THE PEBBLE BED EVOLUTION

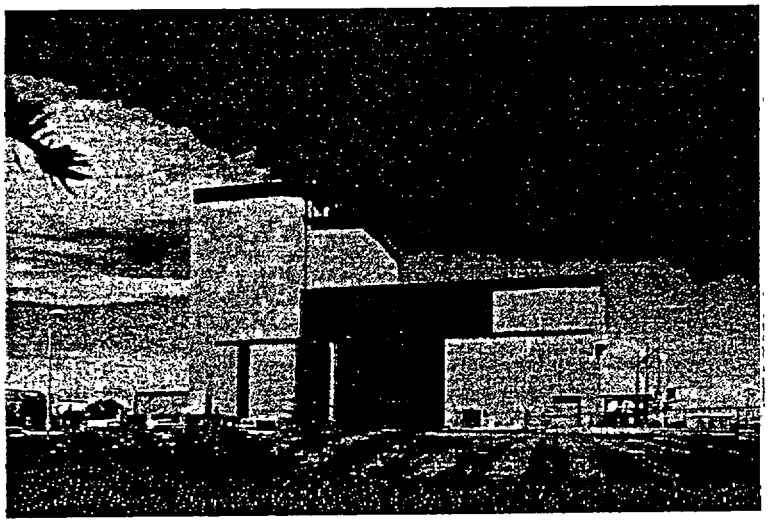
High-Temperature Reactor (HTR) technology had been successfully developed by the mid-1980s in Germany with the building of the AVR research reactor and the Thorium High-Temperature Reactor (THTR) power reactor The PBMR is a follow-on plant based on the fundamental research and development results gained on these plants, as well as the UK, USA and Japanese experience.

The 15MW AVR was a research reactor built to demonstrate the characteristics of the HTR reactor type based on the pebble bed concept Different types of fuel design, fuel loading configurations and HTR safety characteristics were tested and demonstrated. Despite being the first prototype, the AVR achieved a utilisation factor of approximately 70 percent over its 21-year operating life The value of the inherent safety features of this type of small HTR was only fully recognised after the Three Mile Island accident in the USA

The 300MW THTR (Thorium High-temperature Reactor) was built as a first-of-its-kind production plant, which was intended to demonstrate the viability of the different subsystem hardware designs, with specific emphasis on plant availability and maintainability The design, therefore, concentrated on building a plant with a life span of 40 years and an availability of 80 to 90 percent The THTR-300 was going to be the front-runner of a commercial machine, namely the HTR-500

Following the Chernobyl accident in 1986, the West German government came under severe pressure to start closing down nuclear plants It was easier to close down the HTR research reactors which had no impact on the electricity supply to Germany, than commercial nuclear power stations.

Although both were pebble bed reactors, there were fundamental differences between the AVR and THTR-300 plants. The key engineering differences resulted from the size of the reactor. The change in size from AVR (40MWth) to the THTR (800MWth) resulted in major engineering differences in the THTR such as a much larger core diameter (2,5m to 5m), a concrete pressure vessel, in-core control rods and active safety-grade systems.



The 330MW Fort St Vrain High-Temperature Gas Reactor which operated for 14 years in the US.

These changes were largely driven by the presumed need for larger reactor power levels and resulted in the vast majority of the commissioning problems with the THTR The concrete pressure vessel led to difficulties in insulation of the low temperature concrete (limit 60°C) from the high temperature gases (650°C). Due to the need to insert the control rods into the pebble bed by force, the in-core control rods resulted in damage to fuel elements. The resulting high scrap level in the fuel system led to low availability of the fuel handling system

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In 1996, Eskom purchased the PBMR license from HTR, a joint venture of Siemens and ABB.

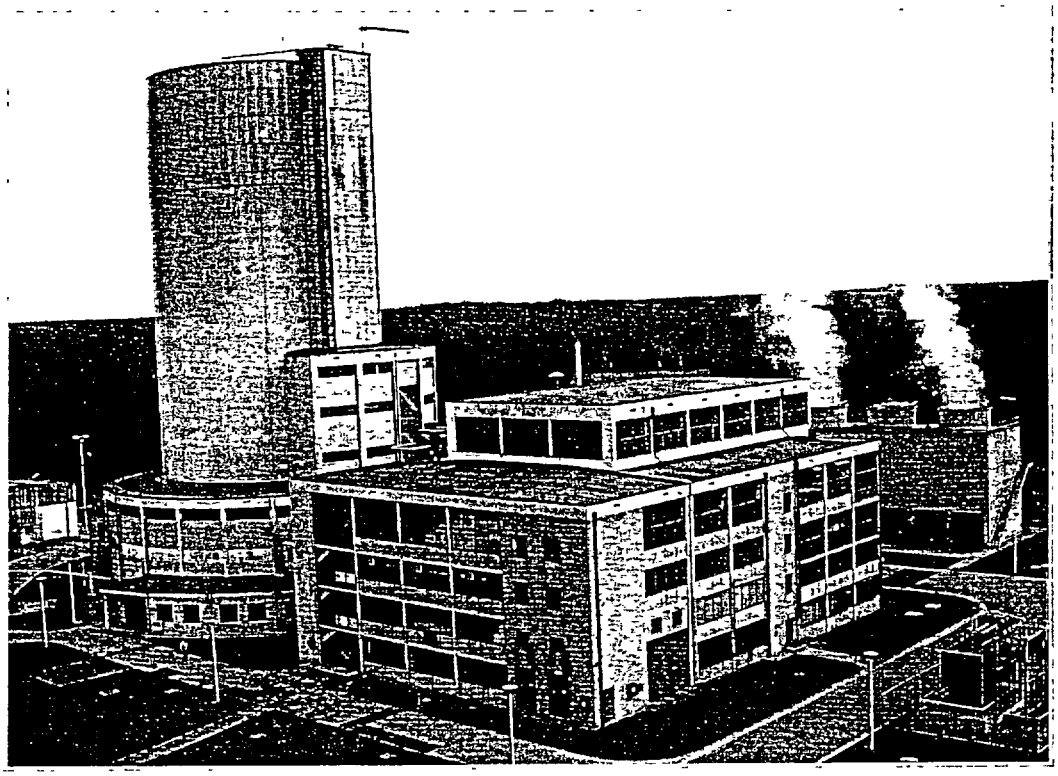
The PBMR project team believes that it has improved upon the design concepts of the THTR-300 plant Some technical design concepts which were not successful, have specifically been addressed by the PBMR, such as a steel pressure vessel instead of a concrete pressure vessel and control rods in the reflector instead of in the core.

The PBMR concept also includes the technological advances made in gas turbine technology since the 1980s and provides a plant configuration with the most robust safety case of any HTR yet designed. The small plant size and the elimination of a steam cycle, allows the achievement of the robust safety case of the PBMR

Despite its technical deficiencies, the THTR-300 achieved the following milestones

- first nuclear power on 6 September 1985,
- first power into the grid on 16 November 1985,
- 100 percent power performance on 23 September 1986, and
- handover to the utilities' consortium (HKG) on 1 June 1987

The fuel design of the PBMR falls within the qualified fuel design parameters of the German fuel programme. The actual fuel design is that specified for the Interatom Modul reactor design, which was qualified and certified in Germany. There was a large range of specific fuel designs (in terms of coatings and kernel dimensions) used on the THTR and AVR



The 15MW experimental pebble bed reactor which operated in Germany for 21 years.