temperature process heat** or cogeneration applications (Coal-to-Liquid, Oil Sands).
- PBMR consequently decided to change its product focus to a **plant that will generate steam** for process heat applications or electricity generation or both (cogeneration).
- Established a Design Baseline from the HTR-Modul design (Reactor with indirect steam cycle power conversion).
- Updating the design to comply with modern regulatory and customer requirements.
- Identified the critical design trade-offs and issues that need to be addressed.

FUEL:

- Establishment of the PBMR Fuel Design Authority.
- Progressing with improving the fuel design regarding control mechanism for transport of fission products in normal and accident conditions.

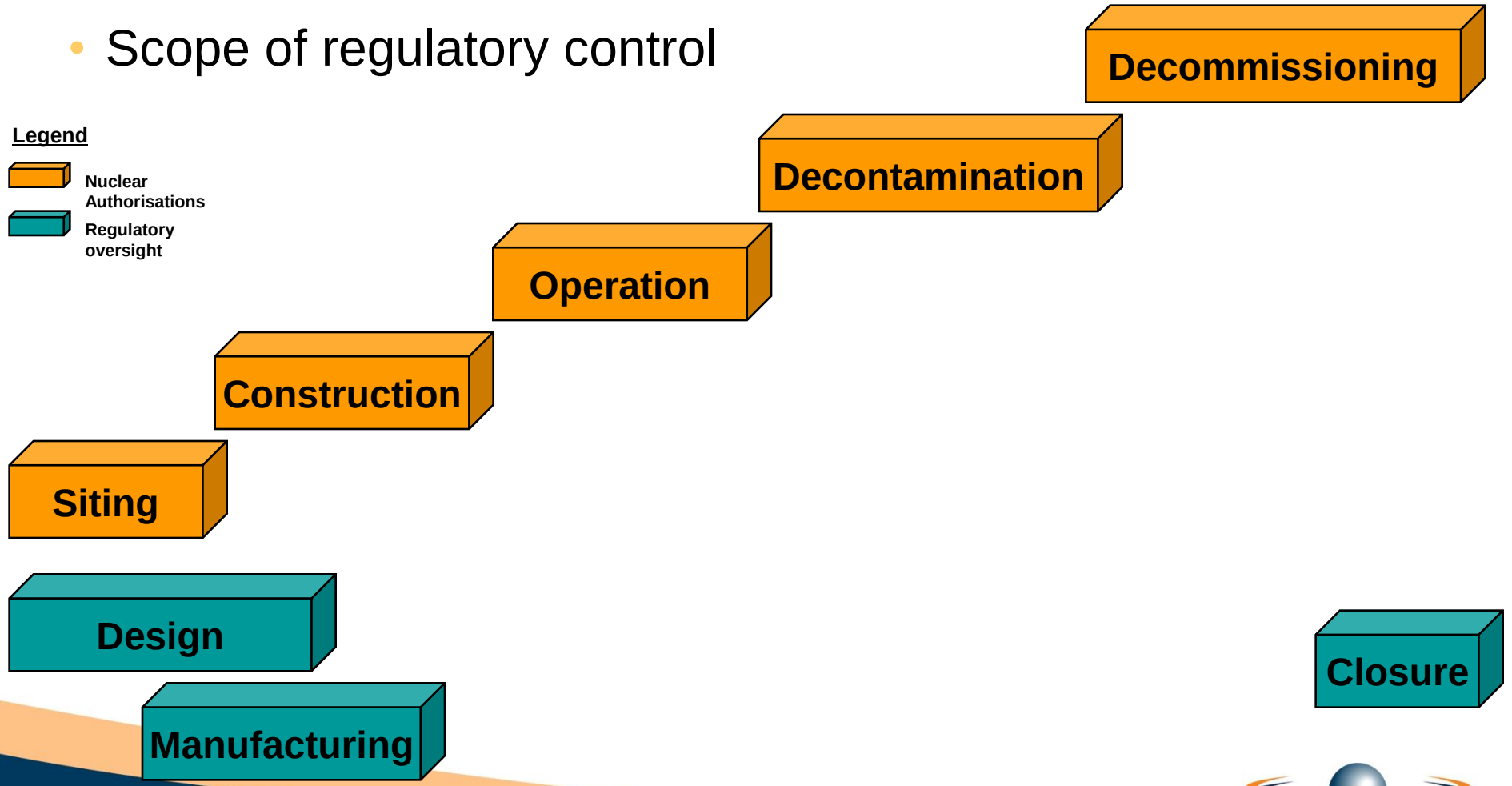
DESIGN REVIEWS



Nuclear Authorisation Process

Key Authorisation Steps for Nuclear Installation

- Scope of regulatory control



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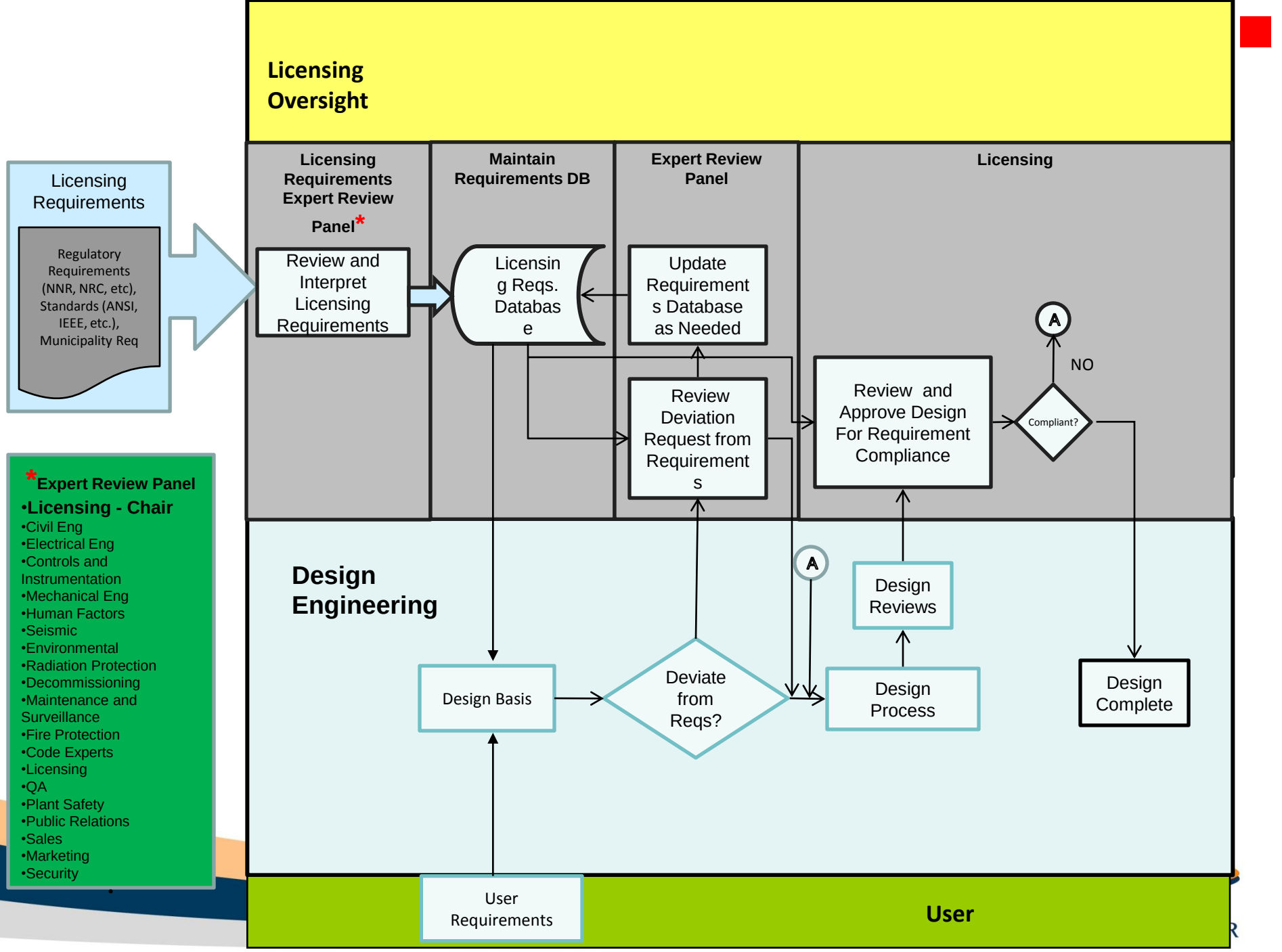
Licensing Oversight
Licensing Requirements
Regulatory Requirements (NNR, NRC, etc), Standards (ANSI, IEEE, etc.), Municipality Req
Licensing Requirements Expert Review Panel*
Maintain Requirements DB
Expert Review Panel
Licensing
Review and Interpret Licensing Requirements
Licensing Reqs. Database
Update Requirements Database as Needed
Review Deviation Request from Requirements
Review and Approve Design For Requirement Compliance
Compliant?
NO
A
Design Engineering
Design Basis
Deviate from Reqs?
Design Process
Design Reviews
Design Complete
User Requirements
User
*Expert Review Panel
•Licensing - Chair
•Civil Eng
•Electrical Eng
•Controls and Instrumentation
•Mechanical Eng
•Human Factors
•Seismic
•Environmental
•Radiation Protection
•Decommissioning
•Maintenance and Surveillance
•Fire Protection
•Code Experts
•Licensing
•QA
•Plant Safety
•Public Relations
•Sales
•Marketing
•Security

DESIGN REVIEW ACTIVITIES

- Two types of reviews are performed:
  - Independent review of individual design deliverables for accuracy and completeness
  - Design reviews to determine design maturity
- Design reviews are planned at different Plant / SSC levels and are executed in accordance with a controlling procedure.
- Design reviews may cover a specific topic (e.g. Human Factors) or may cover the total design at a defined point in the project phase (e.g. End-of-Phase Review)
- Typical End-of-Phase design reviews include:
  - System Requirements Review (Is the requirement set complete?)
  - System Design Review (Is the system design appropriate?)
  - Critical Design Review (Is the design ready for manufacturing and procurement?)

  Note: Risk identification and mitigation is an integral part of the design review
- Design review requirements are placed on suppliers and attended by PBMR in accordance with applicable QA requirements.

INTERNATIONAL COLLABORATIONS(1/2)

DIGITAL INSTRUMENTATION CONTROL:

- Design review of DPP400 (Direct Brayton Cycle) Thermo-hydraulic Control philosophy and algorithms at Westinghouse, Mannheim in October 2008.
- PBMR Employees representing South Africa on technical subcommittee 45A 'Instrumentation and control of nuclear facilities'.
- PBMR Employees have in the past participated in IAEA activities such as digital I&C licensing workshops, and classification of I&C functions.
- PBMR I&C engineers apply requirements / guidance from publications from the following organizations:
  - IAEA's (e.g. NS-G 1.3 'Instrumentation and Control Systems Important to Safety in NPPs')
  - IEC (e.g. IEC 61513 'NPPs – I&C important to safety – General requirements for systems')
  - US NRC (e.g. Regulator Guides and Interim Staff Guides)

INTERNATIONAL COLLABORATIONS(2/2)

VENDOR INSPECTIONS COOPERATION:

- None

CODES AND STANDARDS:

- PBMR Employees (x3) serve as volunteer members of the following ASME Boiler & Pressure Vessel Code Committees
  - Standards Committee Section III – Nuclear Facility Components (member)
  - Standards Committee Section XI – Nuclear In-service Inspection (member)
  - Sub-group on Graphite Core Components Section III (member)
  - Working Group HTGR Section III – Rules for Construction of HTGR (Chair)
  - Special Working Group HTGR Section XI – Rules for In-service Inspection of HTGR (Chair)
  - Sub-group Strategy and Management Section III (member).

BENEFIT FROM MDEP(1/3)

DIGITAL INSTRUMENTATION CONTROL:

- International peer review of Plant thermo-hydraulic control.
- Share in international experience in plant thermo-hydraulic control.
- Endorsement of a suite of codes, standards, principles and concepts applicable to I&C by regulators in various countries where PBMR may want to sell plants without having to significantly change the I&C design to meet local requirements.
- Harmonization between major I&C design standards (e.g. IEC and IEEE), such that a single I&C design can conform to both suites of standards.
- Lowered I&C project risk as result of:
  - ‘up front’ understanding of regulatory requirements; and
  - available and documented I&C safety principles and concepts.

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BENEFIT FROM MDEP(2/3)

VENDOR INSPECTIONS COOPERATION:

- Cost savings benefit where Inspectors from other countries can represent PBMR in certain vendor inspection activities where PBMR cannot.
- Should any collaborations be formed bilateral information exchange arrangements between the Regulators would be a benefit.
- Regulators would have the advantage of the knowledge of their own country legislation to ensure that other Regulators understand them hence resulting in good knowledge of codes and standards.
- Collaborations might result in the use of common procedures by the different countries, where applicable.

CODES AND STANDARDS:

- Endorsement of a chosen suite of codes by regulators in various countries where PBMR may want to sell plants without having to change the design to meet local requirements
- A convergence in regulatory practices would ease the obtaining of a license in countries where PBMR may want to sell plants without having to change the design to meet local requirements.
- Enhanced regulatory cooperation could lead to a situation whereby a code, standard and/or code case accepted by one regulatory body could be more easily accepted by other regulatory bodies. This would avoid the duplication of effort in terms of a once-off presentation to one of the regulatory bodies.

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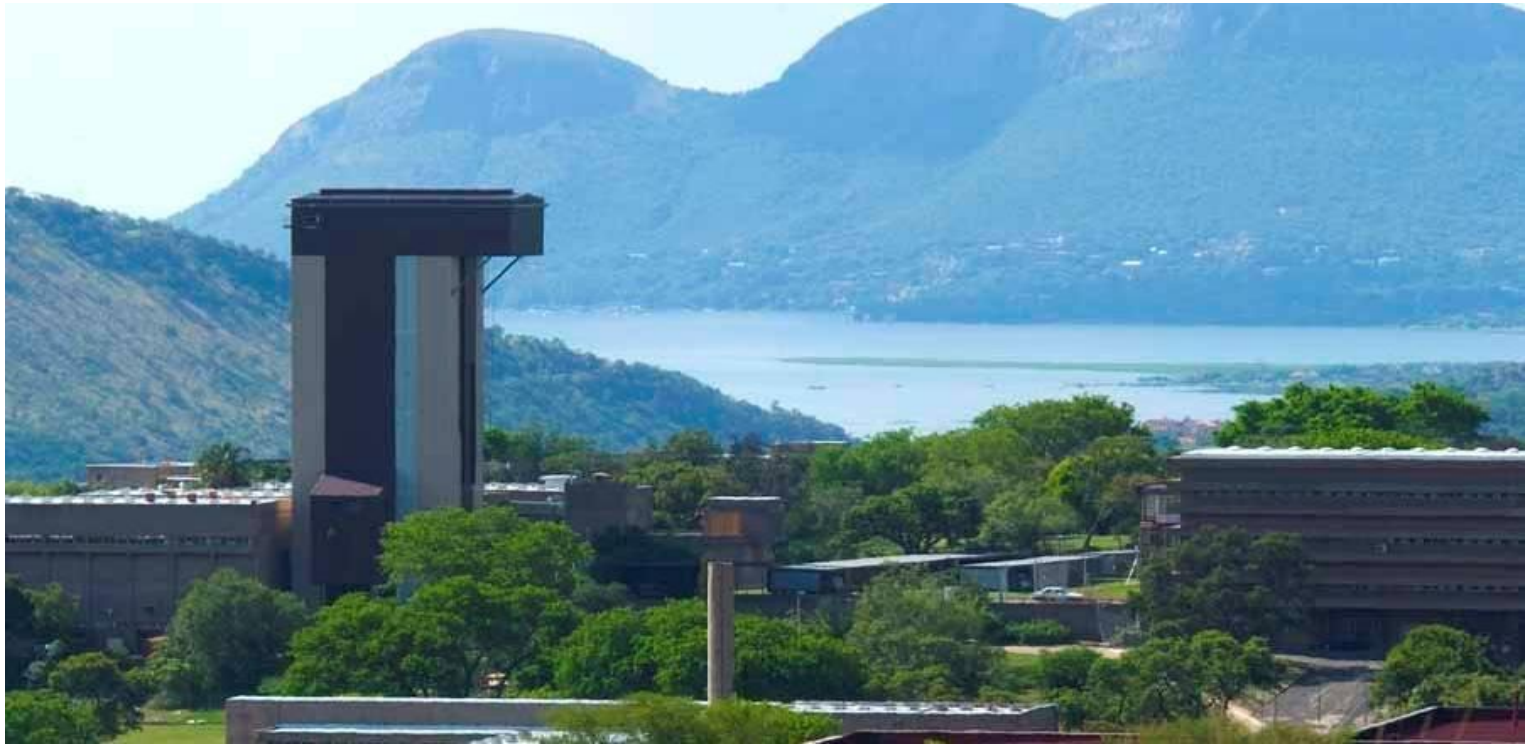
Helium Test Facility



The HTF at Pelindaba tests the helium blower, valves, heaters, coolers, recuperator and other components at pressures up to 95 bar and 1200 degrees C.

PBMR

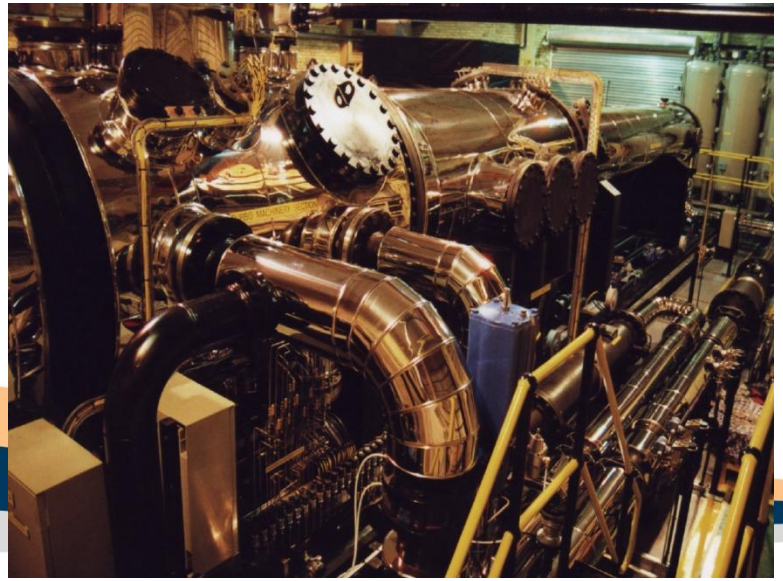
Helium Test Facility: Pelindaba

PBMR

Test facilities at the North-West University

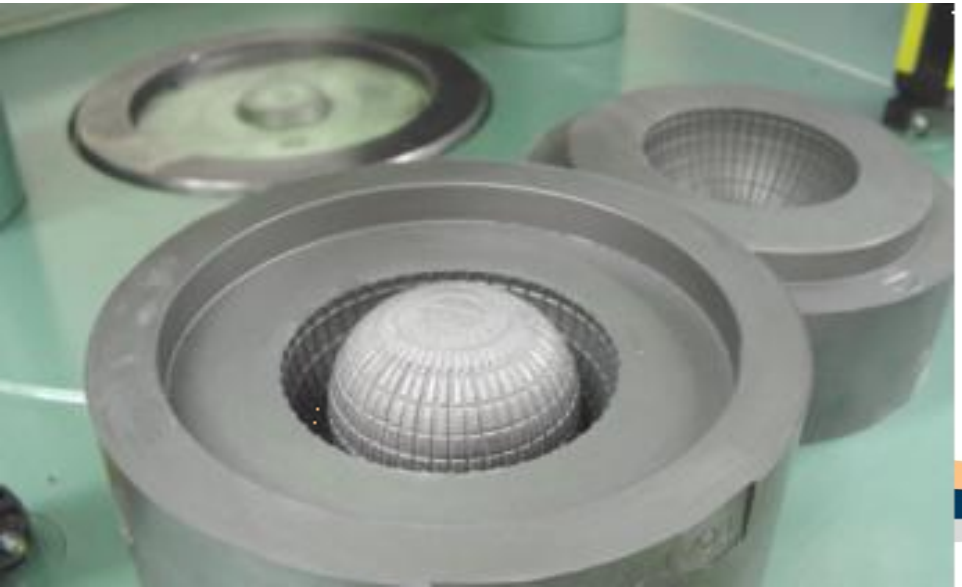
High Pressure Test Unit

High Temperature Test Unit

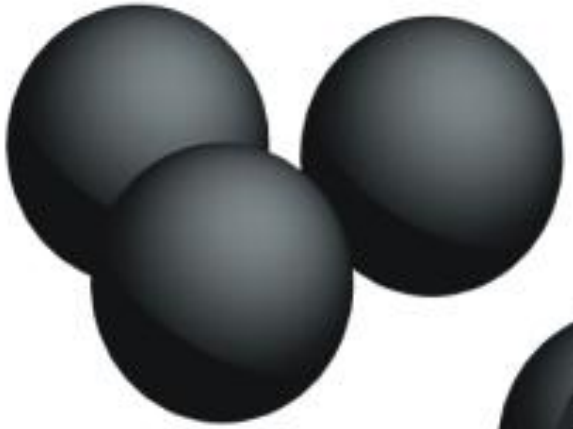


Pebble Bed Micro Model

Fuel Fabrication at Pelindaba

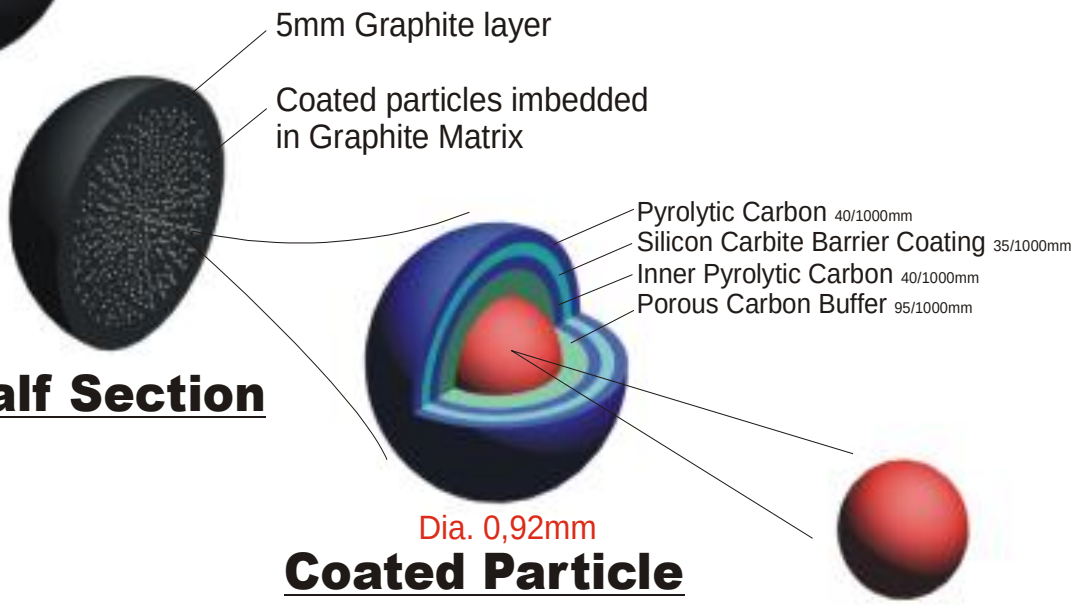


PBMR Fuel



Dia. 60mm

Fuel Sphere



Half Section

Dia. 0,92mm

Coated Particle

Dia.0,5mm

Uranium Dioxide

Fuel

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REACTOR / GENERATOR BUILDING
ADMINISTRATION BUILDING
PEBBLE BED MODULAR REACTOR
BRADSHAW ARCHITECTS

Thank you