The South African Nuclear Power Programme: Submission to the Portfolio Committee on Environmental Affairs and Tourism

by

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1. Executive summary

The nuclear power programme envisaged by the South African government and Eskom would require the expenditure of about R400bn of public money to build the plants (see Appendix). Waste disposal and decommissioning would cost an additional sum of a similar order of magnitude. A new nuclear programme should be launched only with the full and informed consent of the South African public. Such a huge commitment of public money should not be rushed or short-circuited. A realistic view of the nuclear programme suggests that even if no new problems are encountered, new nuclear capacity cannot start making a significant contribution to South African electricity supplies before about 2020. So nuclear is, at best, irrelevant to the current issues facing the South African electricity industry and, at worst, a dangerous distraction from dealing with urgent issues.

This paper examines what has gone wrong with the Pebble Bed Modular Reactor programme and what the future prospects are. It looks at the proposed programme of 'conventional' nuclear power plants assessing how realistic the targets are. Finally, it examines the risks and consequences of relying on nuclear power to meet South Africa's electricity needs. It concludes that a new nuclear programme should be launched only with the full and informed consent of the South African public.

The PBMR programme needs a fresh, independent review that is open to full public scrutiny. Costs and time estimates have escalated out of control, markets and partners have not emerged, and targets and deadlines have been consistently missed. The Government seems to have no clear idea how the project should be run. The next phase of the project will require more than five times as much public money as has been spent so far. The most recent estimate of about R15bn for this phase is likely to be an under-estimate. The expected commercial orders to follow on from the Demonstration plant might cost around R76bn (see Appendix). Turning back once this phase has been embarked on will be politically even more unpalatable than abandoning the project is now. It is therefore essential that before further public money is spent that the project should be subject to independent scrutiny. Among the issues that should be covered are:

- Can a design be produced that satisfies the National Nuclear Regulator?
- Will the construction cost of such a design be competitive?
- Can it be assumed that PBMR plants will be reliable and economic?
- Will there be a market for PBMRs outside South Africa?

The proposals for 'conventional' nuclear power plants seem little better thought out. The time-scales seem highly optimistic and the advantages that were said to make the PBMR so attractive would be lost. These 'conventional' designs have been under development for about 15 years, and their design characteristics were known when the PBMR programme was launched. So it is hard to understand why, if they were so unattractive a decade ago, they are now a good option. They remain unproven in operation and the only construction experience to date, in Finland, has been appalling.

One of the main costs of the PBMR programme has been the 'opportunity cost' of not improving energy efficiency to anything like best practice and of not developing South Africa's sustainable energy sources, such as wind, biomass and solar. Had the money and resources spent on the PBMR been spent on energy efficiency and renewables, the problems of black-outs experienced in the Cape region in 2006 might have been much less severe. There would also not be the aura of panic that seems now to surround decision-making on the power sector. There can be little confidence that the latest proposals are any better conceived than previous proposals. The risk of such a large programme is that for the next 10-15 years, South Africa will be locked into an expensive nuclear programme that will have absorbed many of the available resources, but which will have come to nothing or will have produced only one or two 'white elephants'. There will be few resources to develop options that could have helped South Africa meet its energy needs in a more sustainable way, such as energy efficiency and renewables. Equally, it will be difficult to take advantage of developments elsewhere in the world on renewables and energy efficiency.

2. Introduction

Despite apparent decisions by the new ANC government in the mid-1990s not to pursue civil nuclear power, Eskom began work on developing a new design of nuclear power plant in 1993, the Pebble Bed Modular Reactor (PBMR) although this was not made public until 1998. Progress with this design has been very slow and by 2006, the programme was more than a decade late. In response to an apparent need for a large amount of new power station capacity, Eskom and the South African government announced their intention in 2006 to pursue what they called ‘conventional nuclear technology’. Eskom announced in 2007 that it expected to build up to 20,000MW of nuclear capacity (presumably PBMR and conventional nuclear) by 2025. This would be equivalent to building ten nuclear power stations equivalent in size to the one existing South African nuclear power plant at Koeberg. Such a programme would require an investment in the region of R400bn just for the construction of the plants with further cost of the same order of magnitude to decommission the plants at the end of their life and dispose of the waste.

This paper examines what has gone wrong with the PBMR programme and what the future prospects for it are. It then looks at the proposed programme of ‘conventional’ nuclear power plants assessing how realistic the targets are. Finally, it examines the risks and consequences of relying on nuclear power to meet South Africa’s electricity needs.

3. The Pebble Bed Modular Reactor

The PBMR has been under development in South Africa since about 1993, although it was not until 1998 that these efforts were publicised. Eskom formally took a license with a German company, HTR, for pebble bed technology in 1999. It was expected in 1998 that work on construction of a demonstration plant would begin in 1999 and be complete before 2003 to allow commercial orders soon after (see D R Nicholls, 2000). Eskom projected that the market would be about 30 units per year, about 20 of which would be exported. In April 2000, the South African Cabinet approved Eskom’s continuation and completion of a Detailed Feasibility Study (DFS) on the proposed PBMR. Subsequently, Eskom formed a company, PBMR (Pty) Ltd to develop and market the technology. PBMR (Pty) Ltd foresaw four phases: research and development (already then completed), feasibility study (then underway), demonstration, and commercial application.

Since then, the timetable has slipped so that the Demonstration Plant, planned to be built at Koeberg, is not now forecast by PBMR Co to be in service before 2012 at the earliest, although recent delays make a 2012 completion date implausible. The Demonstration Plant would have to run for, say three years, to prove the technology works. This issue of proving the technology was taken up in the Revised Final Environmental Scoping Report (RFESR) published in January 2007 (Mawatsan, 2007, p 55). It divides ‘demonstration’ into demonstration of functional integrity and demonstration of commercial performance. It lists 13 separate attributes that should be demonstrated. Three of these will take at least three years to be partially demonstrated (plant availability, plant efficiency and sustainability, operational and maintenance cost, and first outage). Eleven of them will take at least seven years to be fully demonstrated (e.g., main power system integrity and helium leakage verification).

Even if construction and operation of the Demonstration Plant goes entirely to plan and no problems emerge and we assume partial demonstration is a sufficient basis for commercial orders to be placed, this means commercial orders could not be placed before mid-2017, with first power from the first commercial plant in 2021. So in less than ten years since the PBMR programme was made public, the timescale for the first commercial units has slipped by about 15 years.

Costs have also escalated alarmingly. In 2000, Eskom’s estimates suggested that the cost of the Demonstration phase would be about R2bn (Thomas, 2006). However, in August 2005 Ferreira confirmed that the estimated cost of the demonstration phase had increased again to

R14.5bn[1]. There has not been a more recent published estimate than this, but it would be extremely surprising if the latest cost estimate was not substantially higher.

The PBMR Programme has disappointed in other ways. There has long been a promise from the PBMR Co that partners would be brought in to share risks, bring in additional technical skills and open up new markets. A number of partners have been brought in, including the government's Industrial Development Corporation (IDC) in 2002 with 25 per cent. However, some have withdrawn (a US utility, Exelon) and others reduced their stake (the nationally-owned UK fuel cycle company, BNFL). Eskom itself has been trying to distance itself from the project by reducing its stake but as prospects of new partners being attracted recede, it is now being required to take over the project again. It, and perhaps the South African, government are the only reasonably assured investors for the demonstration phase.

The PBMR programme was launched as an export project with an expectation that 20 units a year could be exported. Nine years after the launch, there are no export customers in sight and, as with project management, Eskom is likely to be required to bear the burden of keeping the project afloat by placing orders for plants even if they represent poor value for money.

The latest plans foresee Eskom making an initial order of 24 units (4000MW). No estimates have been published on the price of commercial PBMR units, but even if we assume PBMR units can be built as cheaply as conventional nuclear plants, each unit would cost a little over R3bn and the total investment in construction costs alone (excluding decommissioning and waste disposal costs) would be about R76bn.

The most recent blow to the project was the news that the South African safety regulator (NNR) had required Eskom and PBMR Co to halt all work on the manufacture of safety related components in October 2006. This decision was only made known in response to a specific question from the international trade journal, Nucleonics Week, in June 2007[2]. It is not clear when this restriction will be lifted and how much delay it will introduce.

3.1. Eskom's position

After initial enthusiasm for the project, Eskom has been seeking to distance itself from it for the past five years. The organization developing the PBMR was placed in a separate company, PBMR Co, controlled by Eskom and three partner companies but PBMR Co was re-absorbed into Eskom in 2005 and is now expected to continue to be owned by Eskom. This means that the cost of developing the PBMR will fall on electricity consumers.

3.2. The government's position

The government has been uncertain in its position towards the project. Following a government review in January 2004, IDC was expected to take a more prominent role in the project, and in November 2004, the CEO of Eskom told the Parliamentary Portfolio Committee on Trade & Industry that IDC would be replacing Eskom as project leader.[3] However, since then, the role of IDC has been reduced again to that of no more than a passive partner. In August 2006, a spokeswoman for Minister of Public Enterprises Alec Erwin said that IDC would no longer act as the government's "nominee" or agent in the PBMR project.[4] It is not clear whether this means IDC would have no stake in the demonstration phase. It has also emerged that, unreported at the time, IDC had reduced its stake to 13 per cent in 2002.

Finally, in May 2007, it emerged that the PBMR Co was expected to stay within Eskom rather than being run by government[5]. These continual swings in policy give little confidence

[1] Business Day, August 16, 2005, p 2.
[2] Nucleonics Week, June 7, 2007, p 1.
[3] Sunday Times, November 10, 2004.
[4] Nucleonics Week, August 31, 2006, p 3
[5] Business Day, May 3, 2007

that government has a clear conception of what it takes to bring a challenging project such as this to commercial status.

3.3. Public information

One of the major problems throughout the PBMR's history has been the lack of meaningful public information. Eskom, the Government and PBMR Co have seldom volunteered information to the South African public about costs and delays. Most information has entered the public domain via Nucleonics Week and only in answer to specific questions from the newsletter. Nucleonics Week is a highly reputable and authoritative publication, but one which very few of the South African public has any access to. This is hard to reconcile with the fact that throughout the project's history, the project has been driven by South African taxpayers' and electricity consumers' money. As financiers of the project, the South African public has a right to expect to be fully informed on how their money is being spent.

4. The proposal for a 'conventional' nuclear plant

In April 2006, in the wake of severe power shortages in the Cape area following a serious error in the maintenance of the existing nuclear power plant at Koeberg, Alec Erwin, the DEAT Minister announced that he had asked Eskom to examine the possibility of building a 'conventional nuclear power station' at Koeberg. By February 2007, these plans had been firmed up sufficiently that it was forecast that a large plant would be on line by 2014 with a total of 2000-3000MW to be completed in the 'near-term'[6] By June, Eskom was saying that it was targeting the addition of up to 20,000MW of nuclear capacity by 2025. Are these plans any more realistic than those for the PBMR? A number of issues arise:

- What 'conventional' technologies are available and how proven are they?
- What regulatory burden would this impose?
- Is the timescale realistic? and
- How would such a unit fit into the South African system?

These questions must be put in the context of the statements by Eskom that: 'By 1993 it had become clear that building a new traditional Pressurised Water Reactor (PWR) such as Koeberg would be prohibitively expensive.'[7] They must also be seen in the light of claimed, albeit disputed, advantages of the PBMR over conventional nuclear technologies, including small size, appropriate for weakly connected regions, use of passive safety design, low production of radioactive waste and no need for a large distance from population centres.

The 'conventional' nuclear technologies were known about in 1998. They are evolutions of existing designs and, fundamentally, have a great deal in common with the existing Koeberg plant, which Eskom spoke disparagingly of when it was trying to promote the PBMR.

4.1. What 'conventional' technologies are available?

The clear implication from the use by Erwin and Eskom of the word 'conventional' is that there are well-proven, off-the-peg nuclear designs that South Africa could order with confidence. This is far from the case. Of the reactor designs being developed and which are currently on offer, there are only two obvious candidates: the European Pressurised Water Reactor (EPR) offered by Areva; and the AP-1000 offered by Westinghouse.[8]

4.1.1. The EPR

The EPR (1700MW) has been under development by Areva since 1991, but only two orders had been placed by June 2007. One was placed in December 2003 for a plant to be built in Finland, while a second order for France was finalized in 2007. Experience with the Finnish

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[6] Nucleonics Week, February 15, p 14.
[7] http://www.eskom.co.za/nuclear_energy/pebble_bed/pebble_bed.html
[8] See S Thomas, P Bradford, A Froggatt, D Milborrow (2007) 'The economics of nuclear power' Greenpeace, London

reactor (Olkiluoto 3) has been appalling. After 18 months of construction, the plant was already 18 months late and the costs had escalated by about a third. While EPR has received safety approval from the French and Finnish authorities, it is not expected to complete its review by US authorities until about 2011. If the US authorities require significant design changes, as is entirely possible, this will raise questions about the status of existing orders. The EPR remains totally unproven in operation and the little experience to date of construction is poor.

4.1.2. The AP-1000

The AP-1000 (1200MW) has been under development since 1999 and was given regulatory approval in 2006 by the US authorities (NRC). It was based on a design, the AP-600, which, after more than a decade of development, was given safety approval in 1999. However, by that time, it was clear the AP-600 was uneconomic and it was abandoned without ever having been built. In December 2006, China placed the first orders for an AP-1000 with four units on which construction may start later in 2007. The AP-1000 is unproven in construction and operation and is based on a design that is also unproven. It has received regulatory approval in the USA, but nowhere else.

4.2. What regulatory burden would this impose?

The regulatory burden imposed on NNR by the PBMR will be a huge strain to its human resources. A 'conventional' nuclear plant cannot be 'nodded through' the safety regulatory process and a full evaluation needs to be undertaken, albeit that it can draw on existing work by the US, French or Finnish authorities. It seems improbable that NNR would have the resources to carry out a proper evaluation of the PBMR and a conventional nuclear plant to the required standard without serious delays to one or other of the programmes.

4.3. Is the time-scale realistic?

If Eskom were to proceed with the conventional nuclear option, it would have to identify a site and open a call for tenders. Identifying a site would be hugely controversial and the most likely option is Koeberg, where the existing nuclear plants are sited and where the demonstration PBMR is expected to be built. An EIA would have to be completed to get approval for a site and it is unlikely this process could be completed in less than three years. A call for tenders could also take up to three years to be completed (China took longer before it ordered the AP-1000 units in 2006) once the call has gone out, vendors have developed and submitted their designs and costings, Eskom had evaluated the offers and awarded the contracts. So it would be a minimum of 3 years before work could start. Finland expected to build its EPR in 54 months but it is already 18 months late, France expects to take about 5 years to build its order and the UK projects a construction time of six years. All three countries have far more recent nuclear experience with construction than South Africa so a forecast construction time of less than six years seems optimistic. So the prospect of having a plant on-line by 2014 seems improbable and even an accelerated process, where everything went without a hitch would be unlikely to see a plant on-line before 2017. It seems unlikely that keeping to such a timetable would allow a full and open public consultation.

For comparison, Tony Blair was reported as saying that the latest UK plans meant that 'nuclear power is back on the agenda with a vengeance'.[9] This was widely seen as an indication that there would be a rapid expansion of nuclear power in the UK. However, if we examine the plans in detail, in the central case, there would be a period of eight years in which safety approval was undertaken, a site identified and approved and contracts placed. This would be followed by a six-year construction programme with first power from a new plant in 2021, followed by 2-3 further units by 2026. Already, this timing has slipped when a High Court judgement ruled that the consultation process leading to Blair's statement was inadequate and would have to be restarted, delaying the programme by 2-3 years.

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[9] 'Blair to push for new wave of nuclear construction in UK' *Nucleonics Week*, 18 May 2006

Nevertheless, the British forecast of about 15 years from a decision to proceed with a new nuclear programme to first power make Erwin's forecast of seven years seem very optimistic.

4.3.1. How would such a unit fit into the South African system?

The favoured site for both the demonstration plant and the first conventional nuclear plant is the Cape region, most likely the Koeberg site. This may well give some difficult logistical problems of trying to fit the construction of a PBMR, the construction of a conventional nuclear plant and the operation of a nuclear plant into one site. In addition, the power shortages of 2006 point to the problems of fitting large units into a region that has limited electricity demand and has limited connections to the rest of South Africa. The Cape region has a maximum demand of about 4000MW and two 900MW units, such as the existing plants, is difficult to fit in. If demand is about 3000MW at any one time, replacing the output of one unit, if it should break down is going to be very difficult. The EPR would be nearly double the output of each unit there now, while the AP-1000 would be about a third larger, so unless there was a huge strengthening of the transmission network to allow replacement power to be brought in when the plant breaks down (as it inevitably will on occasions), a large new nuclear plant would create almost as many problems as it solves. Of course, if the transmission network was strong enough to allow the siting of such a large unit in the Cape, then there would be no specific reason to site the plant there.

4.4. Summary

The proposal for a 'conventional nuclear' plant appears ill-thought out and unrealistic. Whether, as has been suggested by Erwin, it would be possible to proceed with both a conventional nuclear plant and the PBMR programme appears doubtful. Proceeding with both would risk scarce South African resources being spread too thinly with the result that, at best, neither project would be carried through efficiently.

5. Conclusions

The nuclear power programme envisaged by the South African government and Eskom would require the expenditure of about R400bn of public money to build the plants. Waste disposal and decommissioning would cost an additional sum of a similar order of magnitude. A new nuclear programme should be launched only with the full and informed consent of the South African public. Such a huge commitment of public money should not be rushed or short-circuited. A realistic view of the nuclear programme suggests that even if no new problems are encountered, new nuclear capacity cannot start making a significant contribution to South African electricity supplies before about 2020. So nuclear is, at best, irrelevant to the current issues facing the South African electricity industry and, at worst, a dangerous distraction from dealing with urgent issues.

The PBMR programme needs a fresh, independent review that is open to full public scrutiny. Costs and time estimates have escalated out of control, markets and partners have not emerged, and targets and deadlines have been consistently missed. The Government seems to have no clear idea how the project should be run. The next phase of the project will require more than five times as much public money as has been spent so far. The most recent estimate of about R15bn for this phase is likely to be an under-estimate. The expected commercial orders to follow on from the Demonstration plant might cost around R76bn. Turning back once this phase has been embarked on will be politically even more unpalatable than abandoning the project is now. It is therefore essential that before further public money is spent that the project should be subject to independent scrutiny. Among the issues that should be covered are:

- Can a design be produced that satisfies the National Nuclear Regulator?
- Will the construction cost of such a design be competitive?
- Can it be assumed that PBMR plants will be reliable and economic?
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The proposals for ‘conventional’ nuclear power plants seem little better thought out. The time-scales seem highly optimistic and the advantages that were said to make the PBMR so attractive would be lost. These ‘conventional’ designs have been under development for about 15 years, and their design characteristics were known when the PBMR programme was launched. So it is hard to understand why, if they were so unattractive a decade ago, they are now a good option. They remain unproven in operation and the only construction experience to date, in Finland, has been appalling.

One of the main costs of the PBMR programme has been the ‘opportunity cost’ of not improving energy efficiency to anything like best practice and of not developing South Africa’s sustainable energy sources, such as wind, biomass and solar. Had the money and resources spent on the PBMR been spent on energy efficiency and renewables, the problems of black-outs experienced in the Cape region in 2006 might have been much less severe. There would also not be the aura of panic that seems now to surround decision-making on the power sector. There can be little confidence that the latest proposals are any better conceived than previous proposals. The risk of such a large programme is that for the next 10-15 years, South Africa will be locked into an expensive nuclear programme that will have absorbed many of the available resources, but which will have come to nothing or will have produced only one or two ‘white elephants’. There will be few resources to develop options that could have helped South Africa meet its energy needs in a more sustainable way, such as energy efficiency and renewables. Equally, it will be difficult to take advantage of developments elsewhere in the world on renewables and energy efficiency.

6. References

D R Nicholls (2000) ‘Status of the pebble bed modular reactor’ Nuclear Energy, 39, 4, pp 231-236.

Mawatsan (2007) ‘Revised Final Environmental Scoping Report’, Mawatsan, Pretoria.

S Thomas (2006) ‘The economic risk to electricity consumers of the Pebble Bed Modular Reactor’ Presentation to NERSA, January 2006. http://www.psiru.org/reports/2006-01-E-PBMR-NER.pdf

7. Appendix Possible cost of a South African nuclear programme

No estimate of the expected cost of the elements of a South African nuclear programme has been published by the South Africa nuclear industry. In any case, on the basis of previous forecasts from the South African nuclear industry, such estimates would have little credibility. However, we can use recent contract and outturn prices to give an order of magnitude of investment cost (excluding decommissioning).

We assume that the programme will compromise a total of 24,000MW, of which, at least the 4000MW (24 units) that the government has announced Eskom would buy, will be PBMRs.

The most recent documented order for a nuclear plant was the Olkiluoto plant bought by Finland in 2005 for a total cost of €3bn, or €2000/kW. At this cost per kW and assuming an exchange rate of €1=R10, the 4000MW of PBMRs would cost R76bn and the whole 24,000MW programme would cost R456bn. In fact, after only 18 months of construction, the Olkiluoto project is at least 25 per cent over budget so this cost could well be an underestimate.

The next most recent documented plant was the Sizewell B nuclear power plant completed in Britain in 1995. This cost in excess of £3bn (1995 money) or £2500/kW. If we assume inflation of 3 per cent per year, this is about £3500/kW in today's money or R50,000/kW (£1=R14). If the South African programme cost this much, the 4000MW PBMR programme would cost R200bn and the entire 24,000MW programme would cost R1200bn.

The Sizewell plant was completed largely to time and while it is acknowledged that mistakes were made in its construction, this cost is a real cost, not an estimate, so it should not be discounted as totally implausible