WHY PBMR TECHNOLOGY?

Pebble bed, modular nuclear reactor technology innovatively rewrites the design concept for nuclear ractors with significant benefits.

A PERSUASIVE BOUQUET OF BENEFITS

Small, safe, clean, cost-competitive and adaptable, these, in a nutshell, are the features of the Pebble Bed Modular Reactor (PBMR).

Locally, the PBMR technology has the potential to provide South Africa with competitive power generation in coastal areas. Internationally, it will be highly competitive with virtually all other forms of energy generation.

Most of South Africa's coal-fired electricity is generated by large-scale plants built near the pit-heads of two extensive coal-producing areas, both of them far inland on the eastern side of the country. This requires long power lines from the coal-rich areas to load centres away from the pit-heads, which in turn implies high capital costs and transmission losses. Transporting coal to distant power stations is not an option, as it is prohibitively expensive.

Although the electricity demand in South Africa is still lower than the capacity, even moderate growth will soon result in peak electricity demand exceeding capacity if no new power stations are built. In addition, Eskom's older power stations reach the end of their design-life after 2025. South Africa will, therefore, need to access and use all natural resources to produce the additional 20 000 MW of electricity that will be needed by 2025 (over and above the currently installed 39 000 MW).

Conventional power stations are expanded in increments of between 600 and 1000 MW. A typical coal-fired power station, consisting of 6 x 600 MW units, requires a lead-time of about eight years and could result in the installation of surplus capacity if economic growth is not as expected. Shorter lead-times would enable power utilities to drastically shorten their decision-making horizon for the addition of new capacity and to add capacity in smaller increments.

Eskom, like most utilities worldwide, also experiences short, sharp demand peaks in winter that are difficult to accommodate with the slow ramping characteristics of the existing large power stations.

These factors prompted Eskom to contemplate small electricity generation plants that can be placed near to the points of demand. The PBMR concept, which has a 24-month construction lead-time, low operating cost and fast load-following characteristics, is such an option.

THE PBMR IS ADAPTABLE

The PBMR is adaptable and flexible. It is being designed in a modular fashion to allow for additional modules in accordance with demand. It is much less location-dependent than, for instance, hydro-electric or fossil-fuelled power stations.

Dry cooling, although more expensive, is an option that would provide even more freedom of location. In addition, the PBMR can be used as base-load station or load-following station and can be configured to the size required by the community it serves. The technology is also well suited for hydrogen production, district heating and desalination purposes.

THE PBMR IS SMALL

The PBMR is based on the philosophy that the new generation of nuclear reactors should be small. The commercial PBMRs would be sized to produce 165 MWe nominal, which is about 18 percent of the output of a conventional reactor such as the ones at Koeberg. To maximise the sharing of support systems, however, the PBMR has been configured into a variety of options, of which the four-pack layout is the most cost-effective. The multi-module concept allows the plants to be brought on line as they are completed.

The main building and generator of a module will cover an area of about 4200 m^2 (113 x 37 m), which means that two modules would fit on a soccer field. The height of the building will be 61,1 m, of which more than a third (22,5 m) will be below ground level.

THE PBMR IS COST-COMPETITIVE

South Africa has one of the lowest power costs in the world, based on its abundant low-cost coal. The PBMR business plan, compiled by the international consultancy McKinsey & Company, confirmed that the PBMR's output cost would be in the same order as the cost of electricity produced by a new South African coal-fired plant situated at the pit-head.

The cost per unit of electricity produced would, however, be much lower than a coal-fired plant at the South African coast or the world average cost of US 3,4c/kWh. The costs of decommissioning, long-term storage of radioactive waste and insurance are included in these estimates. Unlike Eskom's other low cost options such as coal and imported hydro, the PBMR costs are virtually independent of location.

With the recent sustained rise in the cost of fossil fuels (oil, natural gas and coal) to levels of over twice what was seen as "good" long term estimates a couple of years ago, and the increasing recognition that there will be real costs involved with reducing greenhouse gas emissions, the economic advantage of PBMR (as with other nuclear options), is increased significantly.

THE PBMR IS SAFE

The PBMR has a simple design basis, with passive safety features that require no human intervention and that cannot be by-passed or rendered ineffective in any way.

If a fault occurs during reactor operations, the system, at worst, will come to a standstill and merely dissipate heat on a decreasing curve without any core failure or release of radioactivity to the environment.

Its inherent safety is a result of the design, the materials used, the fuel and the natural physics involved, rather than the engineered active safety systems in a pressure water reactor (PWR). The helium, which is used to transfer heat from the core to the power-generating gas turbines, is chemically inert. It is non-combustible and cannot combine with other chemicals.

The inherently safe design, which renders the need for safety grade backup systems and off-site emergency plans obsolete, is fundamental to the cost reduction achieved over other nuclear designs. One of the fundamental design differences between current generation reactors and high temperature gas-cooled reactors (HTGRs) with coated particle fuel, is the individual “containment” function of each fuel particle. The inherent design of these fuel particles, coupled with the advanced design of the reactor, prevents a major or severe loss of containment.

THE PBMR IS CLEAN

The PBMR can provide an economic mitigation strategy for greenhouse gas reductions, since nuclear power generation produces no carbon dioxide emissions, smoke or any other gases. France's carbon dioxide emissions from electricity generation fell by 80 percent between 1980 and 1987 as its nuclear capacity increased, and Germany's nuclear power programme has saved the emission of over two billion tons of carbon dioxide from fossil fuels since it began in 1961.

Emissions of sulphur dioxide in the US would have been three million tons higher and emissions of nitrogen oxides more than two million tons higher if US utilities had built fossil plants instead of nuclear plants. If, by some misfortune, all of America's 103 nuclear plants were shutdown and replaced by fossil plants, it would be necessary to
remove 90 million automobiles from the nation's highways just to keep the emissions at the current levels.

If we really are facing a global emergency on the climate front, building new reactors is the best option to get the world through the crisis of the next generation "Renewables" like solar, wind and biomass can help fill the gap, but only nuclear power offers clean, environmentally friendly energy on a massive scale.

WASTE GENERATION AND DISPOSAL

Compared with the huge atmospheric emissions from fossil-fuel energy, nuclear wastes exist in small, highly manageable amounts that can be stored without harm to people or the environment. A major advantage of radioactive waste from a nuclear power station is that it is so small in volume compared to the equivalent waste from, for example, a coal-fired power station.

One kilogram of uranium in the PBMR fuel has a greater energy output than 430 tons of the best coal with an ash content (waste) of up to 40 percent. A large coal-fired power station uses about 2 200 trainloads of coal per year (six a day), while only two truckloads of fuel per week will be required for 22 PBMR nuclear power stations of equivalent capacity. For the PBMR demonstration unit at Koeberg, 10 truckloads will be needed for the initial load and only four truckloads per year for the replacement of spent fuel.

A 165 MWe PBMR module will generate about 32 tons of spent fuel pebbles per annum, of which about 1 ton is uranium. The storage of PBMR spent fuel is much easier than for fuel rods from conventional nuclear reactors, as no safety graded cooling systems are needed to prevent fuel failure.

The PBMR system has been designed to deal with nuclear waste efficiently and safely. There will be enough room for the spent fuel to be stored in dry storage tanks at the PBMR plant for the power station's expected 40-year life, during which time no spent fuel will have to be removed from the site.

After the plant has been shut down, the spent fuel can be safely stored on site for another 40 years before being sent to a final repository, where the following factors will ensure safe storage:

- Firstly, the fission products are encased in a layer of silicon carbide. This layer forms a protective shell around the fission products, thereby preventing contamination of the environment;
- Secondly, the fuel has been packed in a graphite sphere, which is an inherently stable material. This means that the spheres will not break or disintegrate. The configuration of the spent fuel will therefore not change.
- Finally, the density of spent fuel in each sphere is so minimal that the repository can be packed as efficiently as possible.