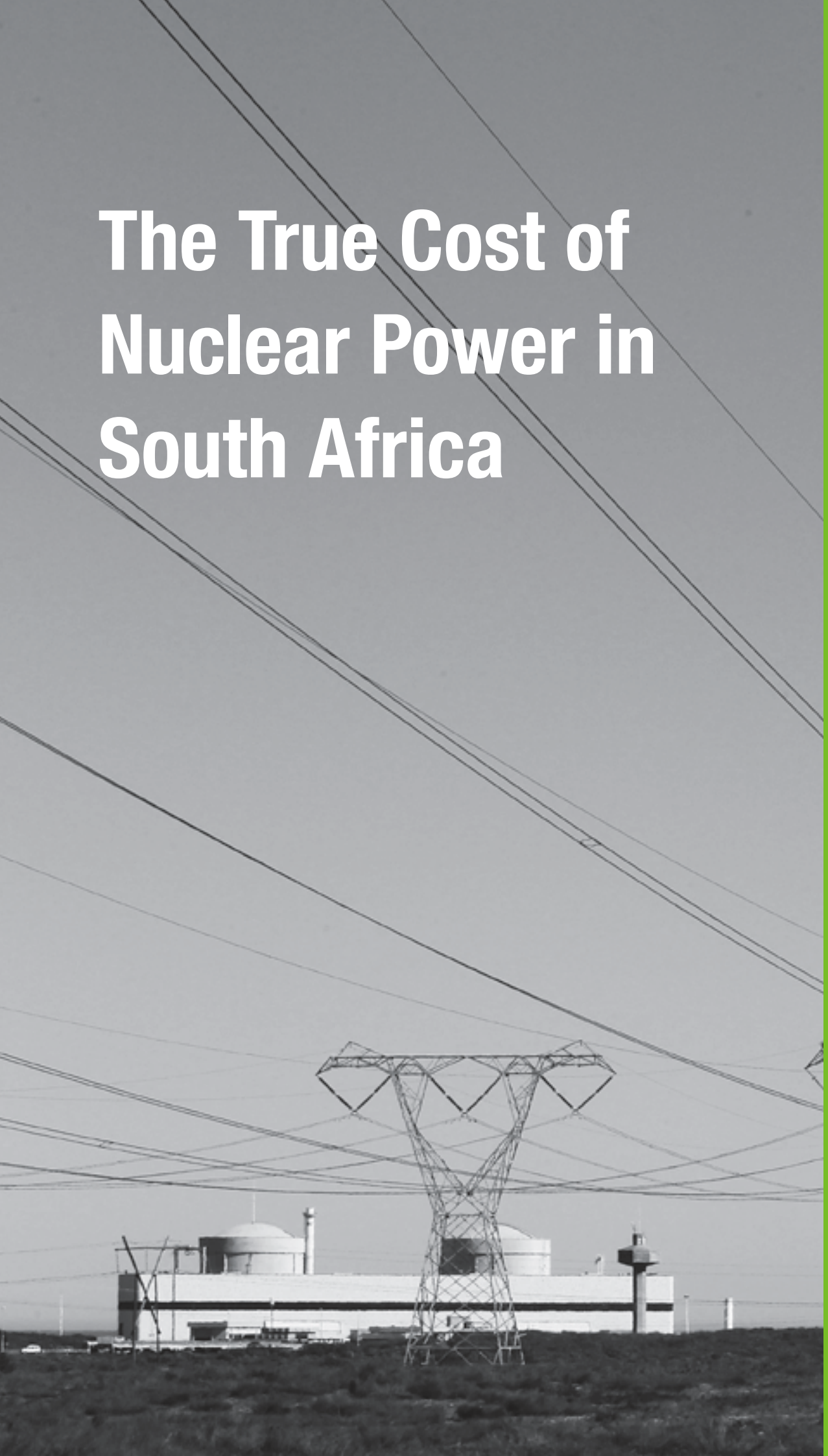
The True Cost of Nuclear Power in South Africa



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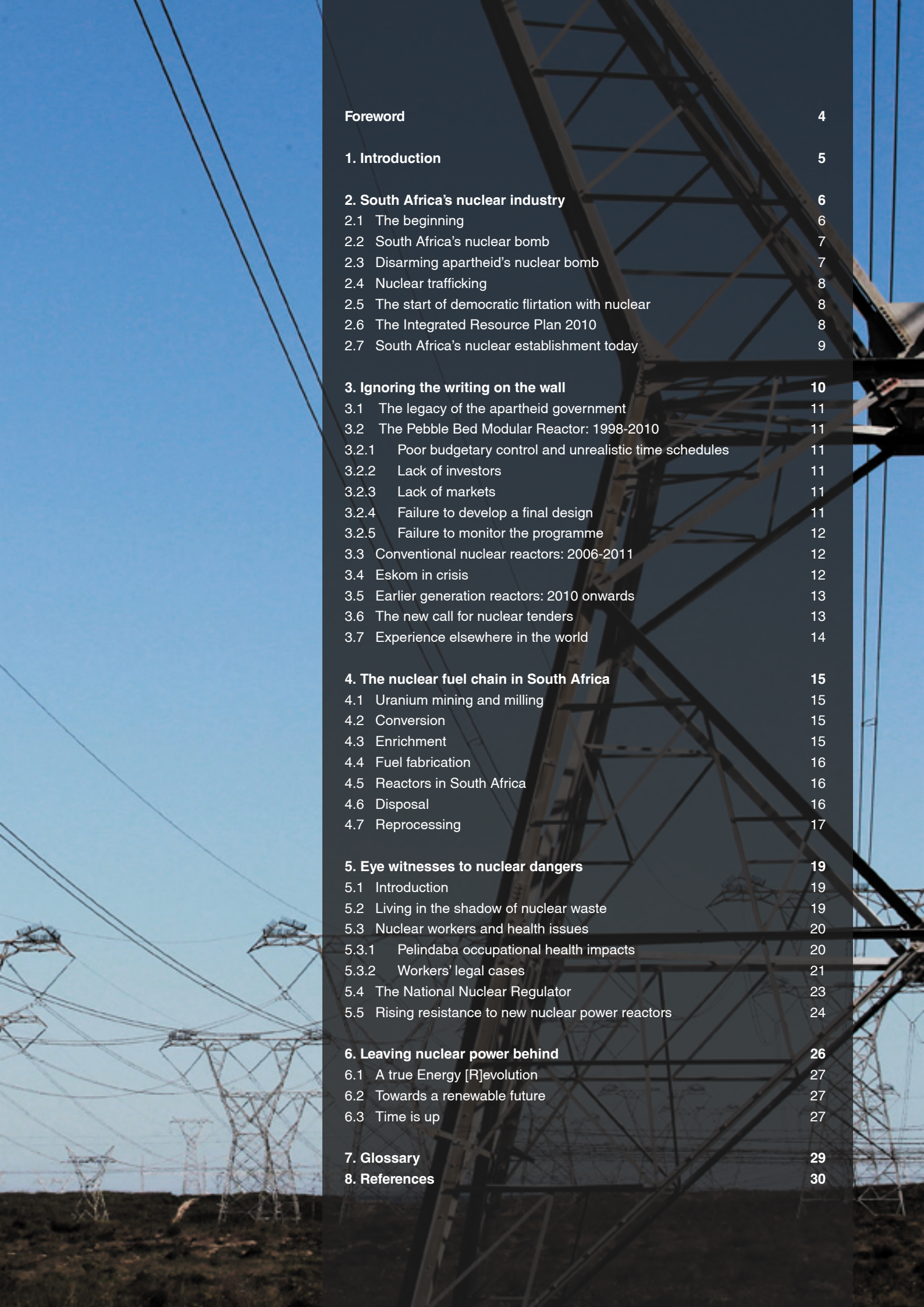


Foreword

Nuclear power is dangerous. The world looked on aghast at the mushroom clouds over Nagasaki and Hiroshima in 1945. A less destructive use of nuclear technology was sought in the production of nuclear power. However, history has shown that nuclear power is a failure: it is expensive, dangerous, polluting and non-democratic. Insisting on the use of nuclear power for South Africa's energy crisis is simply insane.

Nuclear power is not cheap. It's not safe. It's not clean. Chernobyl and Fukushima are all the proof anyone ever needs of that.

And yet there is an alternative; Greenpeace's Energy [R]evolution - a blueprint for the world's energy future that focuses on renewable energies, like solar and wind. The alternative is not only sustainable and cheaper, but provides almost 100,000 green jobs within 30 years in the energy sector.

The Energy [R]evolution protects the environment and is safe. Very safe. The question is whether anyone in power has the courage to pick up this ball and run with it.

As the South African government continues its fatal attraction of nuclear power, we present this report on the true cost of nuclear power. Read it, be emboldened to take action and let's commit ourselves to the Energy [R]evolution in our country.

Kumi Naidoo

Executive Director, Greenpeace International

1. Introduction

Six days after the nuclear catastrophe at Fukushima in Japan in March 2011, South Africa's Minister of Energy Dipuo Peters declared her country's intention to add 9,600 MW of nuclear electricity - or six new nuclear reactors.

South Africa already has 1,844 MW of nuclear generated electricity - while countries such as Germany, Switzerland and Italy have completely rejected nuclear energy in response to the Fukushima disaster. But, speaking at the second regional conference on energy and nuclear power in Africa in Cape Town on May 30 this year, Ms Peters went even further, trumpeting the development of a nuclear-export market to the rest of Africa, supported by both the International Atomic Energy Agency, and the African Union.

South Africa spent 13 years pursuing the Pebble Bed Modular Reactor, wasting billions of rands in the process (R9-billion was spent on research and development and another R22-billion would have been needed to complete a demonstration model) as investors across the world shied away from having anything to do with it. Eventually the state cancelled the project and wrote off the monies it had spent. The government and its wholly owned power utility Eskom remain hell bent on securing what it believes will be a cheap and sustainable nuclear solution for its energy supply crisis.

If the same money had been poured into other lower risk options such as energy efficiency and renewable energy generation, the country would have secured cheaper, sustainable, reliable and indeed, greener, solutions. Instead, South Africa's energy situation, once cheap and reliable, has become expensive and unreliable, blighted by power cuts and the infamous 'load shedding'.

The lessons have not been learnt. The South African government is now wooing nuclear power station pedlars, most of whom have neither the track record nor the capacity to deliver cutting edge nuclear technology. Instead South Africa is likely to get cheaper outdated nuclear technology with none of the safety guarantees demanded by an increasing sceptical and scared world.

In parallel, paying lip service to government's stated commitment to renewable energy, Eskom has secured funding to finance the massive coal-fired plants, Medupi and Kusile, which will generate 4,800 MW each. Together they will cement South Africa as the leading cause of carbon emissions on the continent, to say nothing of air pollution and acid mine drainage linked to the coal sector.

Instead of learning from the 2008 electricity supply crisis, South Africa is mortgaging its environmental future on old and risky technology to support its economy, including potential reinvestments in the apartheid government's nuclear programme of uranium enrichment, conversion, reprocessing and fuel fabrication facilities, opening the door to the proliferation of nuclear weapons.

This report outlines South Africa's nuclear history, its failure to learn from its mistakes, and its current nuclear facilities. In addition, it presents four case studies from eye witnesses to the historic and ongoing nuclear impacts in this country. And finally, an alternative nuclear-free future for South Africa is described.

2. South Africa's nuclear industry

2.1 The beginning

South Africa might be on the tip of Africa, but its mineral wealth has always ensured its voice has been heard across the globe – and its uranium stocks made it a significant player in worldwide atomic developments.

During the last stages of World War II, the Manhattan Project was the code name for British and US efforts to develop the atomic bomb. It was originally intended to be used on Nazi Germany – before the Nazis could develop and deploy their own version – but the war ended in Europe by conventional means before either side was ready with the weapon.

In the end, the bomb was used with devastating consequences on Japan.[1]

The tenuous world peace that followed was dominated by a debate about what to do with the newly developed weapons of mass destruction. One solution was to internationalise and neutralise their future use. Another was to add the weapons to the arsenals of those countries which had developed them.

In 1949 Stalin announced that the USSR had also developed the bomb, spawning a 40 year arms race between the US-led Nato and the Soviet sponsored Warsaw Pact. There was to be no internationalisation of the bomb.

The uranium for the Manhattan weapons had been sourced in the then Belgian Congo.[2] In general uranium had had no prior commercial value, and so was not much in demand as a useful product. Nuclear rearmament though led to a global search for new supplies of uranium. The Soviet Union relied on domestic supply, but the US and UK needed to source their uranium elsewhere. In this, they turned to South Africa.[3]

By the 1920s it was known that uranium, a by-product of Witwatersrand gold, had been dumped with other tailings on the huge mounds which dominated the landscape around Johannesburg. Suddenly it had a value and a purpose. Using refining technologies which included sulphuric acid, it was possible to extract the uranium from both the mine tailing dumps and also from the gold-bearing ores. Prime Minister Jan Smuts' government secretly signed agreements to offer the uranium exclusively to the USA and UK in a ratio of 2:1. These agreements allowed 17 gold mines to open up uranium extraction plants in the Johannesburg area.[4] For at least a decade, all of the uranium ended up in the weapons programmes of the USA and UK.[5]

In this way, South Africa was guaranteed of never being ignored in the nuclear race. Replacing the outdated War Measures, which had governed the use of uranium, Smuts created a Uranium Research Committee in 1945, which was duly replaced in 1949 by the Atomic Energy Board, in terms of the brand new Atomic Energy Act (1948). The board comprised officials, scientists and representatives of the mining industry. The act enabled South Africa to embark on its own domestic nuclear research programme, six months after the apartheid National Party government came to power.

The local programme outgrew the confines of its offices in central Pretoria, being relocated to Pelindaba (isiZulu for "the talking is over"), a farm west of the city in 1965. The US provided a research reactor as part of former president Eisenhower's policy of 'Atoms for Peace', which offered the new technology to its allies – including apartheid South Africa.[6]

In the years that followed, South Africa's growing cohort of nuclear scientists received training at research facilities in the US, UK and West Germany.[7] Other partnerships were forged with France[8] (which built the Koeberg nuclear power station in the 1980s) and Israel[9] (which provided tritium and other knowhow for the weapons programme). Although these scientists maintained that technologies like uranium enrichment were developed entirely locally, it is clear that their experiences in other research establishments played a crucial part in their mastery of different parts of the fuel chain, as well as in the production of weapons. Busting sanctions proved too lucrative for the global nuclear and arms industries.

2.2 South Africa's nuclear bomb

By the mid 1970s, apartheid South Africa was on a war footing. Internally, the mass politicisation of the oppressed black population was about to be threatened by Durban strike actions in 1973 and then the watershed Soweto school riots in 1976. The Portuguese colonies to the north-west and east were summarily abandoned to Marxist indigenous governments, and the apartheid SA Defence Force invaded Angola, while Rhodesia's rebel white government destabilised Mozambique.

In 1978 then Prime Minister B. J. Vorster instructed the state-owned Atomic Energy Corporation (AEC) to initiate a nuclear weapons programme. He wanted a military device which could act as a deterrent, should the increasingly militarised and isolated apartheid regime fall under extreme threat. Vorster knew that the secret efforts at Valindaba, the uranium enrichment and conversion facility abutting Pelindaba, could have military applications without any inspection from the International Atomic Energy Agency in Vienna. On the surface, government had announced that the enrichment facility was being constructed in order to support a peaceful civilian power programme,[10] which was only realised in the mid-1980s. It later transpired that the enrichment process mainly supported the bomb programme.

The programme proved slow and erratic. In the course of 12 years, the bomb programme at Pelindaba's 'Building 500' would produce six complete weapons with progress on a seventh under way, when the project was shut down. In keeping with the new military aims of the project, the apartheid arms parastatal Armscor took over from AEC moving bomb production to the 'Circle Building' (also known as Advena) closer to Pretoria and four kilometres away from the African township of Atteridgeville, while Pelindaba remained responsible for enriching and supplying weapons grade uranium. The completed bombs were stored in vaults on site, to be armed and detonated on command of four senior government officials.[11]

Built with gun type devices, like the ones the US dropped on Hiroshima, part of the fissile uranium had to be shot into the remaining uranium to create a critical mass which would release immense energy. The bomb manufacturers, however, were keen to develop more sophisticated thermonuclear weapons. By the end of the 1980s, a site for this purpose, bordering on the Pretoria suburb Lotus Gardens, was prepared and called Ararat. However the programme was terminated before Ararat could be activated.[12]

2.3 Disarming apartheid's nuclear bomb

When F. W. de Klerk came to power in September 1989, the Cold War was over and the Berlin Wall had fallen. The time had dawned for South Africa to negotiate its own transition from a white oligarchy to a progressive democracy. De Klerk calculated that after democratic elections, the next government would be led by the once-banned African National Congress. He and his advisers were not keen to make the nuclear weapons available to a government of his former enemies, especially as there was no longer a tactical need for them.[13]

De Klerk ordered that 12,000 pages of documentation covering the project should be shredded, protecting the hundreds of people involved in the programme. This act has made it extremely difficult for scholars to reconstruct the full extent of the bomb-making activities and the official decisions that supported them.[14]

The bombs were dismantled in 1990, and the weapons-grade uranium was removed and stored under safeguard at Pelindaba. The sites at Building 500, Advena and Ararat were decontaminated. Identifying marks on all machinery were scored out to prevent the tracing of their origins and to maintain secrecy about which countries had supplied them. De Klerk invited the IAEA to inspect the AEC and Armscor facilities to verify that the programme had come to an end. In 1991, South Africa rejoined the Nuclear Non-Proliferation Treaty which meant that all its nuclear facilities could be inspected by Vienna to prevent future proliferation.[15]

In March 1993, De Klerk publicly announced that the bomb programme had been terminated. By then he was part of a transitional government which included ANC politicians, and foresaw the country's first democratic elections the following year. South Africa was recognised as the first country to voluntarily end its nuclear weapons programme.[16]

After the ANC had won the elections in April 1994, it created a Council on the Non-Proliferation of Weapons of Mass Destruction affiliated to the Department of Trade and Industry. The Council became South Africa's mechanism for ensuring that there is no production of or trade in materials that could be incorporated in nuclear, chemical or biological weapons.[17]

South Africa was also a prime mover in the establishment of the Treaty of Pelindaba, which declared Africa a nuclear weapons-free zone. Although formulated in 1996, it took until July 2009 before sufficient African countries had signed onto the treaty to bring it into force.[18]

2.4 Nuclear trafficking

The Truth and Reconciliation Commission, constituted by the incoming Mandela government, never chose to pursue those who had been involved in producing weapons of mass destruction, leaving them free to rejoin the AEC (since 1999 renamed South African Nuclear Energy Corporation Necsa) or Armscor (renamed Denel) structures, as well as the Pebble Bed Modular Reactor company. Others took on jobs in engineering faculties in universities, or used their severance pay to create their own small enterprises. One group was recruited to join an explosives factory in Keetmanshoop, Namibia. Another group tried to sue the AEC for much larger golden handshakes, but withdrew their case after the courts threatened them for breaching confidentiality clauses in their employment conditions.[19]

In September 2004, a series of arrests implicated some individuals in the crime of trafficking in nuclear materials. A Vanderbijlpark entrepreneur, Johan Meyer, head of a small engineering works, was accused under the Non-Proliferation of Weapons of Mass Destruction Act (No. 87 of 1993) of importing parts for dual-use lathes from Spain for re-export to Pakistan. Meyer and the others involved had formerly been connected to the South African bomb programme. They were now acting as part of the ring of suppliers organised by the 'father' of the Pakistani nuclear bomb, Dr A. Q. Khan.[20] Information about their activities had been released to the CIA as an outcome of Libya's commitment to curbing its nuclear proliferation ambitions. Dr Khan lost his seat in the Pakistani Cabinet as a result of the revelations, but was not otherwise censured. Other weapons components traffickers of Israeli, German and Swiss nationality who were linked to the South African trafficking activities, were arrested in Germany and the US.

Pressured by the US, South African prosecutors attempted to have Meyer and his colleagues tried in camera, but this was successfully resisted by the Freedom of Expression Institute, a local NGO. When Meyer turned state witness, though, the charges against him were dropped, and the case was never fully aired in court.

2.5 The start of democratic flirtation with nuclear

In exile, the ANC had denounced the apartheid regime's ability to sidestep sanctions and acquire nuclear technology. While it never publicly committed to dismantle the country's nuclear power industry, the ANC vowed it would never again take decisions about nuclear behind closed doors in smoke-filled rooms.[21] It initiated a review of all parts of the scientific establishment including Pelindaba (then under the Atomic Energy Corporation).[22] And two years after coming to power, it held an inclusive Energy Summit in 1996, whose final document, the Energy White Paper foresaw a review of South Africa's Koeberg nuclear power station and promised there would be no expansion of nuclear power without integrated planning across all parts of the energy sector.[23]

In July 2007, the South African government developed a policy document on nuclear energy, which it released for public comment the following October.[24] It was the first time the ruling ANC government, in power since May 1994, had stated its position on nuclear comprehensively.

The document maintained that the country was going to invest in more nuclear reactors to meet the country's electricity demand. In addition to this, the policy included the aspiration to acquire other steps in the nuclear fuel chain. This involved reintroducing an enrichment facility, the acquisition of reprocessing technology, and plans to "beneficiate" uranium into nuclear fuel. These would be patrolled by a specially dedicated nuclear security force.

The policy was a vindication for the nuclear lobby, which until then had not been guaranteed any clear signals from government. The lobby mostly consisted of the foreign vending companies (which sell nuclear reactors and services), but it also included the state-owned Nuclear Energy Corporation, large construction and component companies, banks, as well as many of the "bulk users" of South Africa's electricity, such as mining, refining and smelting firms.

The statutory requirement for public comment on the proposals – poorly advertised and lasting through the Christmas break, South Africa's summer holiday season – elicited a total of 27 responses, mainly from members of the lobby. There was no attempt by the government to stage a public debate over the new policy. Instead the decision by cabinet to adopt it was taken without even minimal public discussion.

The expansion of the industry was, however, controversial. Opposition was vested in a number of key trade unions, faith-based organisations, affected residents' associations and environmental groups. For many years these bodies had attempted to educate the public and alert it to decisions made without proper consultation.

2.6 The Integrated Resource Plan 2010

The Government's 1998 Energy White paper called for integrated energy planning, which took more than eleven years to initiate. At first, government commissioned studies on a Long Term Mitigation Strategy to foreground effects on the climate change in future energy planning.[25] An initial attempt to develop an Integrated Resources Plan (IRP1) was ineffectual and had enjoyed minimal consultation.

The government tried to remedy this with its second version of the IRP 2010, but in a bid to avoid time consuming consultations, tried to sidestep this by using a committee comprising mostly large-scale users of electricity and one or two pliant academics to draft the new integrated resource plan. The group favoured the continued use of coal and nuclear to meet South Africa's energy needs. The urgency of the process was rumoured to have been sparked by the

construction deadlines for the country's next nuclear reactor, with its minimum construction time of 10 years, meeting the Minister of Energy's aspirations that South Africa would need a new reactor by 2023.

The IRP 2010 process called for greater use of renewables, and a reduction of the relative contribution of coal (after massive expansion in the short term) and the Department of Energy, which managed the process, promised it would propose adding no further nuclear to the mix. Instead, the plan involves extending nuclear's role in the electricity mix (from 1,844 MW to 11,444 MW)[26], despite several coherent presentations showing the risks of including nuclear in the energy mix at the public hearings.

The final document claimed that three scenarios had been considered regarding nuclear:

(a) commitment to increasing nuclear capacity by 9,600 MW;

(b) indefinitely delaying increases to the nuclear capacity and considering alternatives in the interim;

(c) commitment to constructing one or two nuclear power plants by 2023 but delaying any further decision on extending nuclear capacity beyond that until there was greater clarity on the longer term costs of both nuclear and renewables.[27]

Government rejected the more precautionary approaches and adopted option (a) in the final Policy Adjusted IRP. This was no different a position from that prior to public consultation. The report was subsequently approved by the cabinet in late March 2011 and is due to be proclaimed before the end of the year. However, there may be room for further intervention in the process, as the plan is scheduled to be reviewed every two years.

Shortly after approval of the IRP, Eskom has published the revised draft Environmental Impacts Assessment report for Nuclear-1, that includes 4,000 MW of new reactors to be built at Thyspunt (near Oyster Bay, Eastern Cape), Bantamsklip (near Gansbaai, Western Cape) or on the Koeberg site itself, with Brazil and Schulpfontein on the west coast being earmarked for later developments.[28]

2.7 South Africa's nuclear establishment

South Africa's nuclear industry, still largely in state hands, consists of a number of institutions. It is governed by the Department of Energy, which since 2009 has been a distinct body, formerly having been the Department of Minerals and Energy.

The nuclear industry comprises:

- **The South African Nuclear Energy Corporation (Necsa)**, based at Pelindaba, is responsible for nuclear research, operating Safari-1, a research reactor, and in the past for operating conversion, enrichment and fuel production facilities at Valindaba, adjacent to Pelindaba. It also commercialises nuclear applications like medical isotopes and filters for the mining industry. Necsa has also been responsible for managing Vaalputs in the Northern Cape, which is a storage space for low- and intermediate-level nuclear waste. This will be transferred to a dedicated agency for management of nuclear waste in due course. It is important to note that South Africa has still not found a solution for the disposal of high-level waste. Koeberg's high level waste – mainly spent reactor fuel – is retained in storage ponds on site. High level waste from Safari-1 is placed in dry storage within the complex.

- The **National Nuclear Regulator (NNR)** regulates nuclear safety, monitoring the nuclear industries and their waste production. It is funded by government grants and on the licensing of nuclear facilities. It is required to protect the public from exposure to radioactivity from sources like mining, nuclear research, nuclear electricity production and other industries.

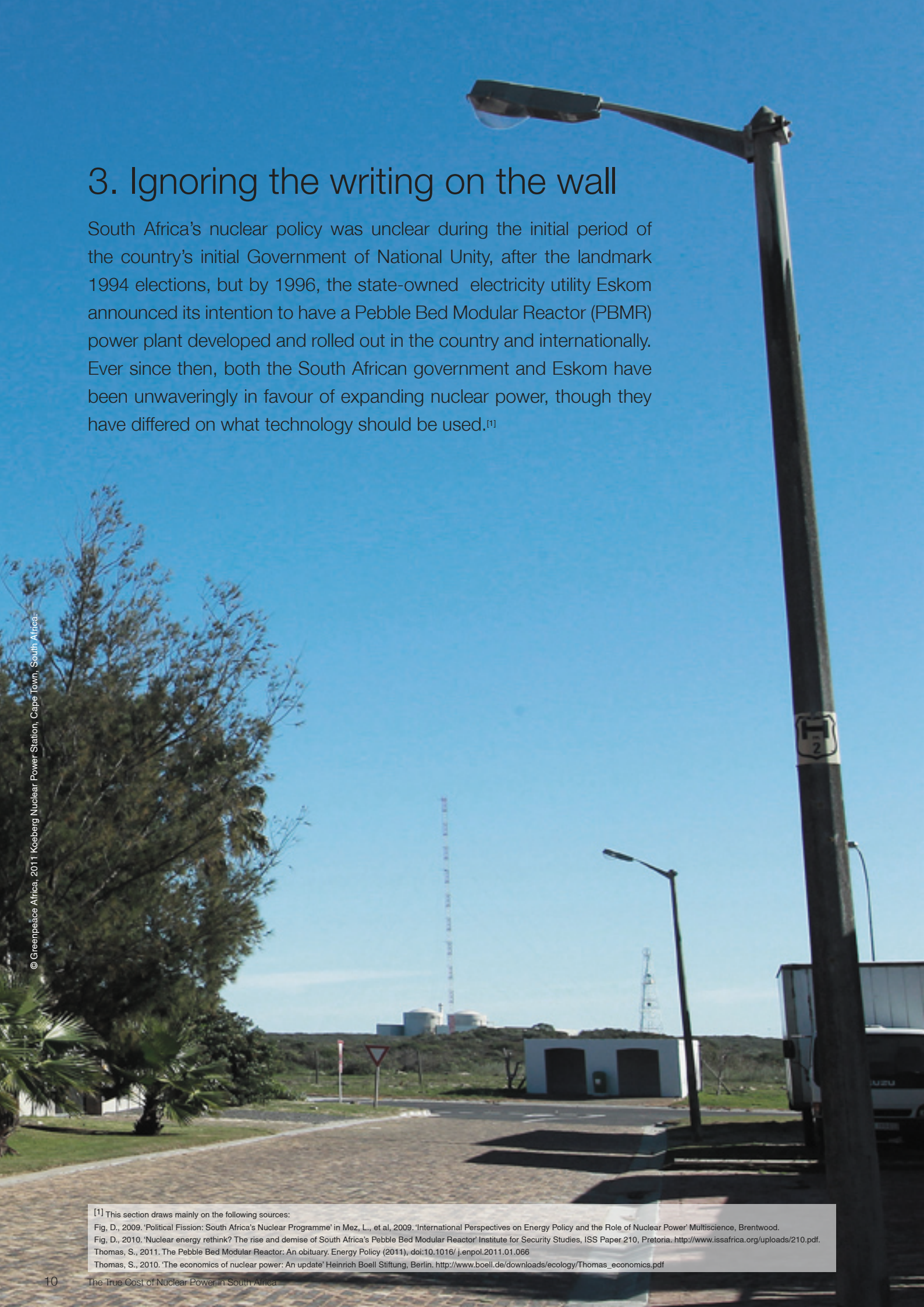
- South Africa has only one nuclear power station, **Koeberg**, operated by the state-owned electricity utility, Eskom. It is located on the Atlantic seaboard, 28 km north of the city of Cape Town and consists of two 922 MW reactors, completed in 1984 and 1985 respectively. Koeberg delivers up to 6% of the country's electricity, with more than 90% of the country's power needs being supplied from coal-fired power stations. Koeberg's reactors were constructed by a French consortium (now falling under the French state-owned Areva corporation).

- **The mining of uranium** has occurred both as a by-product of the gold mining industry and in its own right. For many years the gold was extracted in the **Witwatersrand**, the area around Johannesburg, but this has largely been mined out. Key uranium mining companies have included AngloGold Ashanti, Goldfields, Harmony, and Uranium One.[29] The elevated uranium price has also seen the re-mining of old tailings, and prospecting in areas like the Great Karoo around **Beaufort West**.[30] Exports of uranium are largely handled by **NUFCOR**, a company owned by AngloGold Ashanti, the largest of the uranium mining companies.

- The nuclear establishment has formed a lobbying organisation, the **Nuclear Industry Association of South Africa**, which consists of all the above institutions, as well as vendors, banks, and construction and component companies likely to benefit from the industry's expansion.[31] Government has also formed an organisation called **Women in Nuclear South Africa (Winsa)** to transform the historically male dominated sector.[32]

3. Ignoring the writing on the wall

South Africa's nuclear policy was unclear during the initial period of the country's initial Government of National Unity, after the landmark 1994 elections, but by 1996, the state-owned electricity utility Eskom announced its intention to have a Pebble Bed Modular Reactor (PBMR) power plant developed and rolled out in the country and internationally. Ever since then, both the South African government and Eskom have been unwaveringly in favour of expanding nuclear power, though they have differed on what technology should be used.[1]



[1] This section draws mainly on the following sources:
Fig, D., 2009. 'Political Fission: South Africa's Nuclear Programme' in Mez, L., et al, 2009. 'International Perspectives on Energy Policy and the Role of Nuclear Power' Multiscience, Brentwood.
Fig, D., 2010. 'Nuclear energy rethink? The rise and demise of South Africa's Pebble Bed Modular Reactor' Institute for Security Studies, ISS Paper 210, Pretoria. http://www.issafrica.org/uploads/210.pdf.
Thomas, S., 2011. The Pebble Bed Modular Reactor: An obituary. Energy Policy (2011), doi:10.1016/ j.enpol.2011.01.066
Thomas, S., 2010. 'The economics of nuclear power: An update' Heinrich Boell Stiftung, Berlin. http://www.boell.de/downloads/ecology/Thomas_economics.pdf

3.1 The legacy of the apartheid government

Under the apartheid government, the nuclear programme had both civil and military objectives. In Cape Town, the two civil nuclear reactors at Koeberg have been problematic. Their record of reliability has improved in the past decade but it is still well below the levels achieved elsewhere in the world. Their energy availability factor[2] is 71% whereas the world average for commercial reactors is 77%.[33] Part of the problem is their location in the Western Cape, which has limited electrical connections to the rest of South Africa. This has meant that when both reactors are operating, not all the power available can be used and if one of the reactors does break down, the power supply to Cape Town can fail.

The state-owned South African Atomic Energy Corporation (AEC), which became the Nuclear Energy Corporation of South Africa (Necsa) in 1999, and Eskom both studied PBMR over a decade, prior to 1998. When government decided to pursue the PBMR in 1998, Eskom openly stated that the Koeberg reactors were markedly inferior to the PBMR.

3.2 The Pebble Bed Modular Reactor: 1998-2010

The PBMR is a variant of the class of reactors known as High-Temperature Gas-cooled Reactors (HTGRs) which use helium gas as coolant and graphite as moderator[3]. Unlike other nuclear designs where the fuel is in the form of rods, in the PBMR, the fuel is in the form of 'pebbles' the size of a billiard ball.

The PBMR design was portrayed as an 'unpolished diamond', markedly superior to existing reactor designs. Its German developers were said to have only abandoned the design because of the strong public reaction against nuclear power. In fact, the German THTR-300 design suffered from difficulties with the fuel circulation system, damage in the gas ducts, and a number of other technical problems, some of which were specific to the pebble bed design (for example 18,000 damaged fuel pebbles, graphite dust formation, and thermal insulation failure in the core bottom by overheating).[34] But problems with earlier prototype and demonstration plants were dismissed as not relevant to the South African programme.[35] The fact that the major nuclear design nations had tried and failed to produce a commercial HTGR design from the prototypes built was also ignored.

In 1998, the project was presented as primarily an export project with a minority of reactors going to the home market. A demonstration plant would quickly be built and by 2004, a design would be available for commercial ordering. By all major criteria, the project was a total failure.

3.2.1 Poor budgetary control and unrealistic time schedules

In 1998, the demonstration plant was forecast to cost a little over R1bn.[36] By 2009, just before the project was abandoned, the estimated cost was R31bn. When the project was launched, it was assumed commercial units could be built for an overnight cost (that is excluding finance charges) of less than US$1,000/kW, so that a commercial unit, then expected to produce 110 MW, would cost US$110m (about R600m). The company set up to develop the PBMR, PBMR Ltd (a 100% subsidiary of Eskom), did not produce cost estimates for commercial plants after 2003. The original plans called for commercial units to be available for order by 2004. By the time the project was abandoned, a senior Eskom official estimated the first commercial orders could not be before 2031.[37]

3.2.2 Lack of investors

From 1999 onwards, PBMR Ltd had sought foreign private sector partners to provide finance and technological expertise. Only one foreign privately owned company, a US utility PECO (later renamed Exelon) was recruited, in 2000, but withdrew less than two years later, having contributed about 1% of the development cost of the PBMR. The publicly owned fuel-cycle company, British Nuclear Fuels, was recruited in 2000 but contributed little after 2003 and only provided 5% of the development cost. The rest of the funding was provided by South African public money, through the government directly (81%), Eskom (9%) and the Industrial Development Corporation (5%).[38]

3.2.3 Lack of markets

In November 1998, when the PBMR project was first publicised, Eskom was working on the basis of annual sales of 30 units per year, of which 20 would be exports. However, this was derived by a crude calculation based on an estimate of the world market for power plants of all types and an assumption that the PBMR would win 2% of this market. The nearest the PBMR got to a firm order was a letter of intent from PECO/Exelon that lapsed when it left the project in April 2002. Despite a common belief to the contrary, Eskom was never committed to buy any plants.[39] As the project went further off-track, the likelihood of sales became even more remote.

3.2.4 Failure to develop a final design

From early 2002 onwards, PBMR Ltd consistently claimed that a final design would be sent to the South African nuclear safety regulator, the National Nuclear Regulator (NNR), within 6 months. By 2010, a final design had still not been produced. It is only possible to speculate what technical problems were encountered because PBMR Ltd has never acknowledged what problems it faced.

[2] The "energy availability factor" over a specified period, is the ratio of the energy that the available capacity could have produced during this period, to the energy that the reference unit power could have produced during the same period.

[3] The coolant is the fluid that takes the heat from the reactor to the power generation system while the moderator controls the speed of the nuclear chain reaction.

3.2.5 Failure to monitor the programme

By 2002, Eskom was privately expressing doubts about the project, seeing it as a high risk project.[40] In 2001/02, the US safety regulator, which had begun to assess the design, had raised significant technical and safety issues on core temperatures, which the NNR never acknowledged.[41] Despite these issues, the withdrawal of foreign investors, the lack of markets, escalating costs and extending time-scales, the project was allowed to continue till 2010 before the government abandoned it. The South African government provided almost all the funding from 2004 onwards, a period when nearly 80%[42] of the total development cost was incurred. By then, it should have been clear that the project was doomed, but other official watchdogs that ought to have sounded the alarm, such as standing Parliamentary Committees, Eskom, the NNR, the National Electricity Regulator, and even the South African Auditor General, all did nothing.

3.3 Conventional nuclear reactors: 2006-2011

By 2006, South Africa was beginning to run short of power generation capacity. It was clear that the PBMR would not be available to order for a long time. Eskom began to talk about ordering 'conventional' nuclear power plants. First in line were the EPR supplied by the French company, Areva and the AP1000 supplied by the Japanese owned company, Westinghouse. Eskom's implication was that such designs were well proven. In fact, at that point, only one order had been placed for an EPR and none for the AP1000. By 2011, there were four orders for EPRs, two for China, one for France and one for Finland and four for AP1000s, all for China. None of these orders were in service by 2011 and the two EPR orders for France and Finland were seriously over budget and late.[43]

In 2006, the South African government forecast that a new unit could be on-line between 2010 and 2012.[44] By mid-2007, Eskom was targeting construction of 20,000 MW of new nuclear capacity by 2025, although completion of the first unit had slipped to 2014.[45] It expected an overnight construction cost of US$2,500/kW.

In January 2008, Eskom received two bids in reply to its call for tenders from November of the previous year for 3,200-3,400 MW of new nuclear capacity in the near term and up to 20,000 MW by 2025.[46] One bid was from Areva for two EPRs (plus 10 more for the long-term) and the other from Westinghouse for the three AP1000s (plus 17 more in the long term).

It was later reported that the bids were for around US$6,000/kW (overnight) – more than double the expected price.[47] It was therefore no surprise when Eskom abandoned the tender in December 2008 on the grounds that the magnitude of the investment was too much for it to handle. This was despite the willingness of Coface, the French government's loan guarantee body, to offer export credit guarantees and despite Areva's claims that it could have arranged 85% of the financing.[48]

3.4 Eskom in crisis

Three weeks into January 2008, Eskom had hit a brick wall. It could no longer meet all the country's electricity demands without melting the national grid. Eskom turned to the bulk users, and appealed to them to ration their demand. Even so, for some months the country faced a series of electricity outages (euphemistically called "load shedding"). Not only was this a blow to businesses, agriculture, schools, hospitals and households, but it coincided with global recession.

Eskom had also run out of money and its credit ratings were reduced.[49] Eskom could no longer afford to invest in new infrastructure, without massive extra income. It would take three years before it could make new orders, and until then the board was saying no to new investments. The biggest blow to the nuclear industry was the decision to scrap the tender process for Nuclear-1, the first of a number of new large-scale reactors. The government had to inform vendors Areva and (Toshiba-owned) Westinghouse that their bids would not be considered for the meantime. The policy was not being suspended, but the orders were temporarily shelved.

The utility was in a mess, and suffered from serious conflicts between board and management. CEO Jacob Moroga was largely blamed for the crisis, and resigned but later tried to retract. Incoming board chairperson Bobby Godsell, a former mining house chief executive who had been supportive of Eskom's nuclear plans, resigned when he felt President Jacob Zuma had not backed him in the conflict between the board and Moroga.[50] In the end, Brian Dames, a senior Eskom official, took over as CEO.

Dames tried to rebuild Eskom's reputation and finances. A big hurdle was the steady loss in Eskom's credit ratings. Eskom hoped to raise electricity tariffs substantially, despite this being opposed by the trade union movement and other sections of civil society. The National Energy Regulator reduced Eskom's application for 35% increases for three years to 25%, amounting to a doubling of tariffs over the same period,[51] hitting poor and middle-class households, who objected strongly to the sweetheart commercial deals which Eskom had made in the past with smelters and other large users to be charged minimal tariffs.

The government then guaranteed Eskom's massive investment in two gargantuan coal-fired power stations. Medupi, the first of the two to be built, will be funded by the World Bank despite the enormous carbon emissions the 4,800 MW plant will produce. The loan of US$3,75 billion, was strongly opposed by local NGOs,[52] and even caused countries like the Netherlands, Britain, the US, Norway and Italy to abstain from voting at the bank's decision making committee.[53]

To help Eskom get funding for its future nuclear power stations, companies like Areva have said they will help to intercede with the French government to release development finance. The potential Chinese bidders for Nuclear-1 (China Guangdong Nuclear Power Group) have linked up with the Standard Bank of South Africa, 20% owned by a Chinese bank (Industrial and Commercial Bank of China), in order to assist Eskom to purchase future reactors.

As a result, Eskom's financial woes are less of an obstacle to re-launching the bids for Nuclear-1.

3.5 Earlier generation reactors: 2010 onwards

The South African government seemed to assume that cheap reactors can be found, if only they could be identified. This led it to look at a design offered by Korea, which had won four orders for the UAE with a bid worth about US$4,000/kW (overnight costs), well below the levels offered by Areva and Westinghouse, but 60% above the level assumed by the South African government in 2006.

There seems to be ample scope for things to go wrong with the UAE project:

- The technology is untested: there is only about a year of construction experience with this design;
- There is little nuclear expertise in the Middle East region;
- The timescale will be very difficult to meet and the contract price appears to be about 40% lower than the cost estimates for plants planned by experienced US utilities;
- The South Korean nuclear industry has no experience with supplying reactors outside South Korea; and,
- There is little of the infrastructure needed to operate a nuclear power plant in the UAE – for example a safety regulator was only set up in late 2008.

Despite the precariousness of the Korean option, the South African government has had discussions with the Korean government about the supply of such reactors.

The other design being considered by South Africa is the one that makes up the majority of Chinese orders. China dominates the world market for nuclear power plants accounting for 25 out of 38 of the reactors on which construction has started since January 2008.[54] Of the 25, 19 are supplied by Chinese companies and this CPR-1000 design is based on the design China imported from France in the 1980s. This is the same design as is already installed at Koeberg. Some updating will have taken place, for example taking advantage of better IT equipment, but it is clear that it is fundamentally a 40 year old design. The South African government has also been talking to the Chinese government about importing such reactors.

However, a number of assumptions seem to underlie this attempt:

- That the reactors would be much cheaper than more modern designs, partly because they are older and partly because they would be manufactured in China;
- That China has the spare component manufacturing capacity to export plants; and,
- That the NNR would be comfortable licensing a design that fell well short of the requirements of Western regulators, for example on protection against impact by aircraft.

Eskom seems remote from this process and it is not clear whether it supports the idea of importing older technology. As with its reservations with the PBMR, Eskom could be uncomfortable raising any concerns about South African government policy.

The lessons from the Fukushima disaster in March 2011 have yet to be fully identified, but there does seem to be a strong probability that older designs will be seen, worldwide, not just in the West, as inadequate for new orders. In particular, designs with a greater level of 'passive' safety – ones that in an emergency situation do not require the operation of engineered safety systems to bring them to a safe condition – will be required. Even the French EPR does not incorporate strong passive safety features and the Chinese and Korean designs certainly do not have passive safety.

3.6 The new call for nuclear tenders

The call for tenders expected for 2012 is based on the IRP 2010.[55] The rationale for the integrated resource planning process is that it should identify the lowest cost way to meet electricity demand by considering all resources including energy efficiency measures. The plan includes 9,600 MW of new nuclear capacity to be completed between 2023 and 2030. Whether this nuclear capacity really represents the least cost way of meeting demand depends on the accuracy of the assumptions made on the cost.

The IRP 2010 bases its assumptions on a report commissioned from the US Electric Power Research Institute (EPRI, 2010)[56], a US research organisation funded primarily by US electric utilities. Nuclear power costs are dominated by the costs associated with the construction of the plants, the overnight cost of construction and the cost of borrowing, which is related to the discount rate. For the construction cost, the EPRI report gives an overnight cost of R28,375/kW for an Areva EPR and R33,235/kW for a Westinghouse AP1000. If we assume an exchange

rate of US$1=R6.75, this equates to about US$4,200/kW and US$4,900/kW. It is hard to understand why the South African government should assume costs that are only 70-80% of the prices bid two years earlier. There is certainly no evidence that estimated nuclear costs have gone down since then.

The discount rate of 8% adopted by the South African government also appears too low. For example, the UK government assumed a discount rate of 10% in 2008 when it assessed the economics of nuclear power. The discount rate is effectively a tool to allocate the limited quantity of capital available as profitably as possible. It should ensure that only projects that achieve the given rate of return on capital – the discount rate – are pursued. If nuclear power is assessed using too low a discount rate, it is likely that relatively unprofitable projects will be pursued at the expense of more profitable projects. The use of too low a discount rate is particularly serious because one of the key reasons the previous tender failed appears to have been because affordable finance was not available. Cape Times reported that Rob Adam, CEO of Necsa, has said:[57]

> 'The country's nuclear programme had been canned in 2008 because "we couldn't get a bank to lend the money for long enough. Commercial banks' time frames are too short. So now the vendor must come with a bank or financial institution", and South Africa would repay this over time.'

It appears the South African government did not learn from the previous tender when it assumed far too low a construction cost and proceeded with a call for tenders that had to be abandoned because the prices bid could not be financed. The government also seems heavily involved with the process, with ministers and sometimes the president conducting negotiations and signing agreements with governments of potential suppliers. These efforts have been particularly intense with France with whom an undertaking to explore an intergovernmental agreement on spent-fuel management, co-operation between the countries' nuclear safety authorities, and implementation of the agreement on nuclear R&D between the Necsa and its French counterpart have been agreed.[58]

3.7 Experience elsewhere in the world

Nuclear power has not had any better luck anywhere else in the world despite talk over the last decade of a 'Nuclear Renaissance', spawned by the attractions of a new generation of nuclear power plants, so-called Generation III+ designs, such as the EPR and the AP1000. The nuclear industry claimed that these would incorporate all the lessons from accidents such as Chernobyl. They would be evolved from existing designs but they would be more than just existing designs with additional safety systems added on.

The US Department of Energy claimed:

> 'New Generation III+ designs ... have the advantage of combining technology familiar to operators of current plants with vastly improved safety features and significant simplification is expected to result in lower and more predictable construction and operating costs.' [59]

The nuclear industry claimed that these designs could be built for US$1,000/kW or less,[60] so that a reactor like the EPR (1,600 MW) would cost US$1.6bn. These features would be so compelling that even countries that seemed to have abandoned nuclear ordering, such as Germany, Italy, USA and UK would start ordering again. In 2002, when it launched its programme to order such designs, the US government assumed that one or more plants would be in service by 2010. By 2011, the first order had not been placed and it now looks likely that even if things go smoothly from now on, the first order will not be in operation much before 2020.

It is clear that the early cost estimates were a gross misjudgement. The prices bid in 2008 for the first new South African reactor are similar to bids for other countries and for US utilities with advanced plans to order such designs. The typical cost estimate is now six times the level forecast by the nuclear industry only a decade ago.[61]

Anne Lauvergeon, the former chief executive of Areva, said:

> 'the cost of nuclear reactors has "always" gone up with each generation, because the safety requirements are ever higher. "Safety has a cost"'.[62]

Francois Roussely, a former chief executive of the French utility, EDF, said:

> 'The resulting complexity of the EPR, arising from the choice of design, specifically the level of power, the containment, the core catcher and the redundancy of the security systems is certainly a handicap for its construction and therefore its cost.'[63]

Only eight orders have been placed for Generation III+ designs and six of these have been for China. So the so-called nuclear renaissance was already failing long before the Fukushima disaster. The Fukushima disaster can only raise costs and delay things further. By how much remains to be seen but it will be years before it becomes clear what the lessons from Fukushima are and these are incorporated in new designs that have satisfied the safety regulators.

The nuclear plans in Italy and Germany will be still-born and it is far from clear when and even whether nuclear orders will be placed in the UK and the USA. So, South Africa will not be left behind if it does not order new nuclear power plants.

4. The nuclear fuel chain in South Africa

4.1 Uranium mining and milling

After uranium is mined, it is crushed and leached with chemicals and water in the so-called milling process to separate uranium from the rest of the ore. Since the late 1940s, South Africa has been reworking tailings from the Witwatersrand gold mining complex to extract residual uranium. Although gold mining has mostly reached its limit in these and the Free State mines, the tailings are once again viable to mine, particularly in view of the rise in the uranium price from 2007. Approximately 17 sites are having their tailings processed.[64] South Africa's uranium production peaked in the 1980s. In 2010 it produced 583 tonnes[65], amounting to just over 1% of global production.

The mining of uranium brings several problems with it. One is a residual problem of mine water pollution, including **acid mine drainage**, which is corrosive, toxic and radioactive, and is increasingly entering the environment.[66] This is formed when rainwater collects in abandoned mine shafts and comes into contact with iron pyrites and other minerals. With the end of gold mining, the now radioactive waste water fails to be pumped out of the mine shafts and rises to the surface. People living on radioactive land on the West Rand have had to be rehoused.[67] Mining continues on the Far West Rand, whose inhabitants are resisting the formation of a **superdump**, aimed at housing much of the area's radioactive tailings.[68]

In the past there have been sites where uranium was mined without being associated with gold, such as in Phalaborwa in Limpopo province. Prospecting is taking place in at Ryst Kuil in the Great Karoo, where a French-Chinese consortium is planning to mine 1,750 tonnes a year. Prospecting licences have also been issued in the Vredefort Dome, a UNESCO-registered world heritage site, believed to be the oldest and largest meteorite impact on Earth.[69]

The gold mining companies participated in the establishment of NUFCOR, the Nuclear Fuels Corporation of South Africa Ltd. in order to process and market their uranium. By 1998, only AngloGold (now AngloGold Ashanti) was using the facilities of NUFCOR, which became one of its subsidiaries. More recently other mining companies have utilised its marketing services.[70]

4.2 Conversion

Sold in the form of a powder, uranium oxide (U_3O_8) cannot become nuclear fuel without being enriched (see section 4.3). The enrichment process that was used in South Africa required the U_3O_8 to be converted to uranium hexafluoride or 'hex' (UF_6). During the 1970s, the Atomic Energy Corporation built a conversion plant at Valindaba.[71] The plant proved difficult to operate, and a number of radioactive releases to the environment occurred there.[72] In the mid-1990s, once the enrichment process was ended, there was no longer any reason to keep the conversion plant in operation. However, government now foresees the reacquisition of conversion technology.

4.3 Enrichment

To create a chain of nuclear fission, the reaction that produces energy, the uranium has first to be enriched. When mined, uranium consists mostly of the stable U238 isotope, with small amounts of the more fissile U235 isotope. The enrichment process separates the isotopes and increases the amount of U235 in the mix. Starting at 0,71% of the mix, enrichment can either raise the U235 to 3 - 5% of the mix needed in pressurised water reactors like Koeberg, or go as far as 90%, the mix needed to manufacture weapons.[73]

Although there had been experimentation with enrichment since 1961, a pilot plant (the Y-plant) started operating in 1974 and took a further four years to produce highly-enriched uranium. The pilot process saw enormous technical problems and was shut down in 1979 for almost two years. After 1981 it mostly produced highly enriched uranium for South Africa's weapons programme and the SAFARI-1 research reactor. The semi-commercial Z-plant produced low-enriched uranium for the Koeberg reactors.[74]

With the cancellation of the weapons programme, the Y-plant was closed and decommissioned in 1990, while the Z-plant remained in operation until 1995. At that time it was decided that it would be cheaper to import enriched uranium for the Koeberg power station.[75] In the latest nuclear policy document, government favours the re-establishment of an enrichment facility in South Africa.[76] Chief Executive of NECSA, Rob Adam, stated in 2007 that there would be an enrichment facility in South Africa within 5-10 years.[77]

4.4 Fuel fabrication

The BEVA plant, whose acronym is derived from the Afrikaans for fuel element manufacturing facility (brandstofelementvervaardigingsaanlegging) was built at Pelindaba to transform enriched uranium into pellets that would fit into fuel rods, destined to be inserted into the Koeberg reactors. Eskom was forced to buy the fuel rods from the AEC on long term contract. However the BEVA plant could not meet all of Koeberg's needs and Eskom was able to import much cheaper fuel rods from France. BEVA was closed down in 1995 and its equipment sold to China. The building was earmarked to manufacture fuel for the pebble bed nuclear reactor, but this has been cancelled. Government's most recent policy favours the rebuilding of a fuel fabrication facility.

4.5 Reactors in South Africa

SAFARI-1, a 20 MW research reactor provided by the USA was installed in 1965 on the Pelindaba site. It has been used to develop medical isotopes, silicon doping, and other applications. It ran on highly enriched uranium (45% and 90%) until 2005, when government announced it would be converted to accepting low-enriched uranium by 2008.

Koeberg, consisting of two pressurised water reactors, was designed with a total capacity of 1,844 MW. The reactors produce up to 6% of South Africa's electricity needs, and some power is exported to Namibia. In the summer of 2005/6 the reactors were shut down due to a series of mishaps, including a damaged rotor. The Western Cape economy suffered damages of over R8 billion over a few weeks. While government blamed 'saboteurs', this accusation had to be retracted after a report by the National Energy Regulator blamed Eskom for poor management and lack of compliance with licensing conditions. In another incident on 12 September 2010, 91 maintenance workers were contaminated with radioactivity owing to a faulty indicator switch.

The **Pebble Bed Modular Reactor (PBMR)** was developed from 1998 to 2010, by a subsidiary of Eskom called PBMR Ltd. Since the PBMR was unable to attract private investors and potential customers, government cancelled the project in 2010 (see Chapter 3).

Nuclear-1 is the code name of the next generation of reactors that the government would like to install, as established in the IRP 2010 report that was accepted by cabinet in March 2011 (see section 2.6). Ironically the Environmental Impact Assessment for Nuclear-1 is already at an advanced stage, without the reactor design having been chosen.[78]

4.6 Disposal

There is no solution in sight to the problem of disposing high-level nuclear waste. Certainly South Africa has not developed one.

Low- and intermediate-level wastes from the Koeberg site are trucked in drums to a site 500 km north at **Vaalputs** in the Northern Cape's desert Namaqualand region. The dump was chosen at the end of the apartheid era because of its remoteness from any white settlement and the aridity of the areas that made the possibility of ground water contamination unlikely. Low and intermediate level waste includes gloves and other items of clothing as well as radioactive sludge removed from the filters. Drums are stored below surface in trenches. In the very first consignment, a truck lost an axle and went into a roadside ditch. At times Vaalputs has been shut on orders of the National Nuclear Regulator, which has detected mismanagement of the facility. Currently operated by Necsa, new legislation foresees a National Radioactive Waste Disposal Institute taking over the management of Vaalputs.

High level waste is a particular concern. It is formed from the spent fuel in the reactors and remains radioactive for hundreds of thousands of years, containing elements that include plutonium with a half life of 24,400 years. To reach the end of its radioactivity it must be insulated from the environment for ten times that period or 244,000 years. By comparison, the human race is only 200,000 years old, with agriculture 10,000 years old and cities, 6,000 years old.

Koeberg's highly radioactive high level waste – mainly spent reactor fuel – is placed in storage ponds **on site**. When Koeberg first opened, it was envisioned that the spent fuel would cool off in the ponds for 10 – 15 years before being moved off site. But since no other solution to high-level storage has ever been found, the waste has never been removed from the ponds, something that will become worse with the expansion of the nuclear programme with this same waste situation being replicated at sites across the country.

Most of the wastes from Pelindaba are stored at **Thabana Hill**, formerly called Radiation Hill, within the complex. This includes the high-level waste emanating from Safari-1. Pelindaba authorities have also created an interim retrievable dry store to receive spent fuel elements from the spent fuel racks in the pool of the Safari-1 reactor.

During the course of the Environmental Impact Assessment (EIA) for the Pebble Bed Modular Reactor, the organisation Earthlife Africa found that the then Department of Environmental Affairs and Tourism had approved the PBMR without taking its views into account, violating EIA practice. One of Earthlife's concerns was the likely spread of nuclear technology if the PBMR was approved, without the existence of any policy on nuclear waste management. Earthlife took the Department to court to secure its rights. The Record of Decision was reversed, with the judge declaring that government needed to develop a nuclear waste management policy before resuming the EIA process, the government needed to develop a nuclear waste management policy. It did so in 2005, listing a range of potential waste management strategies, including deep geological disposal of high-level waste, and reprocessing of spent fuel, but is agnostic about which strategy to choose.[79]

4.7 Reprocessing

In reprocessing facilities, the plutonium and unused uranium are separated out from other waste with the intention to reuse it in nuclear plants. In reality, the term 'reprocessing' or 'recycling' is misleading, since a lot of the recovered materials are not reused. Very few countries have the resources to possess reprocessing technology, which is extremely complex and hazardous and involves chemical separation of the spent fuel. Since the separated plutonium can be used in weapons and fast-breeder reactors, reprocessing technology is one of the potential routes to weapons proliferation.

South Africa has never possessed such technology, although it has experimented with hot cells, used to break up spent fuel for the purpose of developing radiopharmaceuticals. Hot cells can also enable the steps undertaken for chemical removal of plutonium from spent fuel, which creates concern about potential proliferation.

In the 1980s, the AEC acquired a site at Gouriqua, near Mossel Bay, where it was intended that research would be undertaken on the extraction of plutonium and tritium from spent fuel. Plans existed for the construction of a 150 MW research reactor on site. However, this was never fully developed and in the mid-90s the site was sold and the equipment removed.[80]

In its 2007 nuclear policy document (see endnote 22), the government declared its intention to develop a reprocessing function, as part of a renewed effort to acquire all the links in the nuclear fuel chain.[81]

© Greenpeace / Eric De Mildt 2006 Greenpeace activists on the 31 year old aging reactor dome at the Tihange Nuclear Plant in Belgium.

© Greenpeace Africa, 2011 Members of the local community around the Koeberg Nuclear Power Station.

5. Eye witnesses to nuclear dangers

5.1 Introduction

Nuclear power doesn't just threaten the environment, it poses health risks to the people that work in the industry throughout the nuclear fuel chain. The widespread impacts of nuclear power are largely ignored and people directly impacted are silenced or neglected. The case studies below are first-hand witness statements describing nuclear risks and harmful impacts in South Africa, and their shocking experience due to lack of industry accountability or government action.

5.2 Living in the shadow of nuclear waste

Like elsewhere in the world, South Africa has not developed even a temporary solution to the problem of high-level nuclear waste. But the decision to bury the low and intermediate level waste at Vaalputs in the desert Namaqualand region must mark as one of the most cynical of the dying years of the apartheid regime. The AEC described a 50 km exclusion zone for white municipalities, but the indigenous Nama people who live there were neither consulted nor included in the buffer zone.

"Must we prepare our own gallows?" is what the local community leader Oom Oulak asked in 1987, when Vaalputs was established. While another revered community spokesperson, Oom Japie Bekeur, went on to question the justice of locating Vaalputs close to the village of Nourivier: "Why should we accept that radioactive waste be buried close to our homes when we are not even supplied with electricity?" During her investigations, local journalist Elizabeth Beukes, writing for *Namaquanuus*[82] stated: that "there was no consultation whatsoever with the people of the area when the site was being selected. For the AEC[4], our people do not seem to exist."

An observation that was also echoed in 2010 by a woman living at Nourivier village: "It began officially in the 1980s. Originally they told us it was going to be a nature reserve. They made various promises to the community. They said they were going to build a high school. In the end, we learnt it would be a nuclear waste dump. All the communities surrounding Vaalputs were misled. We weren't truthfully informed from the start. It happened during the years of apartheid, when we had no say. You had to do what you were told and keep quiet."[83] The communities in the area rely on borehole (underground) water to survive and feed their flocks of goats, and are constantly worried about contamination.

And there are reasons to worry. An inspection visit by the regulator to Vaalputs in September 1996 noted 54 violations of the licence[84]. This caused the closure of the facility until the AEC became compliant. The AEC had failed, amongst other things, to implement quality controls and training programmes, to develop emergency planning, to maintain proper records, to control radioactive effluent, to maintain records of staff radiological protection, to check instrumentation and to audit safety procedures. Even worse, was the realisation that the process of storing the drums of nuclear waste was inadequate and that there were no arrangements to store or retrieve records on the disposed waste. The AEC was accused of a general lack of management and supervision at all levels and having no effective mechanism of complying with licence conditions. The document detailing these allegations took a decade to reach the public domain.

The secrecy around Vaalputs has also alarmed the local population. "We regard it as dangerous, because they are keeping it secret and because they don't want to consult with us. What I still don't understand is that after all these years [Vaalputs has been open since 1987] most people in these small communities still don't know what is going on there. The people they employ – and I am not scared to say this – must shut their mouths in order to keep their jobs", is what Petrus Rosseuw a local inhabitant thinks.[85] And even when meetings are open to the public, the information policy of AEC has upset the locals. "I have attended their meetings where they only tell the people about the positive aspects of nuclear waste but the dangers are never explained to you. If the government thinks it isn't dangerous, then Koeberg can bury the waste in its own back yard", says Oom Wollie Waldeck, who lives at Rooifontein village.[86] Another resident made a recommendation and also pointed to the desperate situation of people living in the area. "The waste should be taken away and stored in Johannesburg where all the important people can keep an eye on it. It is something that will be there for generations and remain radioactive for thousands of years. Where do we go? We are obliged to stay here", Gert Beukes of the Kamasies village states.[87]

In 2009, a National Nuclear Regulator official publicly admitted to an International Atomic Energy Agency conference that the Vaalputs technology was outdated and ageing.[88]

Former workers at Vaalputs have openly voiced their criticism of the waste dump's operations. "When I went to work at Vaalputs, they told me that the underground water

[4] Atomic Energy Corporation, now NECSA

was contained in such a way that it could not reach the surface and could not become contaminated, no matter what you try. Yet we noticed that the water level did not drop but continued to climb. We measured this regularly. What it tells me is that the Vaalputs management was lying to me. I am prepared to testify to this in court."[89] This is what Hendrik Fortuyn, a former Vaalputs worker said. He died a year later. Another former worker observed leaks in the drums for the nuclear waste. "There was a leak in one of the drums containing nuclear waste. People came from Koeberg to see the drums. At that time they closed the drums and reburied them in a square metre of earth set aside for this purpose", observed Willem Ghaal.[90]

But mismanagement has also occurred at the nuclear waste storage site in the Pelindaba complex at Radiation Hill, more recently named Thabana. In 1990, as a result of a nuclear incident, condensers from Safari-1 were contaminated and placed in Trench 7 at Thabana. In 1995, workers were ordered to retrieve them and were issued with a pick axe, a shovel, a pair of boots, an overall, and a paper mask to cover their mouths and noses. According to one of them, Bennie Masomola, "Very soon we unearthed mountains and mountains of drums, many of them were rusty and full of cracks. I remember the dust and the smell, and when I went home the smell would still hang around me. It was very bad. As we dug deeper, we were covered with blue, red and green dust."[91] A senior manager at Pelindaba candidly confessed: "Look we screwed up, made several mistakes, infringed on many of our license conditions and no waste disposal records were kept for Radiation Hill." [92]

Since the beginning of uranium mining in the 1940s, no government had considered a policy on radioactive waste. In 2004, environmental watchdog organisation Earthlife Africa challenged the government's acceptance of a flawed Environmental Impact Assessment of the now defunct pebble bed nuclear reactor. Amongst other things the Cape High Court ruled that the government could not go ahead with the reactor without putting in place a policy on radioactive waste. The Department of Minerals and Energy then set about putting a document together. It enjoyed minimal public consultation, and in fact proved agnostic in relation to the disposal of high-level wastes, relying on the future options of deep geological disposal or reprocessing of the waste. To date neither option has been proven realistic or reliable.

To remove the onus on Necsa for managing the country's radioactive waste, the government set up legislation in 2008 for the creation of a National Radioactive Waste Disposal Institute, which has yet to be finally established. It is doubtful that sufficient managerial, scientific and technical skills are available to the new Institute, and research and development have been scaled down under Necsa's watch.

5.3 Nuclear workers and health issues

Even though working at nuclear power plants harbours severe occupational health risks, many workers in South Africa's nuclear industry claim that they were not told about the risk of radiation contamination and chemical exposure, and were never given safety training or protective clothing. In some cases, they were not legally authorised to work in radiation areas but were told to deal with "clean ups". Black unskilled workers in particular had no idea of the substances with which they worked. Some were retrenched before they fell seriously ill. Those who suffer from the consequences of their occupation continue to battle on for compensation.

To date more than 500 seriously ill former workers at Necsa's Pelindaba complex have sought occupational health compensation.[93] As the body of evidence grows, nuclear workers at Koeberg nuclear power station near Cape Town and at the Vaalputs nuclear waste dump site in Namaqualand in the Northern Cape province have also sought clarity on the causes of their illnesses. But many current nuclear workers are fearful of losing their jobs and are reluctant to come forward. Those who battle on for compensation fear the state and its nuclear industry are "waiting until we all die for the problem to go away".

In 2005, Ron Lockwood, an ex-radiation worker at Koeberg nuclear power station was diagnosed with leukaemia, a cancer caused by radiation. Koeberg authorities had, reportedly falsified his medical records[94], hiding his diagnosis, and persuaded him to apply for early retirement. Lockwood's subsequent legal claim against them failed, and other employees who claimed occupational exposure received nothing other than their usual pensions from Koeberg.

5.3.1 Pelindaba occupational health impacts

When Victor Motha went to work at the Necsa Pelindaba complex, on the morning of the 8th of November 2001, it seemed to be a normal day for the young chemical engineer. But when the 21-year-old came home that night, he suffered from nausea, a burning throat and chest. In the course of the evening he started vomiting. His father rushed him to hospital where Victor Motha died.[95] Fluorine inhalation was the cause, the post-mortem examination concluded. To process uranium as a fuel in nuclear reactors, fluorine, a highly toxic gas is used. After Victor's death, the Motha family received a letter from the then Minerals and Energy Minister, Phumzile Mlambo-Ngcuka. "No stone will be left unturned in this investigation"[96] is what the minister promised the family.[97] "And that is where the correspondence with the department ended", is what Victor´s father, Clive Motha says.

Eleven other workers, who had been on shift with Victor, were hospitalised and later discharged. They were reportedly told not to discuss Motha's death. In 2005, Tseliso Maqubela, chief director of nuclear technology for the Department of Minerals and Energy, told the Mail & Guardian that the Motha investigation was complete. Victor´s family never received the information and reportedly received a cheque from Necsa for R6,000[98] after their plight was covered in the media. "Necsa just wants to prevent us from filing legal actions", is what the family assumed. Maqubela claims that, in the previous 10 years, Necsa had had only one work-

related fatality, that of Motha. He went on to state: "There has never been a nuclear incident or accident involving radioactive material resulting in the death of a Necsa employee."[99]

Allegations[100] followed by ELA that many former Pelindaba employees were suffering from illnesses caused by radiation and chemical exposure. Together with the South African History Archive (SAHA) at Wits University, and an independent occupational health doctor, Dr Murray Coombs, ELA embarked on a health study of former Pelindaba workers.[101]

Dr Coombs finalised his report in late 2006[102] but was unable to continue with all of the 500 new cases that came forward, due to a lack of funding. Of 208 people he examined, almost 40% were suffering probable occupation-related illnesses ranging from respiratory diseases, like lung cancer, asthma and lung fibrosis, to dermatological conditions. Dr Coombs concluded that in an industry in which annual medical surveillance is a legal requirement, the figures appeared to be extremely high. His report found indications of 72 former workers with probable occupational diseases[103] (some workers with multiple diseases) requiring further tests for 52 workers. In at least 8 cases, he found, the worker had been exposed to radiation that caused their diseases plus 2 work-related deaths. Each of his diagnoses was backed up by the company's own records where these could be obtained.

"It is clear from the findings that an investigation into occupational disease for ex-Necsa workers is valid and necessary. The burden of disease, both occupational and non-occupational also indicates the need for further occupational disease, economical and social studies," Dr Coombs concluded in his report. "Anecdotal information from personal interviews and telephonic contacts indicates a much larger group of ex-employees with radiation related illness. These employees are covered by pensions and medical insurance and are reluctant to come forward to join the study."[104]

Another 91 cases required documentation from Necsa, which in some cases took 3 years to obtain. Some requests had to be lodged through the Promotion of Access to Information Act (PAIA), No. 2 of 2000. Findings could not be made for 62 of the victims because of missing information. Those medical files that arrived were often dismally incomplete and did not meet the requirements laid down by the law, said Dr Coombs. "Even if we accept that only 50% of the 72 present problems of potential occupational diseases, it may indicate 5,100 employees with occupational disease (in the historical pool of 30,000 Necsa employees since South Africa's nuclear programme began in the 1960s)," he reported. Dr Coombs referred 11 solid occupational illness cases to the Compensation Commissioner but the lawyers handling the cases said not one had been granted compensation. No grounds were provided.

Dr Coombs then met with Necsa, which, he said, insisted on re-examining the workers but denied all requests for independent monitoring. Necsa claimed it had not consolidated the health files of past workers, which were lodged in multiple locations. In 2005, Necsa set up a R3.5 million inquiry into the Pelindaba workers' claims, without representation of the workers[105]. ELA expressed concern over the exclusion of its nominees to the health study team. "We now have no hope that the Necsa study will be independent. It looks like a whitewash," said spokesperson Mashile Phalane.

Nomfuyo Galeni, Necsa's then acting CEO, promised The Sowetan in July 2005 the inquiry would be wrapped up "within 12 months"[106]. No known workers were interviewed by the commission. And no report was ever released on Motha's accident or Necsa's inquiry.

After *The Sowetan* said Necsa had "quietly closed the "open and transparent" commission of inquiry it had appointed to investigate the claims"[107], Necsa's new administration told reporters once the company became aware of the claims it decided to investigate and release a report[108]. However, in January 2007 newly appointed CEO Rob Adam stood accused on *The Sowetan's* front page that he had "deliberately deceived parliament" when he told Parliament "Necsa can categorically state that not one of these former employees presents symptoms that relate to the adverse effects of radiation." In answer to Necsa's intransigence, labour lawyer Paula Howell said: "The law does not give the company any right to delay these workers' claims for compensation or to judge if their complaints are valid."

5.3.2 Workers' legal cases

The Legal Resource Centre (LRC) took on the compensation cases in 2007. That same year a delegation of embattled and ill ex-Pelindaba workers and a widow testified to parliamentary hearings on nuclear energy.[109] "I became very sick there. They told me to say nothing but their doctors did not explain the illness and they retrenched me," Sipho Jaca testified.[110] The evidence clearly shocked committee members, and their chairperson made promises including a referral of their cases to the Human Rights Commission. To date none of their undertakings have been met.

The workers' legal cases then hinged on the test case of Tilman Roux, 62, a former employee of the South African Uranium Enrichment Corporation (UCOR). He applied for workers' compensation benefits in November 2007. He provided a diagnosis for multiple myeloma he believed were caused by exposure to ionising radiation while working at Valindaba's Y-Plant between 1974 and 1983 at a time when apartheid South Africa was enriching uranium for its weapons programme. His claim was rejected by the Compensation Commissioner without reasons. So he filed another application in the High Court requesting reasons.

The court found Roux's case had not been properly investigated and instructed Necsa to deliver all relevant information to the Commissioner, including radiation levels

in the plant and all incidents and accidents reports during the time he worked there. “It is clear from the records that UCOR provided that they failed to keep proper records of my exposure to radiation through contamination even though, during my employment in the enrichment plant, I was checked for contamination on several occasions and found to be contaminated.” Roux said in his affidavit. Despite his appeal for urgency – dictated by the need for immediate treatment to prolong his life – Necsa took two years to supply information to the commissioner as ordered by the court and then hid the information to prevent any more access to it, making it impossible for Roux to pursue his case.

This was a massive setback for the original compensation claimants. One of the ex-workers examined by Coombs, Alfred Sepepe, testified to the Parliamentary Portfolio Committee on Environment on the plight of Pelindaba workers seeking compensation, saying about 60 of them have since been buried – suffering and penniless.

“Our former bosses are hoping we all die off one by one until the problem disappears,” he said. He has dedicated his life to seeking justice for contaminated workers and still hopes for an audience with three respective presidents, Energy Ministers and recently the Public Protector. The latter is investigating the complaints of those ex-Pelindaba workers who are still alive, but ill.

What is perplexing is why compensation has not been granted. The worker compensation law stipulates the presumption of an occupational disease in circumstances where an applicant is exposed to a particular substance at work and develops a disease that is linked to such exposure. If no credible evidence is provided by the employer, the employee is entitled to benefit from the presumption. Ionizing radiation in the workplace is deemed to cause occupational diseases. “The Commissioner cannot simply accept the employer’s version without a thorough understanding of an applicant’s work environment,” said lawyer Paula Howell.

Unable to conclusively rebut Roux’s claims – meticulously substantiated in his own records - the nuclear industry withheld information shielding itself behind state secrecy laws. This leaves Roux and countless others with no hope for any compensation and a strong belief that the country they served and for which they sacrificed their health, has ultimately failed them.

5.4 The National Nuclear Regulator

Every country with a nuclear energy programme should have an independent regulatory body ensuring that the public are protected from radioactivity. South Africa took 40 years to do just that, after the creation of its uranium mining industry, the Atomic Energy Board, the launch of Safari-1, Koeberg, Vaalputs and the Valindaba secret weapons programme. Before 1988, licensing was conducted by the Atomic Energy Board (later to become the Atomic Energy

- Over 500 ill ex-workers sought help from Earthlife Africa
- 208 workers were examined by Dr Coombs
- 40% suffered probable occupation-related illnesses
- 45% of the ex-employees have more than 10 years’ exposure
- More than 1 disease exists per ex-worker, with a high probability that these are work-related
- 72 probable occupational diseases were found (indicating multiple illnesses in some patients)
- 52 workers required further medical tests for diagnosis
- 8 cases were clearly identifiable as exposure to radiation
- 2 work-related deaths were identifiable as radiation exposure
- No findings were possible on 62 victims because of missing information from employer
- 11 cases were referred to the Compensation Commissioner
- None received compensation for occupational illnesses
- Statistics suggest 5,100 employees in the historic work pool of 30,000 could suffer occupational diseases
- The report concludes there will be a significant increase of disease amongst ex-workers over the next 20 years

© Greenpeace / Shayne Robinson 2011 A Greenpeace vigil in Soweto (South Africa) for victims of the Fukushima nuclear disaster in Japan.

Additional information on the findings of Dr Coombs

- Most international companies average a report of 1 incident every 2 years – 12 admitted incidents reported in one year (2003/2004 under review) are excessive by anyone's standards.

- Information gathered by the doctor indicates there is a much larger group of ex-employees (some dying from cancer and other radiation related illnesses who spoke to the doctor), who are reluctant to come forward to join the study as they are covered by pensions and medical insurance. These employees generally held higher than average positions.

- Urgent action should be requested from the Department of Labour's Compensation Commissioner and Necsa for compensation. Necsa used this form of self-medical insurer merely for administration purposes only, and not to authorise payments.

- From official records that do exist, and obtained by Dr Coombs, he said it appeared that a medical surveillance program was in place at Necsa but merely for the documenting on incidents and not for any appropriate follow-through, and "therefore their program never worked". In addition, Health and Safety Records could not be found, and "there is clear evidence that over the years the quality of the records Necsa did keep, appears to have diminished or disappeared by leaps and bounds with each passing decade of the company's nuclear existence".

- The findings of this report was based on extremely limited information made available to the doctor, including official reports from Necsa despite the Department of Minerals and Energy Gazetted law which states that "an employee has the right of access to his/her medical record and health register at all times". Findings were that most workers have suffered extreme difficulty and in most cases failed to get any of their records from both Necsa and the hospitals at which they were treated.

Corporation). From 1988, these activities were converted into a Council for Nuclear Safety, and only in 1999 did it become the National Nuclear Regulator (NNR). For the first time the body had its own distinct founding legislation separate from the legislation promoting the nuclear industry.[111] The NNR is answerable to the Minister of Energy, whose simultaneous brief is the promotion of nuclear energy. This creates some conflicts of interest, which would be removed if the body was made more independent.

The NNR operates under both budgetary and human resources constraints.[112] But it also suffers from a lack of political will, unable to take on more powerful mining interests to clean up extensive evidence of radioactive contamination emanating from the poor disposal of mining wastes. In addition, there is a severe problem in the NNR's relationship with the public. Having refused for years to convene meetings with environmental groups to account for unanswered questions, the NNR cries poverty. Yet it has recently moved into modern multi-million rand premises. In conducting surveys to test its public profile, the NNR has discovered that public confidence in its activities is rated extremely low.[113]

Why does this watchdog body enjoy so little public trust? One key reason is its ties to the nuclear industry. A large portion of its income derives from licensing services, so that the more nuclear activities that exist, the more income the NNR obtains for its operations. This creates an inbuilt bias in favour of the industry. In turn the NNR[114] becomes more dependent on nuclear activities and less inclined to question or reject licence applications.

To underscore this lack of neutrality, in 2005 the minister of minerals and energy appointed Maurice Magugumela, an employee of the Pebble Bed Modular Reactor company developing the now deceased pebble bed high-temperature nuclear reactor, to head the NNR. At the time the pebble bed company was receiving huge state grants to develop its technology. This indicated the extent of the revolving door syndrome.

The NNR is a weak protector of the public interest, because it often interprets its mandate so narrowly. For example, instead of taking the lead on questions of radioactive contamination, it waits for other government agencies to be active. It rejects its broad responsibility and argues that it is only accountable for overseeing licensed nuclear facilities. Therefore it cannot function effectively to reduce radioactive contamination outside of these facilities, which in the case of South Africa is quite extensive. With regard to the question of acid mine drainage, which involves the seepage of waste water from abandoned mines into the environment, the NNR has played a very ineffectual role, given that the waste water is radioactive and toxic due to the presence of radionuclides. The NNR has essentially ceded the problem to other departments and state bodies like the Department of Water and Environment.[115]

The scientific reporting of the NNR has turned out to be inadequate and unreliable. A recent case in point was its reporting on the levels of contamination in the Tudor Shaft area in the Wonderfonteinspruit catchment, outside Johannesburg, where communities had built informal housing on radioactive land. The NNR reported in a publication that it could find no evidence of a threat to the public. However, diligent NGOs encouraged the intervention of an independent scientist who verified that the contamination was a serious threat to human health. Also, civil society activists identified worrying mistakes in the NNR report, for example on the calculation of dose impacts.[116] Licking its wounds, the NNR claimed that it was "not a research body", and it sheepishly undertook to revise its findings. Clearly its level of scientific and radiological expertise is poor.

The culture of the regulator has become increasingly opaque, despite the question of Stakeholder Engagement being one of its strategic focus areas with highly paid top managers assigned to this portfolio.[117] For the past five years, specific public questions when put to the NNR have remained ignored. Instead members of the public are increasingly referred to the cumbersome process under the Protection of Access to Information Act (PAIA), No 2 of 2000. In a series of requests under PAIA during 2005, Earthlife Africa in conjunction with the South African History Archive sought to gain information on records of mining accidents, licensing of the pebble bed reactor, problems at Vaalputs, exposure of workers in nuclear facilities, safety records at Pelindaba and Koeberg, and minutes of the NNR board meetings with respect to the appointment of its CEO. Despite initial intransigence, the NNR was obliged to release certain documents under pressure. For example, a document detailing the reasons for the temporary closure of Vaalputs nuclear waste dump was finally revealed after ten years.[118]

Another instance of the NNR's lack of transparency is its attempts to shut down the representative role of certain board members, appointed for their strong relations with communities and the labour movement. These board members are denied their representative function, and threatened with sanctions when they try to urge that the NNR become more effective and independent.[119]

As government policy foresees an immense expansion of the nuclear industry, so the question of the competence of the regulator can no longer be seen as a side issue. The NNR needs a major revision of its core competencies, in order to be able to safeguard the population from radiation risks and regain public confidence. It needs to ensure that its mandate to regulate is broadly implemented, and conduct appropriate scientific investigations. It needs to become more independent of the promotional Department of Energy, and simultaneously become more accountable to the public and its elected representatives. It needs to function free from licensing fees for the bulk of its income (which gives it a stake in the expansion of the industry)[120] and develop a culture of transparency, objectivity and neutrality. There needs to be a complete review of the effectiveness of the NNR and a complete overhaul of its skills and response to its mandate.

Mariette Liefferink, an activist with close knowledge of the NNR, stated the following: "You judge the future from the current. I judge the NNR on what they are doing now. And I judge it from physical or real evidence. And I despair. Because if we cannot even manage or monitor our low dose radioactive waste from the mining industry, let alone the radioactivity from nuclear facilities, then I really despair."[121]

5.5 Rising resistance to new nuclear power reactors

Germany, Switzerland and Italy have completely rejected nuclear energy, but Eskom is conducting a mandatory Environmental Impact Assessment (EIA) for new reactors on three sites along the coastline. Normally an EIA can only be conducted when it is clear what the impacts of the new development are. But Eskom has not yet ordered the new reactors, so it is unknown which technology is being assessed. At the same time, resistance along the planned coastal reactor sites is forming.

"Wat gat gebeur van die water en die kelp?" ("What is going to happen to the water and the seaweed?") Auntie Sarah recently asked at a public meeting to discuss the Revised Draft Environmental Impact Report in the coastal town of Gansbaai on 23 May 2011. The passionate community leader from the Buffelsjags fishing community sees their livelihoods at risk, since the proposed reactor site at Bantamsklip will only be three kilometres away from their main source of income. "Since 2001 the community has been harvesting the kelp as part of the only job-creation project in the area," she says.[122] After the EIA consultants suggested that the water temperature might rise as much as 12 degrees, kelp harvesting project manager Chara Niemand echoed the previous concerns. *"Maar die kelp groei in koue water!"* ("But the seaweed grows in cold water!")[123] In a very well-informed deposition, she eloquently described not only the Latin name of the species, but referred to the cold currents of the Southern Atlantic in which they thrive. Ms Niemand also explained that their community was completely different from other communities in that they were harvesting abalone and line fish directly from the sea. *"Allie mense wat daar bly lewe vanaf die see,"* she stated. ("All the people who live there, live off the sea.")[124]

Gansbaai landowner Dave Whitelaw pointed out that temperatures were always local, invalidating the practice of drawing evidence from Koeberg near Cape Town on the Atlantic Coast and then trying to apply it to conditions on the Southern Cape coast. He also touched on the potentially negative impact on penguins and fish populations.

Unfazed by any intervention, the EIA consultant, Reuben Heydenrych replied smoothly: *"Ons weet dat die perlemoen*

kannie in die warmer water lewe nie," ("We know that abalone cannot live in warmer water,"*)* and went on to add "But we are confident that, as long as Eskom performs their work diligently, nothing will happen."[125] In addition, Heydenrych insisted that any detectable radioactivity in the flesh of abalone related to above-ground nuclear weapons testing and that the Marine Biologist from the University of Cape Town, Professor Charles Griffiths, had stated in one of the 30 voluminous EIA Specialist Reports that there would be "no impact" whatsoever.

But the National Nuclear Reactor (NNR) has supplied contrary evidence in which Eskom's own Environmental Science Laboratory's (ESL) Quarterly Reports to the NNR document unscheduled emissions from Koeberg Nuclear Power Station.[126] Given that above-ground nuclear weapons testing came to a dead halt in the early 1970s, and that strontium-90 and caesium-137 each have half-lives of roughly 30 years, one would expect that the detectable levels of strontium-90 in the body mass of abalone and black mussel which ESL samples, as well as in sewage sludge at Melkbosstrand, near Koeberg, would have declined. Contrary to those assumptions, recent analyses[127] indicate that the levels of strontium-90 have actually been rising. Moreover, because of the counter-spin of northern and southern trade winds about the equator, little of such fallout would have made it so far south.[128]

While ESKOM still tries to understand the situation, resistance is forming. At each of the earmarked sites along the coast, Thyspunt, Bantamsklip and Koeberg, a growing movement of anti-nuclear activists is emerging afresh, supported by young and old, black and white, rich and poor. Cape Town has long seen resistance, from the time of the construction of the Koeberg reactors in the 1980s. Almost thirty years later, veteran activist Mike Kantey, national chairperson of the Coalition Against Nuclear Energy[129] which he helped initiate in 2008, found himself travelling from coast to coast, bearing witness to the tremendous effort that has been put into building popular resistance at local level to the proclaimed sites at Bantamsklip and Thyspunt. Local resistance to the potential reactors at Bantamsklip, based in the Overberg District, include the Save Bantamsklip campaign[130], the Wolvengat Action Group, the Strandveld Conservation and Tourism Association, and the Dyer Island Conservation Trust.

"Everywhere I have travelled for the Coalition," admits Kantey, "it has struck me how hard people have laboured and invested both time and money developing a large range of sustainable and sensible livelihoods."[131] The dominant industries in the area are agriculture (including the sustainable harvesting of the local fynbos vegetation itself), dairy production, fishing, mariculture, but – above all – a massive, multi-billion rand investment in ecotourism. To give one small example, Greg Christy, a leading member of the chokka fishing industry in the St Francis Bay area, stated in a similar Thyspunt Alliance meeting that the abalone harvesting industry was worth R250 million (€24.4m).

It is clear that the construction of nuclear plants in the area will have a negative effect on local livelihoods. Are these to be sacrificed in the name of delivering electricity to distant bulk users elsewhere in the country, when viable alternative forms of generation and saving exist? Eskom´s and Arcus Gibb, the EIA consulting firm´s unscientific, speculative, and downright irrelevant responses at EIA hearings seem to fuel the resistance. Or as local Kleinbaai entrepreneur, Wilfred Chivell, a staunch supporter of the Dyer Island Conservation Trust put it: "Do not bull me once; I won't trust you twice."[132]

© Greenpeace Africa, 2011 Members of the local community around the Koeberg Nuclear Power Station.

6. Leaving nuclear power behind

Nuclear power is riddled with safety issues. And when something goes wrong, it can have catastrophic impacts as was seen in Chernobyl in 1986 and in Fukushima in 2011. Also South Africa is not free of nuclear risks and impacts, as this report shows. Nuclear technology is inherently unsafe and needs to be protected against nature and against humans. This results in massively expensive hi-tech plants and security legislation with little conception of human rights. Expansion of nuclear energy does not make any logical sense. This chapter shows that South Africa has a choice to have a nuclear-free future instead.

6.1 A true Energy [R]evolution

The threats posed by nuclear energy and climate change demand nothing short of an Energy [R]evolution, a transformation that has already started as renewable energy markets continue to grow worldwide. At the core of this revolution will be a fundamental change in the way that energy is produced, distributed and consumed.

South Africa is at a critical crossroads making crucial energy choices. New nuclear power plants will lock the country in an outdated, expensive, dangerous and risky energy system based on coal and uranium. But the country has a unique opportunity to learn from historic lessons and distance itself from nuclear energy.

South Africa has massive renewable energy sources, from wind and biomass to some of the best solar resources in the world. Harnessing these resources would not only make a huge contribution to averting runaway climate change, but would also eliminate the need and viability of nuclear energy in the country. The building of new reactors would simply not be justified.

The South African Advanced Energy [R]evolution[133] scenario (a Greenpeace scenario developed in conjunction with the Institute of Technical Thermodynamics at the German Aerospace Centre (DLR), the Dutch Institute Ecofys, the Institute for Sustainable Futures (Sydney) and the European Renewable Energy Council) provides an ambitious and necessary blueprint for how South Africa's energy can be sustainably managed up to the middle of this century. It shows how our consumption of energy can be reduced, while still continuing to develop and provide the same level of energy services.

Renewable energy is mature, ready and can be deployed on a large scale, playing a vital role in providing secure, reliable and zero-emission energy in the future. In fact, if renewable energy is implemented with enough ambition, together with comprehensive energy efficiency measures, South Africa would not have to build one of the biggest coal-fired power stations in the world (Kusile), or 6 new nuclear power stations at all.

Energy efficiency offers some of the simplest, easiest and most cost-effective measures for reducing both greenhouse gas emissions and costs to end-users. South Africa has enormous potential for the country to use energy much more efficiently. An extensive range of energy efficiency measures can substantially reduce demand across industry, homes, business and services.

In addition, the use of decentralised energy systems, where power and heat are produced close to the point of final use, will avoid the current waste of energy during conversion and distribution and increase energy access in South Africa. Building up clusters of renewable micro grids, especially for people living in remote areas, will be a central tool in providing sustainable electricity to the over 2 million households in this country for whom access to electricity is presently denied.

6.2 Towards a renewable future

To achieve a nuclear-free South Africa while reducing the country's dependency on coal, all cost-effective renewable energy sources should be accessed for both heat and electricity generation – these include wind, photovoltaics, solar thermal, geothermal, ocean and hydroelectric power.

The electricity sector needs to be the pioneer of renewable energy utilisation. By 2030, 49% of electricity can be produced from renewable sources, increasing to 94% by 2050[134]. A capacity of 114 GW of different renewable energy technologies can produce 452 TWh of renewable electricity in 2050. A significant share of the fluctuating power generation from wind and solar photovoltaics could be used to supply electricity to vehicle batteries and produce hydrogen as a secondary fuel in transport and industry. By using load management strategies, excess electricity generation will be reduced and more balancing power made available.

The Advanced Energy [R]evolution Scenario describes a major restructuring of energy and transport markets in South Africa. An integral part of the inevitable transition from nuclear and fossil fuels to renewable energy will be ensuring that the overall negative social and economic impacts are kept to a minimum and the opportunities for new employment, investment and innovation are maximised.

This energy transition opens up major new opportunities in skills development, manufacturing and infrastructure development. South Africa should play a leading role in developing renewable energy technologies for Africa. When betting on nuclear energy expansion, the country would require a skilled workforce that is currently not available domestically. In contrast, an energy revolution based on renewable energy technologies will create a green economy based on green jobs for South Africans. Early planning will help ensure that a skilled workforce is ready to deliver South Africa's low-carbon, low-risk future, through a just transition towards a renewable energy-based society.

6.3 Time is up

South Africa needs a much more sustainable society, using existing clean technologies. However, time is not on our side and the transition must begin now. Immediate action is required in making the right choices for South Africa's domestic energy supply. Decisions made today by governments and power utilities will determine power production for decades to come. Nuclear and coal-fired

power plants are incompatible with an energy mix exploiting renewable energy potential. This means that an Energy [R]evolution driven by the creation of green jobs and the creation of a sustainable, clean and low-risk future must be the result of political action taken today.

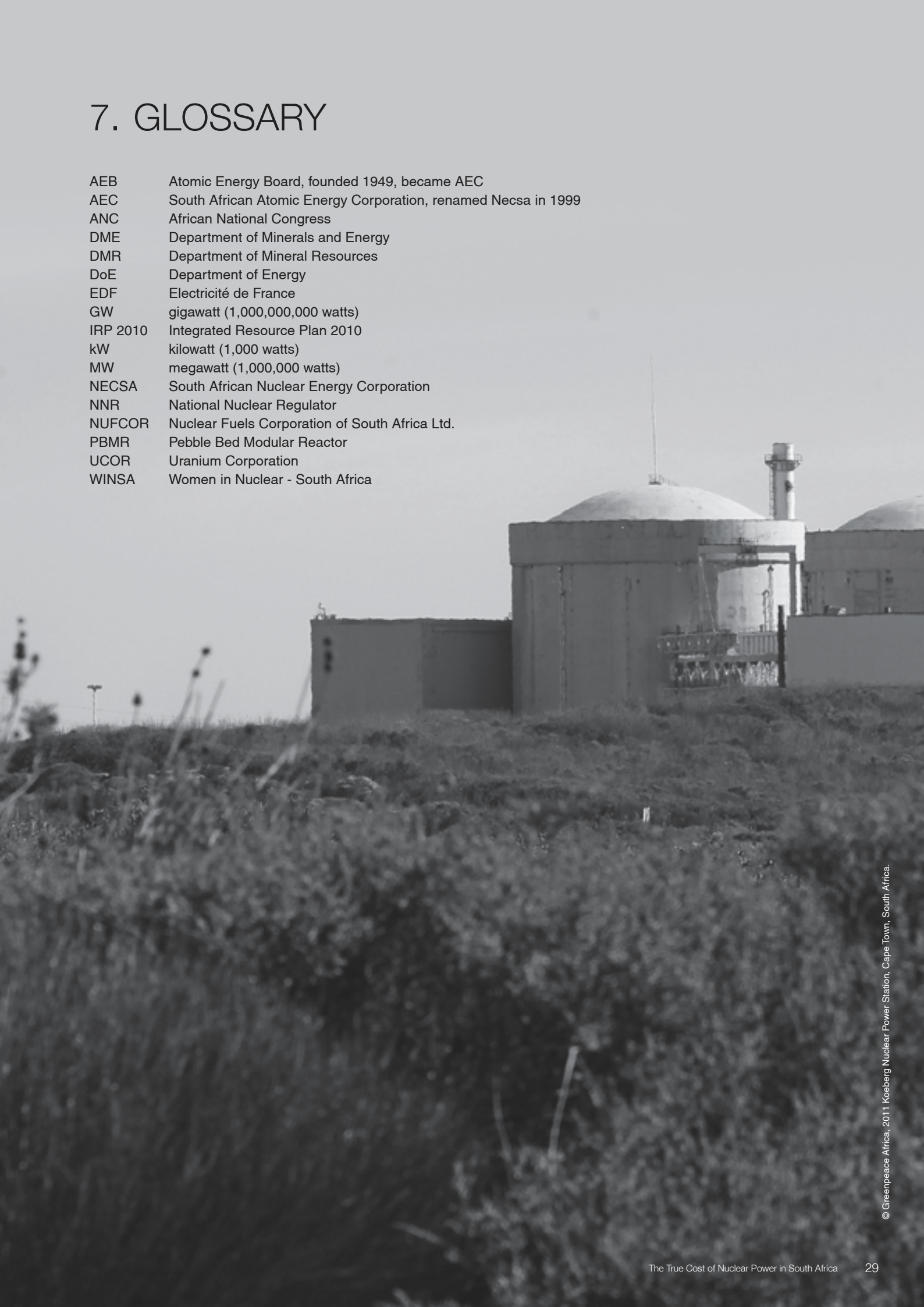
Currently renewable energy is forced to compete on an uneven playing field, as the majority of political and financial support is still enjoyed by the powerful fossil fuel and nuclear industry, and Eskom enjoys a monopoly in the electricity sector. However, this can and must be turned around. With the political will and South Africa's abundance of renewable energy resources, the country could become a renewable energy leader in Africa.

The following policies and actions should be implemented in the energy sector:

1. Phase out all subsidies for fossil fuels and nuclear energy.
2. Mandate strict efficiency standards for all energy consuming appliances, buildings and vehicles.
3. Establish ambitious legally binding targets for renewable energy and combined heat and power generation.
4. Reform the electricity markets by guaranteeing priority access to the grid for renewable power generators.
5. Provide defined and stable returns for investors, for example by effective feed-in tariff programmes.
6. Increase research and development budgets for renewable energy and energy efficiency.
7. Implement better labelling and disclosure mechanisms to provide more environmental product information.
8. Internalise the external (social and environmental) costs of energy production through 'cap and trade' emissions trading.

7. GLOSSARY

AEB	Atomic Energy Board, founded 1949, became AEC
AEC	South African Atomic Energy Corporation, renamed Necsa in 1999
ANC	African National Congress
DME	Department of Minerals and Energy
DMR	Department of Mineral Resources
DoE	Department of Energy
EDF	Electricité de France
GW	gigawatt (1,000,000,000 watts)
IRP 2010	Integrated Resource Plan 2010
kW	kilowatt (1,000 watts)
MW	megawatt (1,000,000 watts)
NECSA	South African Nuclear Energy Corporation
NNR	National Nuclear Regulator
NUFCOR	Nuclear Fuels Corporation of South Africa Ltd.
PBMR	Pebble Bed Modular Reactor
UCOR	Uranium Corporation
WINSA	Women in Nuclear - South Africa



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