Technical Workshop on the Economics of Nuclear Energy: 9 March 2016, Johannesburg

On the 9th of March 2016, the World Wide Fund for Nature (WWF-SA), the Heinrich Böll Stiftung (HBS), the Centre for Renewable and Sustainable Energy Studies (CRSES) and the Goedegedacht Forum hosted a small technical workshop on the Economics of Nuclear Energy in Johannesburg. The purpose of the workshop was to interrogate some of the critical unknowns regarding South Africa's proposed nuclear programme in a small and open discussion with some of the country's leading thinkers on energy policy, nuclear energy and economics.

Key note presentation: Mycle Schneider

Mycle Schneider, an international energy and nuclear policy analyst and the convening lead author and publisher of the World Nuclear Industry Status Report, began the workshop by giving an overview of the status of nuclear energy globally as well as economic trends in the industry.

Key points from Schneider's presentation:

1. The nuclear industry globally remains in decline.
2. There has been a downward trend in reactor start-ups.
   - The majority of new start-ups have been in China.
   - If we exclude China, there is a levelling off from the heights of the 1990's to a full decline in 2011 post-Fukushima.
   - There have been no new start-ups in the European Union (except Romania) or in the US.
3. The relative share of nuclear electricity production in the world peaked in the mid-1990s at 17.6% and declined to less than 11% in 2014.
4. Construction starts from the 2000s have been very low, compared to the 1970s, especially if you exclude China. Even China has slowed construction.
5. Around 40 new plants have come online between 2005 and 2015 - around 4 units per year.
6. The construction time for nuclear plants has increased. The average construction time for 40 units, which started-up between 2005 and July 2015, was 9.4 years.
7. The argument that although the CAPEX for nuclear plants is high, the OPEX is low does not hold true. There are a number of examples in the US and Sweden of reactors that have been taken offline for economic reasons – the costs of operating them was too high. This is not a post-Fukushima phenomenon – nuclear energy was in decline before that. There are a number of reasons for this, including:
   - Operating costs have increased;
   - Low wholesale prices in the power market;
   - Shrinking client base;
   - Stagnating demand.

Download Schneider's presentation at:

http://awsassets.wwf.org.za/downloads/mycle_schneider___the_world_nuclear_industry_status_report_2015_pdf.pdf

Panel One: Energy Planning, the IRP and the Necessity of Nuclear:

The first panel was opened by Professor Anton Eberhard from UCT. Professor Eberhard's presentation can be downloaded at:

http://awsassets.wwf.org.za/downloads/prof_eberhard___nuclear_energy_does_south_africa_need_more_pdf.pdf

South Africa's future electricity demand: Much of the panel discussion focused on South Africa's projected electricity demand. It was noted that that our current demand was far below the lowest forecasts for 2014 and that the current levels for peak demand were last seen in 2005. It was agreed that we are unlikely to see a return to high demand in the near future.

It was noted that historically electricity demand has tracked GDP growth. In many emerging economies it's a 1 to 1 relationship, but in SA GDP growth and electricity demand began decoupling in 2007, partly due to the changing shape of the economy and partly due to other factors such as tariff increases and energy efficiency. This makes it more difficult to predict future electricity demand. Nevertheless, some modelling suggests that we will likely need between 12-27GW of additional capacity by 2027. Considering that we have already committed to significant additional capacity – 16 GW of dispatchable power from Medupi, Kusile and others and 8GW of non-dispatchable power from RE - the question is "do we really need 9.6GW of nuclear energy?"

Panellists agreed that we need to start focusing on the type of capacity that we need. In the short-term, we will require more flexibility in order to balance renewables. It was also noted that energy forecasting has focused on historical facts rather than on future economic possibilities. We need to start looking at what the economy will look like in 2030 and ask if nuclear fits that model.

The question of the IRP and where government was in the process of updating it was raised. It was pointed out that the 2010 IRP projected aggressive demand growth of around 2-3% per year which no longer reflects the position we find ourselves in today. This highlights the importance of regular IRP updates. Nevertheless, it was noted that work on the IRP 2015 was well underway and was being undertaken by a very competent team overseen by the Department of Energy.

It was also noted that key government departments and policy documents warn against pursuing the nuclear programme. The National Planning Commission (NPC) and the National Treasury have raised questions around the affordability and necessity of nuclear energy. The IRP 2013, which was never gazetted, also warned that the decision to build nuclear can be delayed if economic growth is not high and demand is less than originally anticipated.

The nuclear programme is not a solution to the current electricity crisis: It was noted that the nuclear discussion is being linked to the current crisis and that the electricity crisis is being used as a reason to justify the nuclear programme. It was argued that this is incongruous because it will take at least 15 years for the first nuclear reactor to come online. Nuclear is therefore not a solution to our immediate supply challenges.

Small modular nuclear energy may be worth investigating in the future: It was suggested that small modular nuclear energy may hold potential because it mitigates the risks of cost overruns, construction delays etc associated with large, lumpy projects. However, industry has yet to demonstrate the potential of small, modular, standardised, off-the-shelf nuclear solutions.

Presentation by Tara Caetano (UCT ERC): Study on "South Africa's Proposed Nuclear Build Plan: An Analysis of the Potential Socioeconomic Risks"

Tara Caetano presented the finding of UCT's Energy Research Centre's newly launched study into the socio-economic implications of South Africa's proposed nuclear programme. Caetano's presentation can be downloaded at:

http://awsassets.wwf.org.za/downloads/tara_caetano___potential_socioeconomic_risks_of_the_nuclear_build_plan_pdf.pdf

Panel Two: The Cost of Nuclear for South Africa and Financing Options

The second panel was opened by Dr Dawid Serfontein from the North West University. Dr Serfontein's presentation can be downloaded at:

http://awsassets.wwf.org.za/downloads/dr_serfontein___the_impact_of_intermittency_costs_on_the_role_of_nuclear_power_within_th.pdf

The financing of nuclear energy in South Africa: The panel interrogated how South Africa could finance the nuclear programme if it chose to follow this path. It was generally accepted that South Africa did not have the money to finance the programme. It was noted that the South African economy is contracting and that it has reached its limit on sustainable debt. The real possibility of downgrades by rating agencies poses a serious threat of cuts by government, which will impact ordinary people in the form of pension and salary cuts etc. Furthermore, considering that South Africa was struggling to afford diesel for generators and to fund the construction of Medupi and Kusile, it simply could not afford to invest in nuclear.

The panel agreed that if South Africa were to pursue the nuclear programme, it would have to look elsewhere for funding. Most agreed that it was highly unlikely that SA would be able to secure private capital from abroad to fund the nuclear programme. There is currently a liquidity problem in the market and banks simply will not fund nuclear.

The panel agreed that the most plausible financing option for South Africa would be financing deals (a mix of vendor and development funding) from Russia or China for example, but that these came with a number of risks. First, vendors could not finance the programme because they could not afford to take on the risk. Financing would have to come from vendor governments and the SA government would be required to give a sovereign guarantee on that debt. The SA government would need to underwrite any stop work orders or potential catastrophes. South Africa would also have to underwrite the foreign exchange exposure for 60 years and manage the volatility of balance of payments over this period. This is a huge risk for any country.

Finally, it was noted that the global nuclear industry itself is under financial pressure. Russia's Rosatom has been downgraded to junk status, EDF's Chief Financial Officer has recently resigned purportedly over Hinkley C and China's General Nuclear Power Corporation (CGN) was in bad shape. The CGN lost 60% of their share value in the last six months. Toshiba's Westinghouse was found to be faking accounts.

Treasury's position on nuclear energy: It was noted by one of the panellists that two reports by Treasury which were presented to Cabinet make it clear that the nuclear programme is not viable and that unless we could guarantee 70% local finance, there was no way South Africa could afford nuclear.

The costs of decommissioning nuclear plants: The panel interrogated the costs of decommissioning and if and how these costs are included in the overall costs of nuclear energy. It was noted that generally, decommissioning costs are said to be around 15% of overnight costs. This is not a set number and obviously varies from plant to plant. It will depend on a number of factors including the overnight costs of the particular plant and the timing of decommissioning. Importantly, there were no examples globally of plants that have been fully decommissioned and against which full decommissioning costs could be benchmarked. There are a few figures of what decommissioning is expected to cost some plants, but again these are not the full decommissioning costs because a key cost is the continued containment of plutonium. For example, the Wylfa Nuclear Power Plant in Wales is being decommissioned at a price of 756 million pounds according to *The Guardian.* In France, the cost estimate has been increased to a factor of 20, and is currently standing at half a billion Euros.

The sensitivity of the timing of decommissioning was emphasised as a key component of the decommissioning cost. The problem of early decommissioning was highlighted. For example, Eskom should have a fund that they are adding to so that when Koeberg reaches 60 years they have sufficient funds to cover the 15% of overnight costs (with inflation). If it were to be decommissioned 20 years earlier – would Eskom have the funds available? This is not a theoretical question – early shutdowns are being seen in countries like Sweden and in the USA.

It was also noted that when decommissioning costs are built into electricity sales, they are usually not set aside. It was suggested that the decommissioning costs for Koeberg are not being put aside

and that the money recovered for decommissioning is being invested in things like education and health with the aim to grow the economy and claim the money back in time.

Electricity demand: The question of South Africa's future electricity demand was also raised. It was noted that South Africa is at a tipping point where many smelters are standing idle due to high electricity prices and that there is a real possibility that this trend will continue. Based on this uncertainty most of the panellists agreed that there might be a role for nuclear energy in South Africa's future, but that it would not be required before 2030 and Government should not rush into the procurement now.

France's nuclear future: It was noted that France has committed to reduce nuclear energy in its energy mix to 50% by 2025 from the 75% which it currently represents. However, no timelines have been set in the legislation and there are no directives as to which plants should be taken off line. This is currently the subject of heated negotiations between companies and government.

Panel Three: Nuclear Procurement

The third panel was opened by Dr Edwin Ritchken. Dr Ritchken's presentation can be downloaded at:

http://awsassets.wwf.org.za/downloads/dr_ritchken___nuclear_procurement_pdf.pdf

Cost escalation and international experience with the EPR: One panellist described the construction experience with EPR reactors (European Pressurised Water Reactor). He noted that EPR constructions have been mired by delays and cost overruns. For example, the 2005 Finland plant (which was meant to be a turnkey project), was initially expected to cost 2-2.5 billion Euro per reactor but is now expected to cost around 8 billion and this is not the final figure. Flamanville in France is another example of major delays and cost overruns. Construction begun in 2007 and both reactors are scheduled to come online in 2018 – the date for connection has been repeatedly pushed back. The 9 year delay in bringing Flamenville online has been a key driver of cost overruns which is now expected to cost around ten billion Euros.

Steps taken to date by the Government in the procurement process: One of the panellists described South Africa's movements to date on the nuclear energy programme. Having gone to market in 2008, it was realised that the original estimate given was half the price being offered in the market. For this process we allocated R200 million which does not include the opportunity cost of experts' time. When government gets to the point of asking for Requests for Proposals (as opposed to Requests for Information) this indicates seriousness and commitment. Suppliers spend a lot of money on developing RFP's and putting binding commitments on the table. The commercial process only begins with the RFPs. Therefore the idea that government cannot provide the public with the indicative figures derived from the RFIs is not true.

Financing options are key: The panellists noted that large projects are inherently risky, but that nuclear energy has a unique risk assessment. They pointed out that financing options will be critical.

A turnkey project is an option, but would double the price because vendors would have to carry the risk. A negotiated price is another option. The Russians argue that this would result in a better deal. The other possibility is going out to tender in a competitive market. If you consider investments in power projects in Africa, those that have been competitively bid have resulted in better prices and more transparency than those negotiated. Considering this, auctioning a long-term contract would appear to be the best financing model. This has been done successfully for the thermal plant in Kenya. The Department of Energy's Renewable Energy Independent Power Producers (REIPP) programme is probably the most striking example of the potential of competitive bidding. The REIPPPP has procured 6300MW and attracted R90-billion in investment in less than four years. If achieving megawatt hours in the quickest time at the lowest price is the purpose of the nuclear programme then the competitive bidding option would appear the best bet.

Panel four: Viable Alternatives for South Africa

The final panel was opened by Dr Bischof-Niemz from the CSIR. Dr Bischof-Niemz's presentation can be downloaded at:

http://awsassets.wwf.org.za/downloads/dr_bischof_niemz___can_renewables_supply_baseload_pdf.pdf

The future of Eskom's coal plants: The panel considered the future of Eskom's middle-aged coal plants and the potential for upgrades to make them less carbon intensive. It was noted that if we are going to push carbon policy, it is unlikely that the life of these plants will be extended. This is especially true if the current new build continues at the rate it is – in that case we will not need to extend the life of these plants. It was suggested that if these plants continue producing coal at the low prices they are then it may make sense to extend them, but they would need to be retrofitted with FGB which would be costly.

The mining of coal without the appropriate water licences: The panel noted that the reason for coal mining companies operating without the appropriate water use licences was due to the administrative backlog at the Department of Water Affairs and Sanitation and the long time it took to secure these licences. It was suggested that the implementation of the Water Act is long overdue and would address some of these backlogs.

Despite SA's RE programme, carbon emissions have not reduced: The question of why South Africa's emissions have not reduced despite the introduction of the RE programme was addressed by one of the panellists. He noted that the effects on the existing coal fleet of introducing alternatives is often causal. In the RE space, for low penetration, the first order effect is one that saves fuel. If there is a high diversification, the first fuel replaced is gas. This will mean a low level of CO^2 reduction as gas emits low CO^2, and this could mean high emissions as more coal is used. In long-term, the fleet built to back up RE will not be today's fleet but one from technical specifications that will be able to supply requirements but with lower carbon emissions. It is very unlikely that in SA RE will decrease

CO^2 emissions as most of our energy comes from coal, not gas, at the moment. The turning point depends on what the country's existing fleet is. There is a running system that is optimised without RE, and once RE is introduced, you have to redesign the optimum fleet. It is easier for emerging economies where the existing supply is not based on stable demand.

South Africa's success in demand side management, energy efficiency and demand response: The panellists considered SA's track record in these three areas. It was explained that there are three aspects: energy efficiency, demand-side management (stimulating consumers to do things that are of benefit to manufacturers) and demand response (DR) (stimulating users to use only at certain times). In SA we have done well on industrial energy efficiency. Eskom has been successful with industrial customers. If, all of a sudden, the operator loses supply, they have to respond immediately in order to balance the system. DR has been very effective, but we need to do more. Given current electricity prices, houses that can afford it will go to solar. Even farmers across the country are installing solar. People are leaving the grid which is a problem for Eskom.

The implications of South Africa's current economic conditions, reaching a ceiling on state guarantees and low exchange rates on RE: The panel considered the impact of South Africa's current economic conditions on the future of RE. It was noted that not building power generation is an ingredient for failure and we cannot just decide to stop building. We need plants to supply electricity at the lowest possible cost. It was noted that the SA economy is very energy intensive. Australia, by contrast, has 4 times higher GDP and 50% less energy input than SA. It was noted that no-one can predict South Africa's economic outlook, but that very simply if we want to double GDP, we will need to double our energy input.

Can RE provide baseload: The panel considered the question of RE and baseload capacity. It was noted that we are not dealing with a base load that is constant; it is higher in the day and has several peaks. In SA, the difference is still quite small between night and day because mining activities continue in the evening. However, as the nature of the economy changes, this too will shift. At the moment, the total demand for wind and solar PV is day heavy so it is a perfect match for the commercial sector – at a substantially lower price. One of the panellists referred to Ireland as an example of a system with high RE penetration. He noted that it is technically possible and economically possible at R1/KWH for a rectangular load.

The pros and cons of alternatives to nuclear: The panel considered the pros and cons of other energy sources such as coal, gas and RE to the nuclear build. It was agreed that no one solution is the panacea. Different sources must be used as part of the collective. It was suggested that because we are at the end of a power crisis, we are all concerned with capacity. However, we will find ourselves in a surplus system when Medupi and Kusile come on line. When we need more base load capacity, we can consider RE to supply it instead of nuclear and coal. The timing of this transitional period is important because we will need to increase flexible generation and coal cannot do this. If demand drops for example by 10% and we build a fleet of RE, the fuel usage will be much less. Therefore, the unit costs will stay the same or decrease from an RE mix. The costs are in the fuel, not

in the running costs. Even if fuel unit costs increase, we will be using less – which means that costs will be saved. Coal does not use this structure; the running costs are a larger part of generation than fuel.

The future of shale gas and how it compares with nuclear: The panellists considered the future of shale gas in South Africa. It was noted that government is pursuing a gas programme and that part of this programme involves establishing a substantial anchor client for gas, which South Africa currently does not have. The first step in the programme is importing LG. This is a bold gesture and an important starting point for establishing a proper gas industry. Once we have established a gas industry and local supply we can look to supplying the rest of the region with gas.

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