Role of Science Diplomacy in Procurement of New Nuclear Power Station in South Africa

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Introduction

South Africa is poised to embark on an ambitious programme for establishing 20, 000 MW additional power units over the next 20 years and more. This programme aims diversion from coal generation (currently about 90 per cent) to nuclear and renewable sources for ensuring affordable power supply in areas far from coal deposits. The purchase of a fleet of nuclear power stations would be a major opportunity for placing a cluster of high-technology industries supporting the following: (i) manufacturing of PWR reactors; (ii) supply of fuel to reactors; and (iii) civil and maintenance services. This would result in a progressive development of human capacity and infrastructure. Nuclear build would involve establishment of conversion, enrichment and fuel manufacturing capabilities and also in manufacturing key reactor components. Local industries would manufacture pumps, valves and "non-nuclear" components and would be involved in civil engineering aspects. To be successful, nuclear build would require thousands of scientists and engineers, and tens of thousands of artisans and semi-skilled workers; which is where the Science Diplomacy would come to play an important to have nuclear scientists from science diplomatic countries to South Africa; as South Africa does not have enough of world-class nuclear scientists.

Background

According to the WNA (2010), South Africa is the only country in Africa with a commercial nuclear power plant with two reactors - at the Koeberg, accounting for 4 per cent of South Africa's electricity production. Spent fuel is disposed of at the Vaalputs Radioactive Waste Disposal Facility in the Northern Cape province of South

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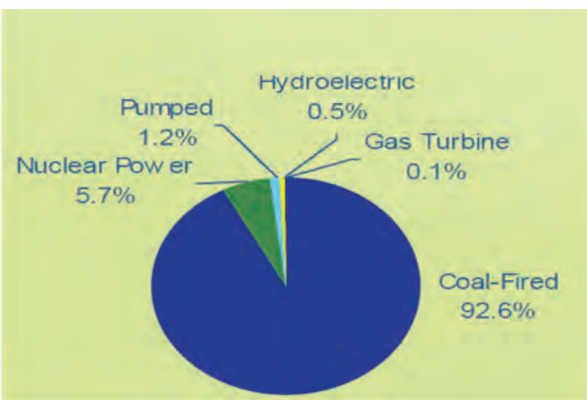
Africa. The SAFARI-1 tank in pool research reactor is located at the Pelindaba Nuclear Research Centre at Gauteng province of South Africa.

In South Africa, electricity market grew from $1.4bn in 2009 to $5.6bn; and electricity generation is dominated by the state-owned power entity Eskom, which currently produces over 96.7 per cent of the total power used in the country. Eskom has a current nominal installed capacity of 44,175MW. The Government is addressing electricity supply issues with Eskom and Independent Power Producers (IPPs). South Africa needs over 40,000 MW by 2025. Eskom is a part of the Southern African Power Pool, a group of state utilities in Southern Africa, managing electricity matters for the respective Governments; it gives Eskom a great bargaining power over peer countries (Eskom 2013).

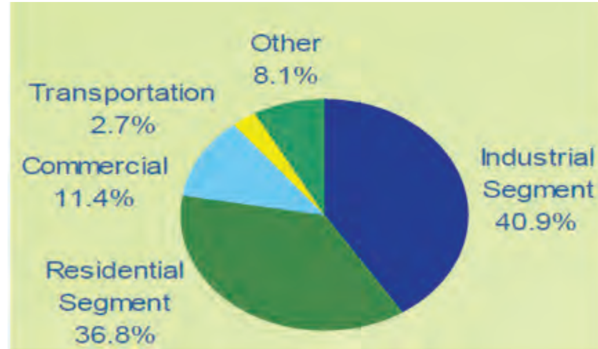
At present, transmission of electricity in South Africa is undertaken by Eskom. The state-owned company has over 28,000 km of transmission lines, spanning the entire country. Electricity distribution is the final stage in the delivery of electricity to end-users, currently undertaken by Eskom, together with the selected local municipalities (Figs 1, 2).

Figure 1: Electricity Production



Source: DME (2013).

Figure 2: Electricity Consumption



Source: DME (2013).

Discussion

Science diplomacy

Science Diplomacy is the use of scientific collaborations among international communities to address common scientific challenges and to build constructive global partnerships and cooperations (Saxena, 2017). Campbell (2012) asserted that scientific cooperation is a useful part of diplomacy which works on problems across borders and without boundaries; cooperation being made possible by international diplomatic language and methodology of science; cooperates in examining evidence which allows scientists to get beyond ideologies and form relationships; and allowing diplomats to neutralize politically explosive situations and tensions.

Role of science diplomacy

According to AAAS (2010), *New Frontiers in Science Diplomacy* report, there are three main roles relating to science diplomacy, and one of them is specifically related to South Africa's following two major scientific projects.

Foreign policy objectives with scientific advice: Science can be used to inform diplomatic decisions or agreements, which can be called science in diplomacy. In this, a scientific study can set out relevant evidence to help resolve disagreements among two or more countries.

International science cooperation: Diplomacy for science often refers to the flagship international projects in which countries come together to collaborate for high-cost and high-risk scientific projects which could not be conducted otherwise by an individual country. It also refers to set of policies, such as those governing international travel to facilitate international science cooperation.

Improving international relations between countries: Science for diplomacy refers to use of science as a means to improve strained relations among countries. For example, science cooperation agreements and joint commissions between the United States and the Soviet Union or China during the cold war very well illustrate the role of science and scientists in diplomacy.

A typical example for South Africa is clearly illustrated when using the second type of science diplomacy role, where huge scientific projects, which are high on risk and costs, are undertaken by the country in the form of Square Kilometer Array (SKA) build and nuclear energy build. However, in this paper, focus would be on the nuclear energy build. South Africa would need international diplomatic science cooperation with countries like India, especially on the project of SKA, and most definitely for cooperation for nuclear energy build from USA, China, France, Russia, Japan, to deliver on these two very risky and costly scientific projects. Therefore, this kind of scientific diplomacy international network would be crucial for ensuring two scientific projects to become a success in the country.

Most recently, in a media statement on 1 February 2017, Eskom's Interim Group Chief Executive Officer, Matshela Koko, stated, "Eskom is pleased to report that the response to the Request for Information (RFI) it issued in relation to the proposed South African Nuclear New Build Programme has been very positive. Some 27 companies have stated that they intend to provide a response to the RFI, including major nuclear vendors from China (SNPTC), France (EdF), Russia (Rusatom Overseas) and South Korea (KEPCO)." This is an indication that more science diplomacy would be needed by South Africa in its quest to deliver first of its kind mega nuclear build in Africa.

Science diplomacy in advancing South Africa's nuclear energy build: Science diplomacy seeks to strengthen interdependence between the interests and the motivations of the scientific and the foreign policy communities. International cooperation is driven often by the desire for accessing the best people, the best research facilities and the new sources of funding; that's what South Africa also needs. Science offers useful networks and channels of communication, which can be used to support wider policy goals. International relations ministries need to place greater emphasis on science within their strategies, and should draw more extensively on scientific advice in the formation and delivery of policy objectives, as was indicated by BRS (2010). In the UK, the appointment of Professor David Clary as the Chief Scientific Adviser at the Foreign and Commonwealth Office (FCO) created an important opportunity to integrate science across FCO priorities, and to develop stronger linkages with science-related policies in other Government departments. Therefore, similar strategies are required by South Africa, wherein mechanisms help achieve the above would include the following:

- Involving more scientists in international relations ministries to advise at the senior and strategic levels;
- Encouraging independent scientific bodies to provide science policy briefings for foreign ministry and embassy staff;
- Encouraging recruitment of science graduates as part of the general intake to the international relations service;
- Ensuring messages regarding the value of science are promulgated throughout foreign ministries and embassies, including all Heads of Mission;
- Incorporating science policy training into induction courses and training for international relations ministry staff and specialist diplomatic training for dedicated science officers;
- Encouraging secondments and pairing among diplomats and scientists internationally; and
- Removing barriers for diplomatic science exchange on South Africa's nuclear energy build.

There are many limitations to science diplomacy which must be taken into account during the commissioning of the two high- risk and high- cost scientific projects, which include regulatory barriers such as visa restrictions and security controls (Joseph 2007). Immediately after 11 September 2001, more stringent travel and visa regimes in the countries like the USA and the UK limited drastically the opportunities for visiting scientists and scholars, particularly from Islamic countries; which if it happens to South Africa, would be a hindrance to nuclear build project. Although efforts have been made to unpick some of these strict controls, still there are significant problems with free mobility of scientists from certain countries. Such policies shut out talented scientists and stop potential opportunities of building scientific relations among countries (BRS, 2010). Security controls can also prevent collaboration on certain scientific subjects such as nuclear physics and microbiology. Although these policies are based on legitimate concerns over the dual use potential of some scientific knowledge, they should also take into consideration diplomatic value of scientific partnerships in sensitive areas to help rebuild trust among nations, especially countries collaborating in major risky and costly projects, like South Africa.

Global trend on nuclear energy

As has been outlined by the WNA (2010), nuclear energy accounts for 15 per cent of world's production of electricity, and in some countries like France, there is no alternative for short term; as 80 per cent of the electricity is from nuclear reactors.

Nuclear energy is the energy held in the nucleus of an atom; obtained through two types of reactions - fission and fusion. Nuclear fission gives energy through splitting of atoms, which release heat energy to generate steam and then that can be used to turn a turbine to produce electricity. All of the present nuclear plants use fission to generate electricity. The fuel most commonly used for fission is uranium; although additional elements such as plutonium or thorium can be used (WNA, 2010).

Nuclear power plants account for 15 per cent of the global electricity generation, and 80 per cent of the installed capacity is in the Organization for Economic Co-operation and Development (OECD) countries like USA, Denmark, etc.; all of this is through nuclear fission. Nuclear energy through fission can release 1 million times more energy per atom than fossil fuels. It can also be integrated into electricity grids, which utilize fossil-fuel generation with a few changes in the existing infrastructure. Nuclear energy has large power-generating capacity and low operating cost, thus making it ideal for base load generation. However, up-front capital costs are intensive and present financial risks for investors. Given to an extended time-frames, power plants must be operated to recuperate costs. Nuclear energy does not emit greenhouse gases. For this reason, it is often seen as a substitute for fossil fuel energy generation, and also a right solution for mitigating climate change (leRoux, 2008).

Nuclear energy build in South Africa

South African Government would need international cooperation and partnership as it doesn't have enough world-class nuclear scientists.

The Minerals and Energy Minister Tina Joemat-Pettersson of South Africa indicated that nuclear build is non-negotiable for South Africa as the country lacks adequate water to support coal-fired power generation; this was stated when many non-governmental organizations (NGOs) and opposition parties had rejected new nuclear energy build while citing among other reasons such as high cost involved (DME, 2011).

According to DME (2011), a Funding Strategy of approximately $5 billion is required - 60 per cent would be invested in advanced manufacturing industries; 20 per cent in technology development and 20 per cent in skill transfer and development. The private sector would lead from the beginning in shallow localization areas (civils), and the funding from the state would be deployed to develop capacity in advanced areas. A coordinated

Table 1: Proposed South African Power Reactors: Draft Updated IPR Base Case

Power plant	Type	Gross capacity MWe	First power
Thyspunt and/or Duynefontein	VVER-TOI? CAP1400?	1360 1360 4080	2037 2039 2041
total		6800	

Source: DME (2011).

approach using expertise in organizations such as the Industrial Development Corporation would be required. It should be noted that the cost estimate to stimulate localization is only about 2.5 per cent of the cost of the new build. In terms of the draft Integrated Energy Resource Plan, an average annual increase in electricity demand is estimated at 2.17 per cent for a high level of energy intensity and at 1.31 per cent for a low level one.

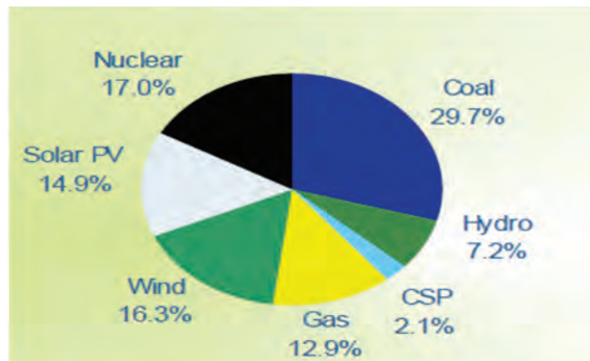
In the 2011 *Draft Integrated Energy Resource Plan for South Africa – 2010 to 2030*, five nuclear prospects were revived for 9600 MWe (in contrast to the data in Table 1); supplying 23 per cent of the electricity. In November 2011, a National Nuclear Energy Executive Coordination Committee (NNEECC) was established for decision-making, monitoring, and general oversight of the nuclear energy expansion programme (Figs 4, 5).

Advantages and disadvantages of nuclear energy in South Africa: China has a huge target for nuclear energy of 80 GW by 2020 but that too came under attack by the NDRC (reform commission of China), which proposed lowering it by substituting it with other renewable energy sources, like solar energy (DST, 2007).

Advantages. *No greenhouse gas emission/air pollution.* Nuclear electricity does not produce any GHG or cause air pollution as it is from combustion of fossil fuels, coal, oil and gas. This makes it an attractive option as the source of cheap, non-carbon-dioxide producing electricity.

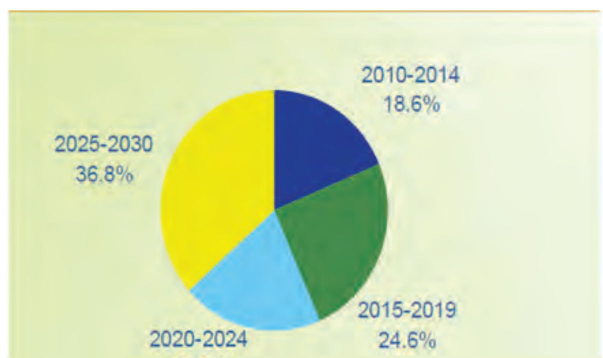
Low fuel cost: Large amounts of nuclear energy can be produced from fission of radioactive elements, like uranium. The cost of nuclear fuel is relatively low compared to other energy sources, like coal and gas.

Figure 3: Planned New Generation Mix 2030



Source:DME (2011).

Figure 4: Time Schedule New Power Generation Building



Source:DME (2011).

Reliability: Nuclear energy is a highly reliable form of energy, almost as good as other fossil fuels. Nuclear power plants, only in exceptional situations, continue to run reliably for the whole day without any changes.

Disadvantages. *Nuclear and radiation accidents.* This is the biggest disadvantage of the nuclear energy, and in 30 years, it happened three times in Japan, Russia and the USA. The fear of a repeat is so great that despite all safety arrangements touted by the nuclear equipment operators and suppliers, this type of energy faces uncertain future.

Nuclear waste disposal: The spent Nuclear Rods of Nuclear Reactors are prohibitively costly and difficult to dispose of. Spent nuclear fuel is very highly radioactive initially and must be handled with great care.

High capital investment, cost overruns and long gestation time. The time to construct a large nuclear power project can take from 5 to 10 years, which leads to time and cost overruns. The Nuclear Plant built in Finland was one of the biggest failures in Project Finance. The reactor was delayed by many years, and led to massive cost and time overruns.

South Africa's new energy mix and diversification

Government is committed to diversify its energy mix, and this includes introduction of renewable energy at a larger scale (DME, 2011).

Incentives for mixed energy generation. According to DME (2013), South Africa gives incentives such as rebates for installation of energy efficiency and demand-side management interventions, tax credits for deploying energy efficiency interventions, and tax credits for investing in green field projects. The South African government has allocated R20 billion to Industrial Development Corporation (IDC) to invest in green projects.

Government policies in mixed energy generation. The following are some policies- Renewable Energy White Paper 2003; Energy Efficiency Strategy 2005; Regulations on Energy Savings Allowance 2011; An Integrated Resource Plan 2010 – 2030; and New Generation Capacity Regulations 2009.

Renewable energy industry. South Africa's renewable energy industry is growing but it is still in infancy. Renewable energy would contribute to a total of 18.2 GW by 2030 (about 42 per cent of the new renewable energy build), comprising wind- 8.4 GW; solar PV- 8.4 GW, CSP- 1 GW and others 0.4 GW. South Africa's Minister of Minerals and Energy is determined to procurement of 3,625 MW across different technologies (diversification).The country has limited natural gas resources (accounts for 3 per cent of energy consumption). South Africa is expecting for the outcome of the assessment of shale gas potential, estimated to be approximately 485 trillion cubic feet by the USA Energy Information Administration. Petro SA (state owned petroleum entity) efforts to source gas for its Gas-to-Liquid facility in Mossel Bay from other African countries are also underway. Integrated Energy Plan 2010-2030 expects imported gas to meet 6 per cent of all new generation capacity and Open Cycle Gas Turbines (OCGTs) to meet 8 per cent (DME, 2011).

Diplomatic Science relations with global country nuclear experts

According to the NIASA (2007), Russia already has a firm presence in South Africa's nuclear sector. Since two decades, Tenex, a subsidiary of Rosatom, is supplying fuel to Koeberg nuclear power plant . Unlike most of the other nuclear plant vendors interested in being picked to supply South Africa in all or in part of its desired 9.6 GW (probably 6-9 units), Rosatom has a complete and running example of the design that it would be most likely to bid in any future tender in South Africa. Novovoronezh 6 reactor has been connected to the Russian power grid in August 2016. Rosatom also has an advantage of a strong order book so far including 42 units; this makes for an attractive sales pitch from the company to participants in its supply chain. Numerous repeat purchases, make it worthwhile to invest in quality control, design engineering and material processing capabilities required to become an approved supplier.

Russian Rosatom would not be alone in trying to make committed nuclear plant deals with South Africa. Westinghouse (USA) and Areva NP (France) have had a long presence in South Africa; the existing reactors at Koeberg were built by Framatome, one of Areva's ancestor companies. Both Westinghouse and Areva have several modern units under construction, but neither yet completed any of their Generation III or Generation III+ reactors. Therefore, there are still to be discovered. South Korea's Kepco, which is currently building four of its APR-1400 reactors in the UAE, would also be a strong contender. Like Rosatom, Kepco's modern export reactor design, APR-1400, has a complete running model to be shown to prospective customers, like South Africa. The unit, Shin Kori 3, was connected to the national grid of South Korea in January 2016; it has nearly a year's worth of operating experience.

Domestic challenges in diplomatic relations with possible bidding countries

The Government's nuclear programme is facing general public opposition. South African Faith Communities Environment Institute (SAFCEI) and Earthlife Africa Johannesburg were in court on the 13-14 December 2016 in a bid to overturn nuclear build programme; which was lost in the court.

The decision to proceed with the construction of a fleet of nuclear power plants in South Africa is destined to become a financially most far-reaching and consequential defining moment of the present administration.

There is a widespread public apprehension for nuclear expansion process. Its roots lie in the extraordinary announcement in 2014 that Russian nuclear agency, Rosatom, secured the rights to build new South African nuclear plants; which was denied by South African Government (INGEROP, 2015).

Critiques by communities to nuclear energy build

The debate surrounding the nuclear project centres was on the following three highly contested questions:

- Is the country's future energy generating potential and demands are such that an expensive nuclear power station building is unavoidable?
- Can South Africa afford associated costs and debt, especially in view of the massive funding demands from other sectors, such as education?
- If approved, would nuclear build result in massive overspending, corruption and beneficiation of politically connected individuals?

Transfer of scientific skills for nuclear energy

The key principle driving technology strategy would be a progressive localization of value chain, through local innovation or technology transfer or through Science Diplomacy programmes with sister countries.

As per the report of skills strategy by the DME (2013), probably the most important aspect underpinning success of South Africa's nascent nuclear cluster is skill development. At full bloom the new build, including industrial localization, would require over 30,000 graduates and over 50,000 artisans. In about five years from now, approximately 4,000 technical university graduates and 5,000– 8,000 new qualified artisans per annum would be required. The current total university enrolment is not enough as there are only about 750,000 learners, with only 30 per cent of them being science and engineering students (DST 2007). It is clear that to compete with other industries and other countries in attracting skills, drastic measures would be required. Key to attracting talent to the industry would be proper outreaching of nuclear cluster vision. Unless young South Africans understand clear and exciting career prospects and Government backs their education and training with resources, these plans are bound to falter. A comprehensive and imaginative communication strategy would be a decisive factor.

The formation of the Nuclear Industry Association of South Africa (NIASA) in 2007 was an important first step (NIASA 2007). The leveraging of supplier relationships (Areva, Rosatom, Westinghouse, etc.) would be critical;

which is the role of Science Diplomacy in transferring technological skills. The emphasis must be on the long-term transfer of skills capacity to South Africa, as it has happened successfully in South Korea over the past three decades. Bilateral relationships with supplier host countries (e.g. France, USA, China, Japan, Russia) as well as key 'South' countries, such as Brazil, India or even all member-countries of an association of five major emerging national economies, Brazil, Russia, India, China and South Africa (BRICS), would also be important. Locally, the identification and proper funding of training and educational institutions, from secondary school-level upwards, directly linked to nuclear build and operating programmes, is essential. Aggressive recruitment of engineers and scientists from abroad, who would contribute a lot on nuclear energy scientific skills transfer, would be of paramount importance (KPMG 2013).

Conclusion

Energy squeeze in South Africa can be turned into advantage in providing drive and funding behind promoting currently resource-based National System of Innovation to a knowledge-based one. Achieving this would require a focused effort. Galvanizing nation behind such a flagship programme would in turn require political vision and dedication in facing competing needs of the South African citizens. The notion of using a power cluster, especially a nuclear power cluster, to leverage economic transformation, may be offbeat in the face of conventional notion of development, particularly where the locus of political discourse lies with the plight of profoundly disadvantaged than to be potentially well-off. This is a choice facing political leadership in South Africa: the need is to be bold and take up the challenge to turn crisis into success, or remain at the mercy of commodity prices in a resource-scarce-based economy.

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