Sustainable Energy Briefing 20: Nuclear energy – the powerlessness of power

In South Africa, while the PBMR has been scheduled for shut down at the end of August 2010, government has not ruled out nuclear power. The recent shortages of electricity have exposed the South African government's tunnel vision and shown that it is only concerned about producing large-scale centralised power from coal and nuclear rather than creating a sustainable long-term solution and providing for an equitable investment in renewable energy. Almost R10 billion was spent on the 80-MW Pebble Bed Modulator Reactor (PBMR) without having built even the demonstration model of the proposed nuclear power plant. Contrast this with a 100-MW Concentrated Solar Thermal Power plant with storage, which is estimated to cost about R6-billion. The wasteful expenditure on the PBMR has not deterred government from investing more in nuclear. It is still keen to bid for the Generation-IV Nuclear Plant contract funded by the US Department of Energy.

The purpose of this briefing is to promote discussion and debate on all aspects of nuclear energy, including the declining number of nuclear Reactors, the costs, the technologies being promoted and the extended construction times. It provides a very basic idea of what nuclear energy is about and some of the technologies used. It then delves into the following issues to highlight the main areas of contention when discussion the nuclear solution:

- Waste
- Cost implications
- Sustainability of resource
- Climate change

In addition, the briefing provides an update of what is happening in South Africa in terms of nuclear energy.

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I. The Science of Nuclear Energy

The science of nuclear energy is quite complex. This complexity is often used by the nuclear industry to undermine objections to nuclear energy implying that people object due to ignorance and lack of knowledge. However, the basic concept behind nuclear energy is simple.

Nuclear energy is a form of energy that is produced from splitting a heavy atom such as uranium. U238 is the most common isotope of uranium in nature. This isotope in itself cannot be used in a nuclear reactor and has to undergo an enrichment process to create enough fissile U235 isotopes in the mix. For Koeberg-type Reactors there has to be 3-4% of U235 in the mix, for PBMR 9-10%, for SAFARI-1 90%, and for weapons also 90%. In some Reactors plutonium (breeder Reactors) or thorium can be used. The process of splitting the atom is called fission – hence the term nuclear fission. The splitting of the atom results in the release of neutrons (small sub-atomic particles), which hit other atoms and causes a chain reaction [refer to Figure 1]. It is the energy given off during this process that is then used in a nuclear power station.

In a technical sense, nuclear energy power plants function very similar to coal or natural gas plants - nuclear plants create electricity by boiling water and creating steam[1]. The steam then turns turbines that create electricity. The difference however is that, with nuclear power plants, the energy to create the steam and drive the turbines is from nuclear fission. However, with nuclear power stations, there is a greater need for safety. Nuclear power stations need containment vessels in case there is an accident and require special disposal precautions for the waste. All nuclear Reactors now in commercial operation use nuclear fission.

Indeed this does sound simple enough; however, this "simple" process actually requires vast regulatory and techincal complications for safety reason unheard of in any other form of electricity generation. There are numerous concerns regarding nuclear energy including the radioactive waste, the cost, the reliability of uranium as a resource and its inability to respond to the climate change challenge.

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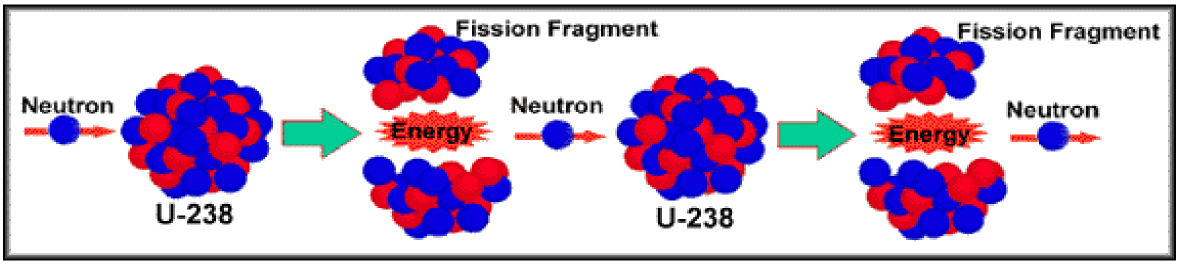
[1] http://www.westinghousenuclear.com/Community/WhatIsNuclearEnergy.shtm

In nuclear fission, the nuclei of atoms are split, causing energy to be released.
The atomic bomb and nuclear Reactors work by fission. The element uranium is the main fuel used to undergo nuclear fission to produce energy since it has many favorable properties. Uranium nuclei can be easily split by shooting neutrons at them. Also, once a uranium nucleus is split, multiple neutrons are released which are used to split other uranium nuclei resulting in a chain reaction.



Fission of uranium 235 nucleus.

[Source: http://library.thinkquest.org/3471/nuclear_energy_body.html]

Figure 1: Fission of uranium 235 nucleus

II. The Technologies being used

The Myth: New technologies will reduce cost, reduce waste and have short construction times.

There are four generations of commercial nuclear plant types that are commonly known and used. Each generation of Reactors was supposed to have been an improved design on the previous one. Generation I were prototype commercial Reactors developed in the 1950s and 1960s. They mostly used natural uranium fuel and used graphite as moderator. Most of these have been decommissioned.

The bulk of the 441 power Reactors in commercial operation worldwide today belong to Generation II. They include Pressurized Water Reactors, Boiling Water Reactors, Gas-cooled Reactors, Graphite Moderated Boiling Water Reactors, Pressurized Heavy Water Reactors and Fast Neutron Reactors.

The nuclear industry is promoting a new generation of Reactors (Generation III and III+). Globally there are around 20 different concepts for the next generation of reactor design, known as Generation III. However, the only Generation III Reactors currently in operation are the Advanced Boiling Water Reactors (ABWR) developed in Japan. By the end of 2006, four ABWRs were in service and two under construction in Taiwan. Other examples of Generation III reactor types include various pressurised water reactor types, the pebble bed modular reactor, boiling water Reactors, heavy water Reactors, gas-cooled Reactors, and fast breeder Reactors.

No Generation III+ plant has yet been completed and only one is under construction. The most widely promoted of these latest designs are the new generation of Pressurised Water Reactors (PWRs) and in particular Areva's European Pressurised Water Reactor (EPR) and the Westinghouse AP1000. The EPR is the only Generation III+ plant under construction, at the Olkiluoto site in Finland and at Flamanville in France (both have run into delivery and cost problems).

Even more speculative are the 'paper' designs for Generation IV plutonium-fuelled Reactors. While several designs are being produced, technical difficulties make it unlikely that they will be deployed for at least two decades, if at all, while the economics of fuel reprocessing also remain unproven. Under the leadership of the US, the "Generation IV International Forum" (GIF) was established in 2000. The GIF also includes Argentina, Brazil, China, Canada, France, Japan, Russia, South Africa, South Korea, Switzerland, the UK, and EURATOM. The development of Generation IV reactor types for commercial deployment will necessarily require huge amounts of financial investments over a period of some decades.

New nuclear reactor types are being promoted with claims that they will produce less nuclear waste than conventional Reactors, reduce weapons proliferation risks, and reduce the risk of serious accidents. While there is certainly scope for considerable improvement on all three fronts, the claims should be treated with some scepticism. It is uncertain whether new reactor types will be developed, with the very large R&D costs being one of the major obstacles. Reactor types with the greatest likelihood of deployment are those which are relatively minor modifications of existing reactor types; as such, any advantages over existing Reactors will be marginal.[2]

III. Nuclear power in the World: A declining industry

The Myth: Nuclear power is the best way to respond to growing energy demands.

While there seems to be quite a bit of industry hype about a new wave of nuclear power for energy use, it seems as if this has not resulted in an increase in nuclear Reactors being built. This is probably due to the time required to build a reactor, the costs and changing government policies. Nuclear energy is on the decline as – most Reactors are close to 'closure' with very few new orders in place.   Mycle Schneider and Antony Froggatt have shown that the world's average reactor is 21 years old, as is the average of the 107 units already permanently retired. Their analysis of reactor demographics found that if the Reactors now operating run for 40 years (32 years under German law), then during the next decade, 80 more will shut down than are planned to start up; in the following decade, 197; in the following, 106; and so on until they're all gone around 2050[3].

Furthermore, Schneider and Frogatt (2008) state "as of December 2007, there are 439 nuclear reactors operating in the world. That is five less than five years ago (see figure 1). There are 34 units listed by the International Atomic Energy Agency (IAEA) as "under construction" – around 20 less than in the late 1990s. In Europe, the number of operating reactors is shrinking rapidly. In 1989, a total of 177 nuclear units were operating in what are now the 27 EU Member States. That number shrank to 146 units as of December 2007, and will decline further by the end of the decade."[4]

In June 2008 the IAEA announced that world nuclear electricity generation had plunged by 2% in 2007[5]. Figure 2 shows that most Reactors startups have been in the seventies and eighties. Reactor shutdowns have been about 5 per year since 1980, with the exception of 1990 which saw 14 shutdowns. Often the USA and European countries are touted as good examples. In the United

[2] http://www.energyscience.org.au/FS15%20Reactor%20types.pdf
[3] M. Schneider, S. Thomas, A. Froggatt, D. Koplow, (2009), World Nuclear Industry Status Report 2009, http://www.bmu.de/files/english/pdf/application/pdf/welt_statusbericht_atomindustrie_0908_en_bf.pdf
[4] Schneider M, Froggat A (2008), 'The Global Nuclear Decline', http://www.chinadialogue.net/article/show/single/en/1602
[5] M. Schneider, S. Thomas, A. Froggatt, D. Koplow, (2009), World Nuclear Industry Status Report 2009, http://www.bmu.de/files/english/pdf/application/pdf/welt_statusbericht_atomindustrie_0908_en_bf.pdf

States, nobody has ordered a new nuclear plant since the 1970s.[6] In addition, a number of the major countries have actual or de facto nuclear phase-out policies, including Sweden, Italy, Belgium, Germany, the Netherlands, Spain, and Switzerland. Unfortuantely, while the policies seem to be in place, phasing-out could take a bit longer. In 2000, the German government announced its decision for the gradual closing down of the country's 19 nuclear power stations by 2020.[7] However, in August 2010 the German Chancellor Angela Merkel backed an extension of nuclear power lifespans to run for another 10 to 15 years[8].

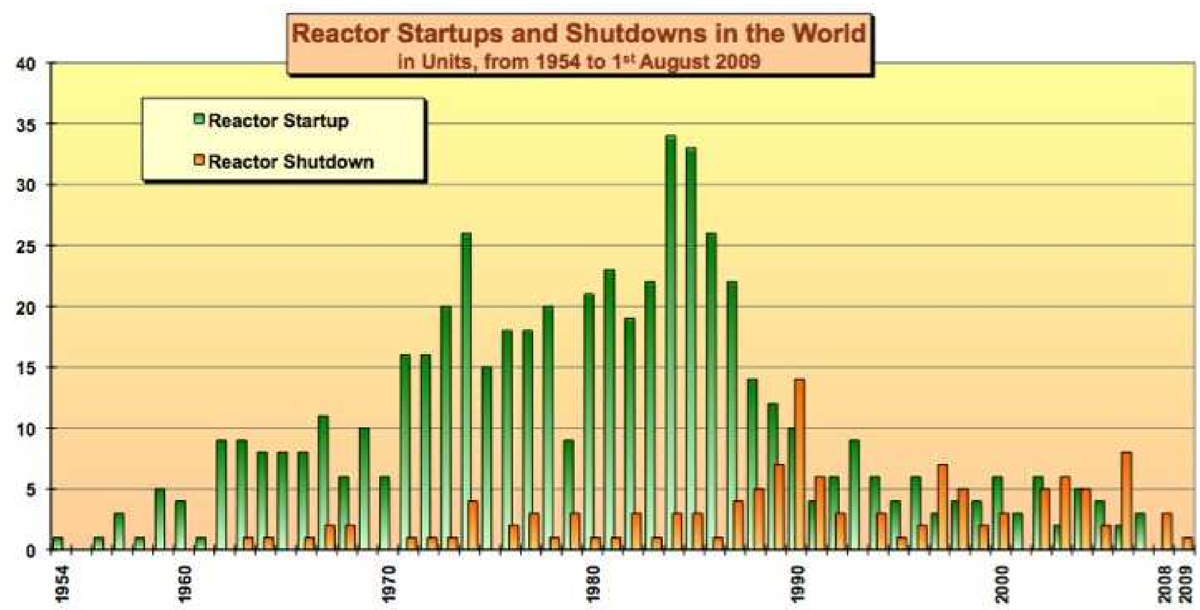


Figure 2: Reactor startups and shutdowns in the world [Source: M. Schneider, S. Thomas, A. Froggatt, D. Koplow, (2009), World Nuclear Industry Status Report 2009]

The declining nuclear industry worldwide means that there is a greater need for the nuclear industry to build Reactors in order to survive. Thus the position that nuclear energy can be the panacea for climate change has to be viewed with a fair amount of cynicism. The most sensible conclusion to be made is one made at the Nucleonics Week of the European Commission meeting about "Nuclear in a changing world" (October 1998), **"Nuclear may need climate change more than climate change needs nuclear."**

IV. Waste not want not!

The Myth: Nuclear waste is not dangerous if handled properly

Often when nuclear energy is discussed, it is only the waste at the end of the fuel cycle that is seen

[6] Mathew Wald (2005), http://www.nytimes.com/2005/09/14/national/14nuke.html?_r=1
[7] **'Germany renounces nuclear power',** http://news.bbc.co.uk/2/hi/europe/791597.stm
[8] 'State Positions on Nuclear plants', http://www.reuters.com/article/idUSLDE67Q13N20100830

as a threat. However, the creation of nuclear energy involves various industrial processes, each of which has a specific hazardous potential. It starts with the dust in uranium mines, continues with potential and actual radioactive threats in the normal operation of a plant, includes accidents and exposure for workers in the nuclear facilities or people living nearby, and ends with the possible contamination of groundwater and soil in a final repository for radioactive waste[9].

Radioactive waste can be classified according to radiological properties (quantity and type of radioactivity), physical properties (form in which the material occurs, i.e. gas liquid or solid) and also whether it is heat producing or not. Radioactive waste emits energy in the form of radiation. This energy appears as alpha, beta and gamma radiation. Radioactive waste is categorised according to the hazards associated with the different waste types. Low-level waste poses a smaller hazard while high-level waste is potentially dangerous and needs to be properly contained and shielded.[10]

Radioactive waste can cause genetic modifications and cancer diseases and, thus, poses a danger to humans and the environment. Therefore, radioactive wastes have to be isolated from nature and safely managed. For example, uranium miners - in Canada, the USA, Namibia and Sweden - breathe radon which is derived from uranium. This gets into their lungs where it emits 'alpha particles' which can cause lung cancer[11].

During the mining of natural uranium (U238), there are a few ways in which radiation is leaked into the environment. One way is through the residue from the milling process, which results in the uranium mill tailings. Interestingly the largest uranium mill tailings dam worldwide probably is that of the Rössing uranium mine in Namibia - it contains more than 350 million tons of tailings. Furthermore, large volumes of contaminated water are pumped out of the mine and released to rivers and lakes, spreading into the environment.[12]

"The question of whether radioactive waste can be safely isolated from the biosphere for hundreds of thousands or millions of years is ultimately philosophical. It defies human imagination." [http://www10.antenna.nl/wise/index.html?http://www10.antenna.nl/wise/644/7.php]

In a nuclear reactor, U238 has to be enriched to produce U235. In natural form uranium ore is only about 0.7% 235U. It must be enriched to bring the percentage of 235U up to about 4%. The enrichment process produces a lot of waste. This is because for every gram of enriched uranium fuel produced, there are about 4 grams of U238 waste. U238 is radioactive and has a half-life of 4,468,000,000 years. This means that it is long-lived. However, some of its "daughter

[9] Jürgen Kreusch, Wolfgang Neumann, Detlef Appel (Chapters 1 And 3), Peter Diehl (Chapter 2) (2005), 'Nuclear Fuel Cycle', Nuclear Power: Myth and Reality, Heinrich Boll Foundation
[10] http://www.necsa.co.za/Necsa/Nuclear-Technology/Nuclear-Waste-442.aspx
[11] www.foe.co.uk/resource/briefings/nuclear_power_climate.pdf
[12] Jürgen Kreusch, Wolfgang Neumann, Detlef Appel (Chapters 1 And 3), Peter Diehl (Chapter 2) (2005), 'Nuclear Fuel Cycle', Nuclear Power: Myth and Reality, Heinrich Boll Foundation

products" are radioactive. Thus, wastes produced as a result of enrichment must be kept in storage. By the way, a "daughter product" is an isotope that results from a decay of another, "parent", isotope. For example, when 238U decays, it produces 234Th, which is very radioactive and has a half-life of about 24 days.

The half-life of an element is the time it will take for the radioactivity in the substance to diminish by 50%. That means it will take 4,468,000,000 years to reduce the intensity of uranium 238 by 50%.

According to Friends of the Earth International, "nuclear power stations release radiation deliberately into the skies and surrounding waters routinely. This is despite the fact that it is known that no safe level of radiation exists. FoEi highlights that according to the International Commission on Radiological Protection whose judgements are used as the international standard on radiation: "*It is assumed that there is no threshold for the induction of the molecular change at specific DNA sites involved in the initial events that result in malignant transformation and ultimately cancer.*"

Given the dangers of radioactive waste, it is thus terrifying that nuclear waste will remain radioactive for thousands of years. While countries claim to be very cautious when dealing with waste, the secrecy within the industry makes it difficult to keep track of the impacts when things do go wrong. The industry claims that nuclear energy is safe and that major disasters such as the explosion and fire of the Chernobyl nuclear plant are rare. While this may be true there are often incidents that are not publicised as much. In 1999, an accident at the Japanese uranium processing plant at Tokaimura exposed fifty-five workers to radiation. More than 300,000 people living near the plant were ordered to stay indoors. Workers had been mixing uranium with nitric acid to make nuclear fuel, but had used too much uranium and set off the accidental uncontrolled reaction. In April 2005, at Sellafield nuclear reprocessing plant in the UK, 20 tons of uranium and 160kg of Plutonium leaked from a cracked pipe onto a floor and lay undetected for three months[13]. [A nuclear bomb with the yield of the Nagasaki bomb could be manufactured with a couple of kilograms of plutonium].

In addition, the manner in which the waste is disposed of is a subject for debate. There have been claims that there is illegal dumping of waste in developing countries. In 2007, authorities in Italy investigated a mafia clan of trafficking nuclear waste and trying to make plutonium[14]. The Ndrangheta mafia was accused of making illegal shipments of radioactive waste to Somalia. The mafia clan worked with eight former employees of the state energy research agency (Enea) who were suspected of paying the mobsters to take waste off their hands. An Enea manager is said to have paid the clan to get rid of 600 drums of toxic and radioactive waste from Italy, Switzerland, France, Germany, and the US.

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13 ' Leak spills 20 tonnes of uranium', http://news.bbc.co.uk/1/hi/england/cumbria/4559771.stm
14 'From cocaine to plutonium: mafia clan accused of trafficking nuclear waste',

So in effect, we are just leaving this dangerous waste for future generations to solve. Even if there are major advances in technological development, the issue of radioactive waste will still be one of the major concerns around nuclear energy. In reality there are no fool-proof methods for storage of high-level waste, and industry has not provided a sufficient solution to isolate the radioactive materials for the time-scale that is necessary.

V. The World's Nuclear Resources

The Myth: There is sufficient Uranium for centruries and new technologies will further reduce the amount of Uranium required

Notwithstanding the waste, nuclear power is just not sustainable. Not only does it take many years to develop a nuclear power station but Uranium (the energy source for nuclear power) is in short supply. It is believed that the supply of Uranium is estimated to last for only 80 years depending on the demand[15] and improved technology could extend the lifespan of Uranium. So in the short to medium term the technology may be available but in the long term it will also be subject to fluctuations. The reality is that Uranium is a non-renewable resource.

Furthermore, there are only a couple of countries, namely Canada and South Africa, which are not dependent on uranium imports. Figure 3 illustrates the available uranium around the world. The main countries that use nuclear power either have essentially no uranium production of their own (France, Japan, Germany, South Korea, Great Britain, Sweden, Spain) or considerably smaller capacities than would be needed to sustain the operation of their Reactors over the long term (USA, Russia). It just does not make business sense to invest billions into something that has such a short life span and that will be such a liability to the environment.

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http://www.guardian.co.uk/world/2007/oct/09/italy.nuclearpower

[15] http://www.world-nuclear.org/info/inf75.htm

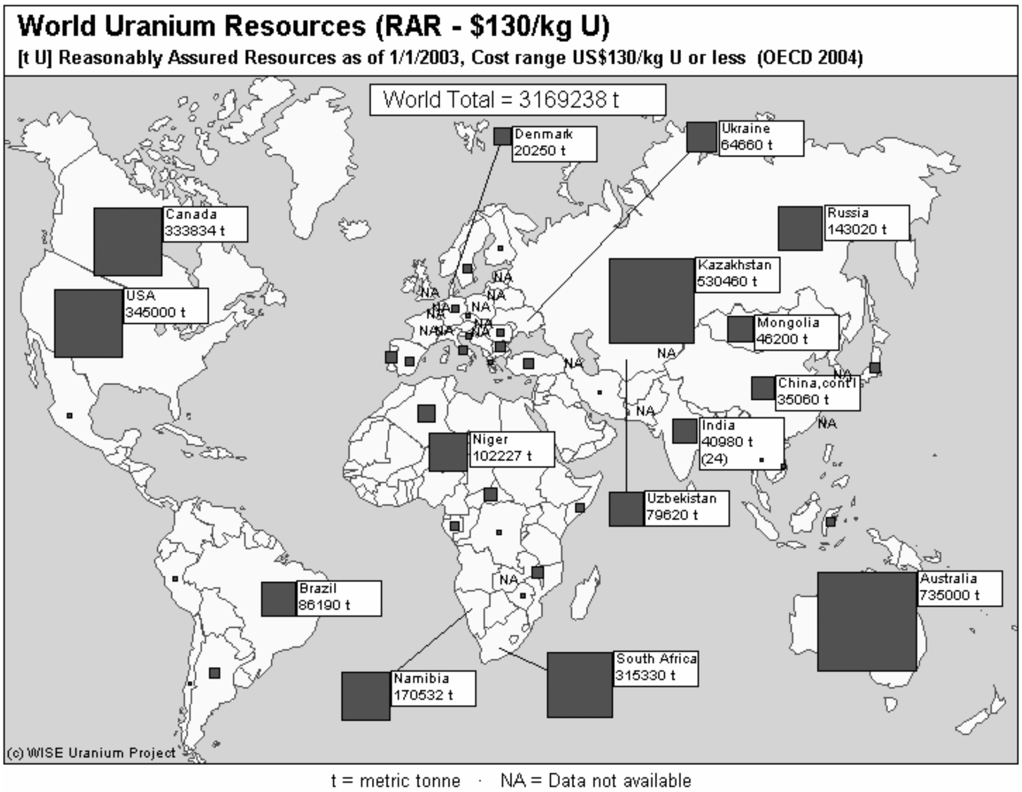

Figure 3: World Uranium Resources [source: *Nuclear Power: Myth and Reality*, Heinrich Boell Foundation]

Proponents for nuclear energy suggest that the shortage of mined uranium is not a problem. Breeder Reactors and recovering uranium from seawater are seen as viable options. A breeder reactor is built with a core of fissionable plutonium, Pu-239. The plutonium-239 core is surrounded by a layer of uranium-238. As the plutonium-239 undergoes spontaneous fission, it releases neutrons. These neutrons convert uranium-238 to plutonium-239. In other words, this reactor breeds fuel (Pu-239) as it operates. After all the uranium-238 has been changed to plutonium-239, the reactor is refuelled. However, plutonium-239 is extremely toxic and adds to the problem of waste.

In addition, it is suggested that new technology allows for the extraction of uranium from seawater. However, the recovery cost is estimated to be 5-10 times of that from mining uranium.

VI. Buy now, pay later?

The Myth: Nuclear energy is a low-cost alternative

One of the major reasons why nuclear power will not be favoured against renewables and energy efficiency is that it is far too expensive to consider realistically. According to Lovins (2005)[16],

[16] Amory B. Lovins (2005), **Nuclear power: economics and climate-protection potential,**

nuclear power's bad economics make it unfinanceable in the private capital market. The World Bank will not even provide loans for nuclear energy. The costs for nuclear energy persist long after the plant has ceased operation. These include disposing of radioactive waste, guarding closed Reactors, and ultimately decommissioning the Reactors following a more or less lengthy "cool-down" period.

Lovins (2005) [17], states that official studies compare new nuclear plants only with coal- or gas-fired central stations. All of which are uncompetitive with windpower and some other renewables, combined-heat-and power (cogeneration), and efficient use of electricity. Nuclear is expensive even if the externality costs are not taken into account - such as cleaning up the uranium mine, the uranium waste in mine dumps, the costs of the final dumps, and the massive decommissioning costs.

In practice, keeping nuclear power alive means diverting private and public investment from the cheaper market winners—cogeneration, renewables, and efficiency. As such nuclear power can only survive through subsidies. According to a study by Citibank the costs of constructing a new nuclear power plant range between 2,500 to 3,500 euros (3,420 US dollars) per kilowatt hour. The study further states that for an average 1,600 megawatt (MW) unit construction costs could be as much as 5.6 billion euros (7.6 billion US dollars).[18]

The PBMR in South Africa is a good example of a project that would not have survived as long as it did without public funding. By 2002, the total amount that had been spent on the PBMR was R684.2m and forecast that the total amount to take the project to the end of the feasibility stage (then expected at end 2002) would be R1013m of which R461m would be provided by Eskom. However, in August 2003, the PBMR development had cost R1.5bn of which R550m had come from Eskom, In October 2004, the government announced support of up to R500m for the PBMR venture to pay for running costs for the company and design development costs (turbine development and construction of a helium test facility were mentioned as particular requirements[19]. By August 2010, the project had been shut down with almost R10 billion spent and nothing to show for it. It is estimated that most of which was South African public money. David Fig (2010) quotes from a presentation by the CEO of the PBMR company, that illustrates almost 83 per cent of the investment in the PBMR company was made by the state. David Fig (2010) further states that "since 2004, most of the funds devoted to the company came straight from the taxpayer."[20]

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www.rmi.org

[17] Amory B. Lovins (2005), Nuclear power: economics and climate-protection potential, www.rmi.org

[18] 'Nuclear Does Not Make Economic Sense Say Studies', http://ipsnews.net/news.asp?idnews=50308

[19] Steve Thomas (2005), The Economic Impact of the Proposed Demonstration Plant for the Pebble Bed Modular Reactor Design

[20] David Fig (2010), 'Nuclear energy rethink? The rise and demise of South Africa's Pebble Bed Modular Reactor', ISS Paper 210, April 2010

In South Africa it is believed that costs of establishing a nuclear reactor have gone up 6-fold in 8 years. Eskom is well aware of this and should it continue to embark on a nuclear route, its credit rating would go down raising prices to consumers.

Some would like to argue that the costs are coming down with new technology, such as "Generation IV" and nuclear is supposed to be more economical, and smaller. According to Thomas (2005)[21] the first Reactors of this series are supposed to start providing electricity around the year 2030. However, even some of the more prominent backers do not expect commercial operation to start "until 2040 or 2045". Such delays increase the costs and thus the true cost of nuclear is not adequately calculated. For example, the construction of two Gen III+ Reactors - one in Finland and one in France – are both behind schedule and over budget. In Finland, construction is four years late and 85% over budget. Flamanville (France) is two years late after 2.5 years construction and 50% over budget.

While the costs for a nuclear reactor keep rising alternative energies such as wind and solar have been declining. First Solar's system in the Nevada desert (USA) can generate 12.6 megawatts of power in direct current, which is then converted to alternating current to feed the electric grid. The plant costs $0.075 per kilowatt hour to install without any subsidies.[22]

VII. Nuclear energy the answer to climate change, or not?

The Myth: Nuclear energy is the quickest way to respond to Climate change.

Climate change is one of the biggest environmental catastrophes facing the world. It is accepted that the world needs to reduce its greenhouse gas (GHG) emissions as fast as possible. Electricity generation is a major source of GHG emissions. As such, tackling global warming means that alternate ways of producing and using electricity must be developed. However, in our attempt to find a solution to climate change, it is imperative to be mindful of the cost effectiveness of alternatives to fossil fuels and the cost of their environmental impact.

As discussed, there is a global decline in the nuclear industry and the growing debate on climate change has succeeded in placing the debate on nuclear energy back on the global agenda. The position is that nuclear energy is quick and has zero greenhouse gas emissions. Both of which are untrue.

According to Lovins (2005)[23] if you are concerned about climate change, it is essential to buy the fastest and most effective climate solutions. Nuclear power is just the opposite. Given the long

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[21] Steve Thomas (2005), "The Economics of Nuclear Power", Nuclear power: Myth and reality, Heinrich Boll Stiftung

[22] First Solar Reaches Grid-Parity Milestone, Says Report http://www.greentechmedia.com/articles/read/first-solar-reaches-grid-parity-milestone-says-report-5389/

[23] Amory B. Lovins (2005), Nuclear power: economics and climate-protection potential, www.rmi.org

planning, construction lead times and constant delays, it would be between 10-15 years or so before any new power stations will be ready to work - even if the decision to go ahead was taken today.

Furthermore, Greenpeace [24] points out that currently, around 441 nuclear power stations provide approximately 15 % of the global primary energy mix. If this figure is doubled, a corresponding number of new nuclear power stations would have to be built in the coming years. The available uranium resources, the construction times and exorbitant costs of nuclear, makes nuclear energy an unlikely solution to respond to climate change quick enough. The United Kingdom's Sustainable Development Commission confirmed in 2007 that the full fuel cycle of nuclear power generation is fossil fuel intensive and emits large amounts of greenhouse gases. The mining, milling, processing, conversion, enrichment and transportation of uranium fuel for Reactors are all carbon-intensive industries[25]. The construction and decommissioning of the plant after use are also very carbon-intensive. Emissions associated with nuclear power plants make nuclear power a more polluting alternative, when compared to electricity saving, cogeneration or renewable energies. In comparison to renewable energy, nuclear power releases 3-4 times more CO2 per unit of energy produced taking account of the whole fuel cycle.

Greenpeace asserts that the nuclear industry's disingenuous claims to a role in alleviating climate change must be rejected for what they are: dangerous and self-serving fantasies which would create a serious legacy of deadly radioactive waste, increase the risks of catastrophic nuclear accidents and also vastly increase the threat of nuclear weapons proliferation[26]. In addition, it states that nuclear energy is not the cheapest of the non-fossil fuel alternatives; nor is it the cleanest. A host of renewable technologies have outstripped nuclear power in development and performance, while energy efficiency measures remain the most cost effective way to address the need for new power.[27]

It is the opportune time to focus on renewable energy, energy efficiency and decentralised power supplies. A WWF (South Africa) study[28] suggests that a renewable energy target of 15% for 2020 is possible. It further states that renewable energy "comprising wind and solar thermal energy, particularly if combined with partner programmes such as an energy efficiency programme, will provide significant greenhouse gas mitigation, together with air quality, health and ecosystem service co-benefits to South Africa" [29].

Furthermore, a study conducted by Agama Energy in 2005, illustrated that renewable energy and energy efficiency can contribute to direct employment benefits. Figure 4 shows the rates of job

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[24] http://archive.greenpeace.org/comms/no.nukes/nenstcc.html
[25] http://www.ngopulse.org/press-release/seccp-nuclear-energy-not-viable-response-climate-change
[26] http://archive.greenpeace.org/comms/no.nukes/nenstcc.html
[27] http://archive.greenpeace.org/comms/no.nukes/nenstcc.html
[28] '50% by 2030: Renewable Energy in a Just Transition to Sustainable Electricity Supply' (2010), World Wildlife Fund South Africa
[29] '50% by 2030: Renewable Energy in a Just Transition to Sustainable Electricity Supply' (2010), World Wildlife Fund South Africa

creation, shown per unit of installed generation capacity and against electricity despatched.

Conventional energy technologies	Direct jobs per		Renewable energy technologies	Direct jobs per	
	MW capacity	GWh generated		MW capacity	GWh generated
Coal (current)	1.7	0.3	Solar Thermal	5.9	10.4
Coal (future)	3.0	0.7	Solar PV	35.4	62.0
Nuclear	0.5	0.1	Wind	4.8	12.6
Nuclear PBMR	1.3	0.2	Biomass	1.0	5.6
Gas	1.2	0.1	Landfills	6.0	23.0

Figure 4: Agama Energy figures on job creation with RE [Source: 50% by 2030: Renewable Energy in a Just Transition to Sustainable Electricity Supply' (2010), World Wildlife Fund South Africa]

The notion of job creation through renewable energy was reiterated by a separate study conducted by Greenpeace SA that suggests renewbale energy could be a major employment creator in South Africa, creating 78,000 direct jobs and thousands of other indirect jobs in less than 20 years.[30]

The one argument always used by the coal and nuclear power industry is that renewable energy will not be able to meet baseload electricity supply. WWF-SA states that baseload demand is a product of how the whole electricity supply system is designed and managed and should be addressed through comprehensive integrated energy planning. It is not an impossible task to have a reliable baseload without coal or nuclear. WWF-SA[31] points out that Concentrating Solar Power (CSP) is just one way in which renewable energy can provide baseload supply by incorporating sufficient thermal storage. A CSP plant with thermal storage and gas co-firing would generally be more efficient, and far more cost-effective than separate solar and gas plants.

30 http://www.greenpeace.org/africa/en/News/news/How-to-create-South-African-jobs--and-save-the-climate/
31 '50% by 2030: Renewable Energy in a Just Transition to Sustainable Electricity Supply' (2010), World Wildlife Fund South Africa

VIII. Nuclear Power in South Africa

The Myth: Nuclear and coal-fired power are the best solutions to providing safe and reliable energy for the country.

The nuclear industry in South Africa dates back to the mid-1940s. In 1959, the government approved the creation of a domestic nuclear industry and planning began the next year on building a research reactor, in cooperation with the US Atoms for Peace program. It was as early as the mid-1970s that a decision was taken to build 1800 We of nuclear capacity at Koeberg near Cape Town[32]. The country's nuclear capacity in the 70s and 80s opened the doors for a uranium enrichment programme that was used for the proliferation of nuclear weapons. The weapons programme was dismantled in 1990.

In 1999, the government started its work on the Pebble Bed Modular Reactor (PBMR). Almost R10 billion has been spent on the PBMR company – which has recently been shut down with no reactor to show for it.

The electricity crisis in South Africa in 2008, prompted the Eskom board to approve a plan to double generating capacity to 80GWe by 2025, including construction of 20 GWe of new nuclear capacity (could be about 10 nuclear plants) so that nuclear contribution to power would rise from 5% to more than 25% and coal's contribution would fall from 87% to below 70%. The new programme would start with up to 4 GWe of Pressurised Water Reactor (PWR) capacity to be built from about 2010, with the first unit commissioned in 2016. The environmental assessment process for the so-called 'Nuclear-1' project considering five sites, and selection of technology was to follow in 2008. However, in December 2008, Eskom announced that it would not proceed due to lack of finance.

Unfortunately, the delay in nuclear plans has not been for reasons such as reconsidering the sustainability of nuclear-based electricity. It is clear that government's commitment to the future of nuclear energy is strong, but restricted due to financial constraints. Often the argument used is that the country will experience severe shortages if there isn't a large enough baseload – which it is claimed that only coal and nuclear can provide. However, moving away from large centralised power to smaller decentralised wind or solar farms could counter this argument.

While the benefits of renewable energy and energy efficiecny has continually been pointed out to government, the focus has still been on coal and nuclear. Eskom plans spending R385 billion (around US$ 50 billion) on new capacity – mainly coal- and gas-fired plants, as well as on returning

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[32] http://www.world-nuclear.org/info/inf88.html

mothballed coal-fired stations to service. Eskom says the country needs 40 GWe of new generation by 2025, doubling its total capacity to 80 GWe. About half of the new capacity was intended to be nuclear, but this is now in doubt given the financial constraints facing government.

IX. Conclusion

While Earthlife Africa has repeatedly published information on why nuclear energy is not the wisest and most sustainable option for South Africa, the renewed focus on nuclear energy warrants a stronger, louder NO! The sale of nuclear as being the panacea to tackle climate change is dishonest. As stated, climate change requires a fast response to reduce GHG emissions. Nuclear energy takes many years to build with very high costs. Often both of these result in long delays and huge cost overruns.

Technologies such as Generations III, III+ and IV have not assisted with reducing costs nor speeding up development times. After more than half a century the world still has not found a better way to deal with radioactive waste.

The world needs to learn from previous mistakes, focusing on another non-renewable, dangerous resource of energy will just bring us back to where we are now – but only the next time, we will have a lot more waste, damaged water and soil resources to contend with.