Discussion Paper on the Dynamics of Nuclear Energy in South Africa

FINAL DISCUSSION PAPER

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Abbreviations and acronyms

ASE	Atomstroyeksport
CfD	Contract for Difference
CGN	China General Nuclear Power Corporation
CO_2	Carbon dioxide, a type of greenhouse gas
CO_2e	Carbon dioxide equivalent (measure for all six greenhouse gases)
CSIR	Council for Scientific and Industrial Research
DG	Director General
DDG	Deputy Director General
ENEC	Emirates Nuclear Energy Corporation
ELA	EarthLife Africa
EU	European Union
FNAIIC	The Fukushima Nuclear Accident Independent Investigation Commission
GDP	Gross Domestic Product
GHG	Greenhouse gas
GNPD	Global Nuclear Power Database
GWe	Gigawatt electrical
HPC	Hinkley Point C
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IRP	Integrated Resource Plan
IRRS	Integrated Regulatory Review Service
KEPCO	Korean Electric Power Corporation
kWh	Kilowatt-hour
MW	Megawatt
NAO	National Audit Office
NEC	National Electricity Company
NGO	Non-governmental Organisation
NIASA	Nuclear Industry Association of South Africa
NNR	National Nuclear Regulator
NPS	Nuclear Power Station
NT	National Treasury
PA	Paris Agreement (of the United Nations Framework on Climate Change Convention)
PV	Photovoltaic (solar PV: a system for the conversion of light into electricity)
SAFCEI	South African Faith Communities' Environment Institute
SCBBEC	Soul City Broad-Based Empowerment Company
SCIJ	Soul City Institute of Justice
SOE	State-Owned Enterprise
TEPCO	Tokyo Electric Power Company
UK	United Kingdom
UAE	United Arab Emirates
UNEP	United Nations Environment Programme
WEC	World Energy Council
WWF	World Wide Fund for Nature

Terms and abbreviations used in measuring electricity

The following terms and abbreviations are used in measuring electricity.

1W	= 1 watt		
1kW	= 1 kilowatt	= 1000W	
1MW	= 1 megawatt	= 1000kW	= 1000,000W
1GW	= 1 gigawatt	= 1000MW	= 1000,000,000W
1TW	= 1 terawatt	= 1000GW	= 1000,000,000,000W

kW – a kilowatt: measures capacity for energy generation or energy consumption intensity. For example, one of the two reactors at Koeberg Nuclear Power Plant has a generation capacity of 970,000kW (970MW).

kWp – a kilowatt peak: measures the maximum generation capacity of an energy source. For example solar PV and wind generators are measured in peak capacity, as they are intermittent and don't always work at 100% of their capacity.

kWh – a kilowatt hour: measures the amount of electricity generated by the energy generator or the amount of electricity used by the consumer over a period of time. For example, the amount of electricity a household consumes per day can be between 10 and 15kWh, depending on their specific energy needs.

Key Messages

- The planned nuclear build programme for South Africa is multi-faceted, with information and analysis indicating that an investment decision is not as clear-cut as it may seem.
- As has historically been the case, energy security, at least cost, are the primary criteria determining energy investment decisions in most countries, including South Africa.
- A major driver affecting energy choices globally has been the need to reduce greenhouse gas emissions (measured in terms of CO_2), which are mainly the result of burning fossil fuels such as coal, oil and gas.
- The 2016 Paris Agreement on Climate Change sent a death knell to fossil fuels, particularly coal, globally, with most countries committing to a reduction in fossil fuel based energy.
- For most countries, energy security has historically been achieved and maintained by massive-scale, public sector energy generation investments that can provide power steadily for at least 99% of the time. The energy resources considered to be the most reliable for this purpose have been coal, nuclear and hydro-electric power. Natural gas is mostly relied on for power supply when demand cycles surge.
- The climate change factor has seen the focus on clean energy resources intensify, particularly renewables such as solar (energy from the sun), wind, biomass and geothermal generated power. However, these sources of energy are intermittent because, for instance, the wind does not blow all the time and technology solutions to mitigate this risk, such as storage, are still under development.
- With this focus on the potential of renewables, the trend toward diversifying energy generation to include private sector investments has accelerated, with Independent Power Producers (IPP) increasing in many countries around the world, generating both large and small scale power that can be sold to national power utilities or other users.
- An important outcome of private sector investment in the power sector is that energy tariffs are being driven down in energy markets that have become more competitive, and, as economies of scale are being achieved in the renewables sector, the costs of wind and solar investments are reducing substantially.
- Wind has over the last year, become the cheapest electricity option in South Africa, and elsewhere, at around R0.62 cents per kWh. Larger scale public power generation investments (i.e. power supplied by Eskom) cost the country and consumer much more, with coal for example costing South Africa around R1.00 per kWh, while nuclear is forecast by experts to cost between R1.50 and R1.70 per kWh.
- Although renewables are proving to be a least cost energy solution in South Africa, wind and other renewable resources are considered as being too unreliable and risky, particularly by the State, to make up a large proportion of the country's overall energy supply base (energy mix), because of the intermittency of supply (the wind does not blow all the time), stating that technology solutions to mitigate this risk are not fully available.
- Many experts in South Africa and around the world disagree, arguing that smarter decisions around an appropriate energy mix are significantly changing the game. These options include backup solutions for when the wind does not blow (such as gas), and the acceleration of disruptive innovation, particularly technology solutions that facilitate storage, decentralised utilisation, and alternative grid management options. A few countries that are moving to 100% renewables, some without neighbours they can purchase power from in an emergency, are demonstrating the validity of these arguments.
- Traditionally, power utilities are vertically integrated, with the generation, transmission and distribution of power all managed by the monopoly state-owned entity. The IPP model, however,

is primarily centred around renewable energy, and therefore threatens the future of power utilities around the world. Renewable energy is thus even more unpopular to utilities such as Eskom.

- In South Africa, it is evident that the political powers have prioritised a nuclear build programme and that relevant state organs have been set up to enable and drive this priority as a matter of urgency.
- This decision has come at a time when energy demand is at an all-time low, coupled with new power generation having come on stream (two new coal fired power stations and a wide range of renewable energy IPPs).
- Although the country obviously aspires to return to the steady economic growth levels of 3,5%, experienced between 1980 and 2007, this sort of growth has not been experienced for many years and the economic future of South Africa is extremely uncertain.
- Additionally, future global energy demands are on a downward trend, largely because of the drive to reduce emissions and increases in energy efficiencies.
- A massive-scale investment in the planned nuclear-build programme in South Africa will lock the country into relatively expensive energy tariffs which may be unaffordable for many; while also locking up large amounts of capital over a long period of time. This comes at a time when flexible solutions are needed most; and presents the country and investors with an enormous risk of stranded assets as the energy landscape is already undergoing significant change, with all signs of this accelerating rapidly.
- The world's largest exporter of nuclear technologies is currently Russia; whose state-owned nuclear entity, Rosatom, has a contested agreement with the South African Department of Energy, to build the country's nuclear programme, in spite of the procurement process currently under way.
- Evidence from various quarters points towards the existence of large-scale corruption (termed grand corruption) surrounding the nuclear programme, involving state actors, international finance and other countries. This evidence cannot be ignored, and is a view expressed by an overwhelming number of credible actors.
- Whatever the drivers, nuclear is relatively expensive for a country like South Africa where the triple challenges of poverty, employment and equality continue to be the main focus; ultimately, the consumer will bear the brunt of the country's energy choices.

Box 1. Purpose of this Discussion Paper

This Discussion Paper aims to provide the Boards of the Soul City Institute of Justice (SCIJ) with a succinct, evidence based report on the viability of investing in nuclear energy in South Africa. As a world-renowned NGO, the SCIJ works to bring about social change and create a just society, with gender equality and creating an enabling environment for young women being a main priority. As such, the Soul City Broad-Based Empowerment Company (SCBBEC), is aimed at acquiring an equity portfolio that will contribute to the long-term funding, and hence the sustainability, of the SCIJ. With the SCBBEC currently considering investment opportunities in the proposed nuclear build programme in South Africa, the organisation considers it important to evaluate the investment risks associated with this project, and thus ensure that its investment is sustainable and adheres to its SCBBEC Investment Charter. The SCIJ therefore commissioned OneWorld to provide a Discussion Paper as the basis for such an evaluation.

The main purpose of this paper is to assist the SCIJ in determining whether an investment in nuclear energy is in line with the principles and values outlined in the SCBBEC Investment Charter, thus not compromising the organisation in its core objectives of promoting social justice. In terms of the Investment Charter, selected investments must not only have financial value for the company, but should also promote the health and safety of the country's population, environmental sustainability, human rights and socially responsible business practices, as well as job creation and fair employment practices. These are the principles of ethical investment, taking into account environmental, social and governance principles. With the Investment Charter in mind, these principles are critical when considering investments related to the provision of public goods and services, as is the case in the nuclear energy build programme. Therefore, it is crucial for SCIJ to make sure that an investment decision regarding this project is made, based on evidence of the economic, political, technical and environmental sustainability of the project. This paper is based on expert desktop and literature review, further informed by key interviews, using the most up to date information available.

A I Introduction

"We see clear winners for the next 25 years – natural gas but especially wind and solar – replacing the champion of the previous 25 years, coal, but there is no single story about the future of global energy: in practice, government policies will determine where we go from here." (WEO, 2016: Dr Fatih Birol, Executive Director of the International Energy Agency)

Globally, 2016 was a game changer for the energy sector – and potentially for future climate change. At the heart of change was the Paris Agreement (PA), a global agreement aimed at reducing the carbon dioxide (CO2) emissions that destabilise the world's climate, and supporting poorer countries affected by climate change. The agreement was reached by 187 countries in France, December 2015 – the culmination of the efforts of the multilateral climate negotiations in the recent years of the post-Kyoto Protocol (KP) era. The PA was subsequently and relatively quickly ratified, entering into force in November 2016. In essence, the PA is an agreement about energy, a view strongly supported by the International Energy Agency's most recent World Energy Outlook (WEO) report published in November 2016. The report states that transformative change in the energy sector is essential to reach the objectives of the PA, noting that the energy sector accounts for around two-thirds of global greenhouse gas (GHG) emissions (measured in terms of carbon dioxide equivalent, or CO2e), thanks to decades of burning environmentally harmful fossil fuels, such as coal. CO2 emissions are the primary cause of climate change and variability, increasing global temperatures, and the frequency of extreme weather events such as flooding and drought, impacting on livelihoods and economies around the world.

Changes have been underway in the energy sector for some time, demonstrating growing global commitment to a low carbon future. The recent years of the 21st Century have seen remarkable shifts in the global energy sector, with many signs that this cycle of change is still revealing itself. Nonetheless, a different CO2 future is strongly apparent as a primary driving force behind the global effort to find alternate solutions. At the same time, *energy security* remains of paramount concern for industrialised and emerging economies alike, while developing economies seek sufficient energy capacity to fuel much needed development. Energy security refers to a country's ability to generate consistent and reliable power, at least cost to the country. Parallel changes affecting the energy sector are population growth and urbanisation, impacting energy demand and supply patterns. Predictably, with change of this magnitude in a central global economic sector, come winners and losers – or those who stand to gain, or lose from the process of change. This manifests in various ways such as protectionism and opportunism, with emergent coalitions, all of which contribute in some way to shaping trends.

Box 2. Climate change and its relevance to nuclear power

A critical indicator of commitment to action on climate change is the altering status of CO2e. Emissions growth in 2015 stalled, primarily because of a 1.8% improvement in the energy intensity of the global economy. This trend was augmented by improvements in energy efficiency, alongside a sharp increase in the use of renewable energy (such as solar and wind power) and other clean energy sources (WEC, 2016, WEO 2016). Other important indicators include global investments in the clean energy sector, accompanied by reductions in fossil fuel investments, and in the value of global fossil fuel consumption and subsidies. The value of fossil fuel consumption subsidies dropped sharply from around $500bn in 2014 to $325bn in 2016, from a combination of lower fossil fuel prices resultant to global commodity cycle fluctuations (i.e. this trend may not be sustained), and a global subsidy reform process that gathered momentum in 2016, in parallel with commitment to the PA (Petrie 2016: OECD Yearbook, WEO, 2016).

This discussion paper further considers global energy trends (section B) and how these both influence trends and enable investment in the South African energy sector, contextualised by the energy situation in this country, as it is today (section C), before considering the risks and opportunities – and recommendations for SCI - (sections D and E). In so doing, it aims to address the requirements set out by the Soul City Justice Institute, as outlined at the beginning of this document.

Notably, nuclear is already to a small extent part of the current energy mix in South Africa (SA) and looks set to play a greater role in the future energy mix – as are other technologies. Unavoidably, therefore, the discussion delves into pertinent aspects of the unfolding overall energy story globally, and particularly in South Africa.

An understanding of the place of nuclear energy in South Africa's future energy mix is considered critical to investment decisions, noting that it will take, at a minimum, ten years to commission and build new nuclear capacity in the country. Access to reliable and safe energy supply is a crucial factor for socio-economic development as South Africa's recent experience of an energy crisis demonstrated. The proposed nuclear build programme, in which the Soul City Institute of Justice is considering investing, is intended as an integral component to ensuring the country's future energy security, in turn deemed necessary to enabling economic growth and social development in the country.

B I Global energy trends

This section examines global energy trends in more depth. These trends are driven by critical considerations of energy security, on the one hand, and the implications for energy security of addressing climate change on the other, with particular reference to the role of nuclear. Thus, the question of where nuclear is located in the global shift toward cleaner energy, while maintaining or delivering energy security, is overarching. Specifically, we explore the following questions: Is nuclear on the rise globally? To what extent is CO_2 a driver? What are the key trends in how global leaders consider securing energy for economic growth and local development? Are there other drivers at play? Who are the major global players in nuclear (domestic build programmes and technology developments and exports)? Are there coalitions emerging among global players?

The political importance of national energy security

The electricity sector comprises the three primary and essential sub-sectors of generation, transmission and distribution (explained in more detail later). As noted, energy security refers to a country's ability to generate consistent and reliable power, at the least cost to the country, and this in turn is reliant on delivery and efficiencies across all three sub-sectors. The highly integrated nature of the three sub-sectors (one cannot deliver without another) resulted in the establishment of vertically integrated, monopoly state owned utilities, a model still widely in operation around the world today, typically entrusting these utilities with the responsibility for delivering a nation's energy security.

This is not a straightforward task. Energy demand varies cyclically throughout the day, typically reaching a peak during the early evening, and dropping back down during late night and early morning, however always remaining at a certain base level. Energy security therefore requires meeting minimum demand levels (called base load power), as well as meeting as near as possible to 100% of demand when it is needed most (called peak power demand). Base load is typically at 30-40% of the maximum load, and base load power plants usually operate at this level (PSU, 2015). In turn, power plants that supply at peak times (effectively topping up base load power to meet peak demand cycles) are known as peaking plants.

Globally, sources of base-load power have traditionally been limited to coal, hydroelectric power and nuclear. This is because these have, over time, proven to be the most reliable, least-cost options (noting that reliability trumps cost). Reliable power, at least cost, is widely considered as electricity generated by power stations that can run at least 99% of the time. In contrast, a peaking plant is able to be fired up quickly, as required by peak load demand at a given point in time.

An important characteristic of baseload power is that it provides stability for the grid. A stable grid is one which can deliver power consistently, including at times when there are sudden changes in supply or demand. This could happen, for example, when the electrical load (the demand by users connected to the grid) exceeds on-line electrical generation capacity), resulting in brown-outs and/or power outages. Historically, the grid operator coordinates with utilities and power producers (those that generate the power) to ensure that there is sufficient reserve generation on-line to cover anticipated load swings, as the load goes up and down during the day. However, the addition of renewable energy (solar, wind, etc.) generation into the energy resources that make up a country's energy mix introduces a very significant change to the stability of the grid. The introduction of renewables means that the historic grid operating methods are no longer sufficient, with new or revised grid codes needed for example to accommodate new technologies. Furthermore, the supply of renewable energy is known to be uneven and can be intermittent, because it cannot be controlled or scheduled (the wind stops blowing, or clouds cover the sun). It should be noted though that this assumption assumes a stable technology that is unable to harvest power in cloudy conditions. However, new, disruptive technology breakthroughs (i.e. innovative technologies that are better than those currently in use, which as they come down in costs, disrupt existing markets) that are able to harvest power in cloudy conditions and also store it, are accelerating and at rapidly reducing cost (Seba, 2016). Thus, it seems that energy actors around the world can no longer assume the same technology conditions in situations where disruptive innovation is the order of the day.

Nonetheless, the old order, or more traditional perspective prevails at present, with a number of countries holding the view that renewables are too risky (and therefore more expensive than they seem). For this, and other reasons (e.g. holding onto vertically integrated state owned utility models), most countries still favour the traditional base load options (coal, hydroelectric power and nuclear) to provide secure base load power, over renewable energy (RE), although RE is fast becoming cheaper than the traditional options.

Base load power generation investments have therefore traditionally been closely tied to national grids, which are typically public assets, controlled by the State. Furthermore, the magnitude of base load power investments, particularly in larger countries and emerging or developed economies, typically means that these are also state financed, or at a minimum, secured through public sector provided guarantees. Moreover, the State has a duty to provide basic services, such as reliable energy, to its citizens, while also establishing an enabling environment for investments necessary to stimulating economic growth and stability. The political pressure to deliver energy security is therefore immense, encompassing both meeting the needs of economic growth and the needs of its citizens. When a large majority of the latter are poor, the cost of providing electricity becomes an important consideration. Coupled with the scale of the associated investments driving significant public sector investments, this is the basis of energy politics around the world. Providing energy security is therefore not simply a technical issue but is embedded in political economy issues. It involves struggles and conflict over who benefits, who drives the process, and how it is achieved through marshalling constellations of alliances.

Indications that the game is changing abound however, as outlined above for example. In question is the ability of renewable energy (and other sources of power such as natural gas) to contribute to base load power, and to changes to utilisation and consumption of power which in turn impact on the quantum and character of base load power. This is however coupled with changes to the traditional structure of electricity sectors around the world.

Historically, base load power delivery has relied exclusively on large power plants. Today, however, more and more experts and engineers believe that, technically, base load requirements can be met by an appropriate mix of intermittent sources (i.e. renewables), peaking power plants (gas, pump storage), and large scale, constant plants (nuclear, coal, hydroelectric power). Some countries now include a large percentage of renewables in their energy mix; as much as 100% in some Scandinavian countries and German states. However, these countries usually have access to electricity imported from neighbouring countries as a backup when supply and demand patterns are not in sync.

Certainly though, renewables and gas provide more flexibility, as demand patterns around the world change. Renewables are also reducing in cost, at a time when 'least cost' is increasingly being considered in terms of an uncertain future. Longer term demand patterns are generally uncertain, for example because of changing economic growth cycles, variations in population growth and rates of urbanisation. These variations, combined with more recent global trends to reduce greenhouse gas emissions, have led to increased flexibility in the energy mix related to securing both base and peak load power. This has allowed other – often more expensive – technologies such as gas, to enter the mix.

Coupled with these changes, the past three decades have seen fundamental reform and restructuring of electricity sectors in countries all over the world. The old model of a vertically integrated, state-owned monopoly has been challenged and new institutional models have been explored and adopted. These new models involve different levels of integration/unbundling, competition and public or private ownership (Eberhard, 2016). Germany, Europe's largest energy market, for example, has unbundled (or separated) its transmission sector in accordance with the independent transmission system operator model, and has also unbundled most of its generation, distribution, and retail activities in the electricity sector (RAP, 2015). This is in accordance with the requirements of European Law for electricity sector reform. In accordance with these developments, and particularly in markets that are deregulating, the Independent Power Producer (IPP) model has gained traction across the world. Independent Power Producers are privately owned and operated entities for generating electrical power as alternatives to those traditionally operated by the State, which can be sold, for example, to a power utility or end users. (In South Africa, the majority of the IPPs that exist today have emerged from the internationally acclaimed Renewable Energy Independent Power Producer Procurement Programme (RE IPPPP), generating electricity at scale, primarily from wind and solar, that is sold into the national grid). This means that power generation is an increasingly outsourced activity, but still within strictly controlled state regulations. With this, IPPs are exerting increasing influence over developments around generation capacity within their markets.

Additionally, and as indicated, disruptive (or game changing) technologies are emerging, potentially positioning renewable energy as a central contributor to energy security. Specifically, these include storage capabilities for wind or solar energy (technologies that allow for surplus generated energy to be stored and released when it is needed most); smart grids or grids that encompass a variety of operational and energy measures such as smart meters and appliances; renewable energy resources; and energy efficient resources. Importantly, they also encompass new technologies to generate renewable energy under conditions previously unthought-of of, or regarded as possible. Advancements in these technologies are such that there is little doubt of their future efficacy and therefore uptake; however, they are not yet fully recognised technology solutions, in that the capacities to apply them are not widely entrenched – particularly not in developing and emerging economies.

The barriers to change are significant, slowing the pace in many regions around the world. For example, state-owned, monopoly utilities employ large numbers of people, are mandated to deliver reliable energy when needed most, and are often significant revenue generators for the State. There are few incentives for them to relinquish control and with this, utilities are able to threaten governments with power instability, thus securing their unchanged futures. Moreover, some of the larger BRICS countries, notably Russia and China (along with their neighbours) and the more established Western European economies (for example France and Germany) seek to grow their economies through energy exports, thus further influencing power sector changes.

Global policy responses to climate change are key

Global diplomacy efforts in the fields of climate change and development culminated in potentially game changing agreements in 2015; firstly, through renewed global commitment to sustainable development goals in the 2030 Sustainable Development Agenda and subsequently through the Paris Agreement (PA) on climate change. Significantly, the PA seeks to raise global ambition on climate change mitigation (the reduction of global carbon emissions) in an effort to limit temperature rise to 2 degrees, and preferably, 1,5 degrees Celsius. Notably though, reasons for limiting CO_2 emissions are not only about the threats of global warming. Economies that are fossil fuel-intensive (particularly coal) are also suffering from localised threats; for example, local air pollution causes around 1,2 million premature deaths per annum in China. This was one of the primary reasons behind China's ratification of the PA just ahead of the G20 meeting in September 2016. Deaths from smoky indoor environments (for example from burning wood, charcoal and coal) are linked to 3,5 million premature deaths each year (WEO 2016).

Is renewable energy (RE) a cheap, clean alternative?

A central question is the extent to which other technologies, particularly renewables, which are increasingly becoming cheaper than conventional sources of energy, are able to contribute to peak and even baseload power supply. Despite a significant drop in global coal prices in the last decade, the cost of electricity produced by renewable energy sources has already become cheaper than electricity produced by coal in some parts of the world. Throughout 2016, countries such as Mexico, India and the United Arab Emirates continued to break records on the cost of generating electricity from sunlight and prices reached less than 3 USD cents per kilowatt-hour, which amounts to half the average global cost of coal power (IRENA, 2016, PV Magazine, 10 February, 2017 and BNEF, 2016). The cost of solar PV energy continues to decline at a 10% annual rate and it is expected to become the cheapest source of energy globally by 2025 (IEEFA, 2016 and Bloomberg, 3 January, 2017). Put another way, a burning question in the energy sector today is to what extent can increasingly cheaper renewables provide a given country with energy security? Since there is no single answer to this question (country circumstances vary greatly, for example the quality of wind or solar regimes), this is dealt with specifically in Section C on South Africa.

Since 2004, Europe and China have overall experienced the most reliable and steady growth in RE (UNEP, 2015), with China overtaking Europe in 2015. With this, prices for RE (previously high cost technologies) have decreased significantly, making the economic case for renewables as attractive as the case for their reducing CO_2, thereby greatly enhancing the business case for renewables. *A reliable investment climate for renewable energy (RE) has consequently emerged*, altering the investment profile of the energy sector over the past decade.

Is nuclear power an alternative to coal?

Alongside the increase in RE, a simultaneous, more tentative and nuanced trend is evident in the global rise of the adoption of nuclear power. Nuclear, alongside hydroelectric power (HEP), is the only recognised alternative to coal for secure, reliable baseload power. Nuclear also has the advantage of being able to provide large amounts of energy around the clock, while seeming not to produce carbon emissions, thus meeting energy and climate security needs. Nuclear has been making a selective comeback post the disastrous Fukushima nuclear accident in 2011 (see Case study 1), and coinciding with CO_2 reduction requirements.

According to Fortune 2016 energy trends report, 2016 was an important year for the global energy sector, with coal continuing to die a slow death (apart from India, where it is rising), the solar industry continuing to boom with yet another year of records, and nuclear making a tentative comeback (http://fortune.com/2015/12/30/5-trends-energy-2016/). The report alleges that "Environmentalists are increasingly starting to stand behind nuclear for just that reason [zero or very low CO2 emissions]". However, the global perception that nuclear generates no CO2 or low CO2 emissions is arguable. Producing energy from a nuclear reactor relies on a steady supply of uranium, supplied through mining operations in the emissions intensive extractive sector. In addition, building nuclear plants uses substantial quantities of cement, the production of which is also recognised as being highly emissions intensive. Existing reports that analyse the lifecycle of a nuclear plant, including inputs and outputs, support the argument that nuclear power is a relatively low carbon technology (OECD NEA, 2015).

Is nuclear power a safe option?

In addition to the question of whether nuclear power really is a zero/low CO2 energy solution, nuclear power presents very obvious dangers to health and well-being in the case of nuclear accidents and disasters, when radiation is released into the air and water. This is illustrated by the far-reaching and long-term impacts of the accident at the Fukushima Dai-ichi Nuclear Power Station in 2011 (see Case study 1, below).

The Fukushima case also raises another point; which is the question of the safety of nuclear power stations in the event of natural disasters, such as earthquakes, or a tidal wave, like the one that caused the initial damage at Fukushima. The case study furthermore poses the question of the degree to which human error and poor governance or regulatory systems can prevent or mitigate large-scale accidents. The Fukushima commission that investigated the accident concluded that "Nuclear energy accidents, even in cases when these are related to the occurrence of natural disasters, are most commonly assessed as man-made accidents, as they are ultimately caused by regulatory and governance deficiencies". Ultimately, however, whether the disaster at Fukushima was a result of a chain of events caused by a natural event, or whether it was caused by human error (poor governance and regulatory systems), the consequences of such an accident are extreme.

These questions are relevant when considering South Africa's track record in managing complex, large-scale operations, that require discipline in compliance with complex safety and regulatory mechanisms. This issue is dealt with in more detail in Section C, regarding the situation in South Africa.

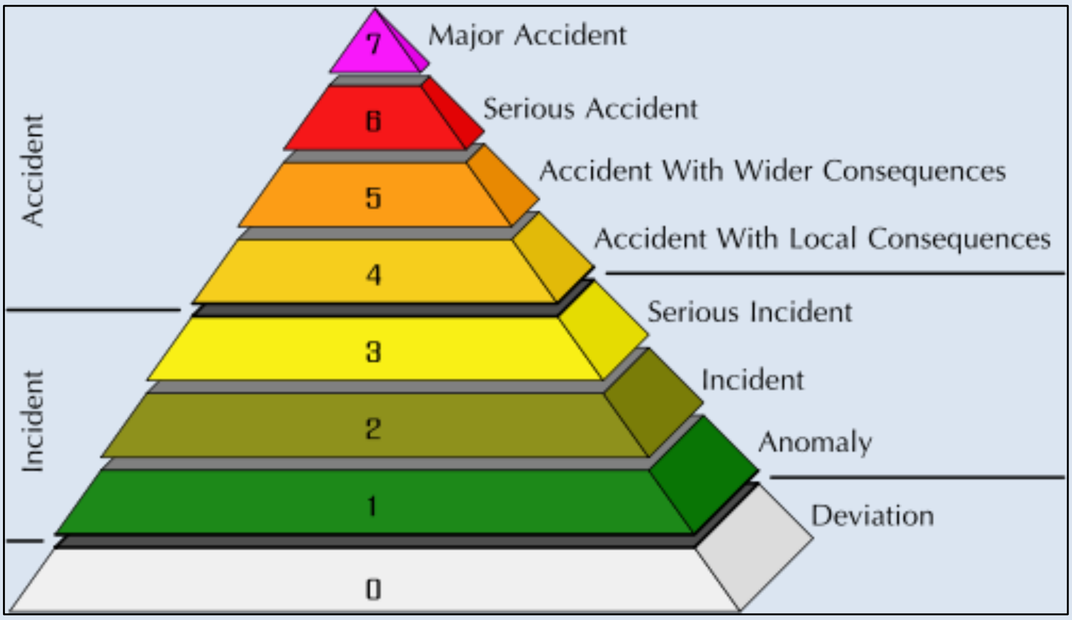
Case study 1. The Fukushima Dai-ichi Nuclear Power Station Disaster of 2011

The Great East Japan Earthquake of 11 March 2011 triggered a tsunami that struck a wide area of the east coast of Japan, with several waves on the north-eastern coast reaching heights of more than ten metres. Tens of thousands of people were killed and injured by the tsunami itself, and considerable damage was caused to housing and infrastructure. Several nuclear power stations (NPS) situated along the coast were affected by the disaster. The most serious consequences were felt at the Fukushima Dai-ichi NPS, where the earthquake damaged power lines supplying electricity to the site, and the tsunami caused substantial damage to operational and safety infrastructure on the site. The complete loss of off-site and on-site supply of electricity lead to the loss of the cooling function of the station's reactor units and the pools of spent fuel, or waste material (IAEA, 2014). While the other NPSs along the coast were also affected to different degrees, the emergency operating teams at those stations managed to safely shut down all operating reactor units and thus prevent the disastrous consequences experienced at Fukushima Dai-ichi NPS.

Following the loss of cooling functions, the cores of reactors one, two and three of the Fukushima Dai-ichi plant overheated, leading to the melting of the nuclear fuel and the breach of their containment vessels. Escaped hydrogen, which was released in the process by the reactor pressure vessels, lead to an explosion inside the reactor buildings, in which significant damage to the equipment was caused and workers were injured. The radiation released from the reactors as a result of the explosion was released into the atmosphere and also contaminated the land and ocean (IAEA, 2014). Within a radius of 20km from the site approximately 150,000 people had to be evacuated and restrictions were placed on the distribution and consumption of food and drinking water in and from the area (FNAIIC, 2012). While dealing with the consequences of the accident at the station, approximately 167 workers were exposed to extremely high levels of radiation, at unit measurement levels that have extreme impacts on human health. These levels contaminated an estimated 1,800 square kilometres of land in Fukushima. The devastating accident was declared a Level 7 ("Severe Accident"), according to the International Nuclear Event Scale (INES) (see Figure 1). The Chernobyl NPS accident in Ukraine in 1986 is the only other nuclear accident rated 7, using this scale.

Figure 1. International Nuclear Event Scale (INES)

Source: IAEA



Efforts to prepare the station for decommissioning, as well as towards revitalising affected communities and infrastructure, began in 2011. Despite stabilisation of the conditions of the reactors at the station, many people are still living outside of the evacuated areas (IAEA, 2014). These people are faced with health issues, caused by exposure to high levels of radiation, as well as the negative effects of displacement, leading to the dissolution of families and disruption of their lifestyles. Radiation contamination has had grave consequences for people and the environment in the Fukushima Prefecture, which will be felt for decades and will require significant decontamination and restoration actions, which will be essential for rebuilding destroyed communities (FNAIIC, 2012).

The Fukushima Dai-ichi NPS was operated by the Tokyo Electric Power Company (TEPCO), which is the Japanese electricity utility company, servicing the region. According to conclusions of the Fukushima Nuclear Accident Independent Investigation Commission (FNAIIC), the accident "was the result of collusion between the government, the regulators and TEPCO, and the lack of governance by said parties" (FNAIIC, 2012). The Commission ruled that the national energy regulators "effectively betrayed the nation's right to be safe from nuclear accidents" and therefore classifies the accident as "man made" (FNAIIC, 2012). Further to that the commission stresses that "the root causes were the organizational and regulatory systems that supported faulty rationales for decisions and actions, rather than issues relating to the competency of any specific individual" (FNAIIC, 2012).

Notwithstanding massive disasters such as Fukushima, which have long term health consequences, several studies show that the nuclear industry actually has a high safety record around the world, as measured by the number of fatalities during the full lifecycle of the power plants, a statistic that does not do justice to disasters such as Fukushima. A 2002 compilation of such studies, conducted by the International Energy Agency (IEA) included deaths related to accidents, as well as to long-term exposure to emissions or radiation, and concluded that nuclear was in fact the safest energy industry, while coal energy generation led to the most fatalities, mainly due to the number of deaths caused by air pollution (IEA, 2002).

The discussion above regarding safety does not address or include the issue of decommissioning of nuclear plants. Decommissioning of a nuclear plant entails not only the dismantling of the actual building and systems, but provision for the long-term storage and disposal of the extremely toxic nuclear fuel known as nuclear waste (as seen in the case study on Fukushima).

Global expansion of nuclear energy programmes

China seems to be at the forefront of nuclear energy expansion and is set to become the world's biggest nuclear energy provider by 2030, with reduction of CO2 emissions being the country's biggest driver. For baseload power, China can either build more nuclear plants or continue to depend on coal, with accompanying GHG emissions and local pollution (noting that the country is also at the forefront of renewable energy expansion). China currently operates 30 nuclear reactors (supplying 2.4% of the nation's energy consumption) and has 21 new plants under construction (WEC 2016). The World Nuclear Association counts 135 proposed reactors under serious consideration in China (http://www.world-nuclear.org/search.aspx?searchtext=china). By 2030, officials expect nuclear to account for around 10% of China's electricity generation. This would be the equivalent of around 150 gigawatts of generating capacity by 2030, accounting for one third of the current global capacity (adapted from Buckley C., 21 November 2015 and the World Energy Council (WEC)).

China is also establishing itself as an exporter of nuclear technology. At present, Chinese technology is being tested in its domestic nuclear build programme, although a safety and cost-effective track record has still to be demonstrated. In parallel, China is establishing partnerships with older technology players, such as French-owned Areva. For instance, Areva, supported by Chinese finance, is building a 3200 MWe nuclear plant at Hinkley Point in Somerset, England (see Case study 2).

Nuclear power is also a strategic priority for South Korea. About one-third of South Korea's electricity is generated from 25 reactors (23 GWe of plant). Intentions are to expand this by 70% by 2029. The country has also started to export technology, building four nuclear reactors in UAE, under a $20 billion contract. It is noteworthy that South Korea is presently seeking treaty relief from the USA, as the existing treaty limits its fuel cycle options, thus potentially also constraining South Korea's proposed nuclear build programme.

Other growth nodes are evident in Asia, as well as in eastern Europe where Russia is a major proponent. The rise of nuclear described here is not presently evident in the USA and Western Europe, suggesting that the trend has yet to gain full traction and that it is following geopolitical lines. Conversely, Germany, which until 2011 obtained one quarter of its electricity from nuclear energy, using 17 reactors, has embarked on a 100% decommissioning programme. Following the Fukushima accident in 2011, eight reactors shut down immediately in Germany, with the remaining reactors to be phased out over the coming decade.

Only a handful of countries are positioned to export nuclear technologies today, meaning that few countries can build nuclear programmes without external technology supply. This even includes the UK (see Case Study 2). Currently the main players are Russia (Rosatom State Nuclear Energy Corporation), France (Areva, majority owned by the State), South Korea (KEPCO), USA (Westinghouse, US based but 87% owned by Toshiba America Nuclear Energy Corporation (TANE), in turn owned by Toshiba's Global Energy business (Japanese multinational conglomerate) and China. Of these, Japan, France and the US have seen declines in their business and technologies; Japan, because of Fukushima, also affecting the US, given the ownership model; and Areva, because of increasing costs and slow turnaround times in building nuclear programmes around the world. This leaves Russia, Korea and China as the main technology exporters in the world today, with Russia cited by many global power experts and analysts as being the most reliable and robust provider in present terms (Yelland C., personal communication, 19 January, 2017 and Joubert, P., personal communication, 16 January, 2017).

If Germany achieves its decommissioning objectives, it will be the first country that can demonstrate experience – and therefore a comprehensive understanding of the related costs – of fully decommissioning a nuclear operation. Decommissioning of a nuclear plant entails not only the dismantling of the actual building and systems, but provisions for the long-term storage and disposal of the extremely toxic nuclear fuel (as seen in Case study 1, regarding the disaster at Fukushima). Nowhere in the world has a nuclear operation been fully decommissioned, creating a significant gap in global understanding and analysis of the full costs of nuclear across the lifecycle, and moreover, of the waste management capabilities needed in the long term.

The cost of nuclear energy to the consumer

With energy security being partly based on affordability, it is critical to consider the costs of nuclear energy. The cost calculation must include the costs of the build as well as the costs of the entire lifecycle of the plant. Hinkley Point C nuclear power station in the UK provides a case study (see Case study 2, below) of the unpredictability of the cost of nuclear power, and the difficulties in costing nuclear power accurately. The plant was originally proposed by the UK government as a way of providing safe, reliable residential electricity, expected to bring the cost to consumers down by ten per cent (DECC, 21 October, 2013). However, a recent report by the UK Audit Office warned the project could cost consumers £30bn in "top-up payments" (NAO, 13 July, 2016). Building nuclear energy power plants is a large scale and longterm project, which can take anywhere between 10 to 30 years or longer from commissioning to coming online. With such longterm projects come many uncertainties, which arise mainly from overrun costs. The industry generally has to rely on fixed contracts for the sale of electricity, however, the global energy market has been changing so rapidly in the last ten years, that very often these prices become outdated (and are much higher in relation to electricity prices that have dropped due to the inclusion of other technologies such as wind and solar).

In the case of Hinkley Point C nuclear power station, high capital costs and overruns led the UK government to an agreement with Chinese investment capital, which now raises worries over China's influence over energy structure in the UK. The cost of the energy from Hinkley Point C, in rand terms, will be R1.77/KwH. (See Case study 2.)

Case study 2. Hinkley Point C, UK – Costs of nuclear energy to the consumer

The $25 billion planned new nuclear build project at Hinkley Point C (HPC) in Somerset in the United Kingdom (UK) will be the first new nuclear power station in the UK in 20 years. In terms of cost, the project is expected to be bigger than the London Olympic Park and on a par with Crossrail, a railway running under central London (The Economist Online, 27 February, 2016). The plant is expected to provide 7% of the UK's electricity and is seen as central to the government's commitment to low carbon energy generation.

The project is led by EDF Energy - a UK integrated energy company and subsidiary of the French Électricité de France, with operations spanning electricity generation and the sale of gas and electricity to homes and businesses throughout the UK. According to EDF Energy, nuclear power is vital for the UK's future energy security, as a baseload generation source which provides a steady supply of electricity and underpins the intermittent energy supply from solar and offshore wind generators. At the same time, EDF Energy stresses that energy from HPC is environmentally friendly, as it is expected to help the UK avoid 9 million tonnes of CO_2 emissions annually (EDF Energy, November 2015).

HPC is expected to provide reliable and affordable electricity for 60 years, starting in 2025. According to EDF Energy, consumers will pay a price for the electricity produced by the nuclear plant, of £92.50/MWh, which "is competitive with the lifetime costs of other forms of generation in the mid-2020s" (EDF Energy, November 2015). The Secretary of State for Energy and Climate Change, Edward Davey, who in March 2013 announced the government's decision to grant planning consent for the HPC project, stated that the new nuclear build would enhance the country's energy security and resilience, by providing a safe and reliable domestic source of electricity and by reducing consumers' electricity bills by around 10% compared to a non-nuclear future (DECC, 21 October, 2013).

The HPC would be the first nuclear power plant in the UK to be built under the country's Contracts for Difference (CfD) mechanism, established by the Electricity Bill. The aim of the CfDs is to encourage the development of low-carbon energy sources through guaranteeing suppliers fixed energy prices. Through fixed prices, the CfDs secure predictable future revenues for the suppliers and thus make it easier for energy development projects to secure investments. At the same time, the CfDs are intended to protect electricity consumers from future electricity price increases (DECC, 21 October, 2013).

In the case of HPC, the CfD guarantees EDF Energy a set electricity price for 35 years, which depends on the number of units ultimately built. In case only one of the planned reactors is completed, the fixed price will be set at £92.5/MWh ($115.46 /MWh), while if the second planned reactor is completed on time, the fixed price would be £89.5 (US$111.72/MWh), factoring for economies of scale on the project. Put in perspective, the cost of electricity per kilowatt-hour (KwH) in South African Rand (ZAR) terms, is around R1.77, high by most countries' standards. The CfD, however, provides EDF Energy with an allowance of annual electricity price increases in line with the increase in the UK retail price index (Schneider et al., 2016).

While this agreement was initially considered to be to the benefit of the final electricity consumer, a recent report by the UK National Audit Office (NAO) criticised the arrangements of the EDF Energy CfD. Under the terms of the mechanism, the consumer is liable to compensate EDF Energy for any difference between the set price and current wholesale electricity prices. Such payments are termed "top-up payments" and are looking increasingly bad for the UK consumer as energy costs have plummeted in recent years due to a fall in the cost of fossil fuels and renewable energy. The public auditor warned in their report that in these conditions the project could cost consumers £30bn in "top-up payments" (NAO, 13 July, 2016).

The report also expresses concern that UK taxpayers may be burdened in the long term by the debt guarantee that the government provided for the nuclear project. The auditor also points to the fact that costs of nuclear waste disposal and the consequences in the event of a nuclear accident may not have been properly factored into the cost of the power plant (NAO, 13 July, 2016). The report estimates that "the value of future top-up payments under the proposed HPC CFD have increased from £6.1bn in October 2013 when the strike price was agreed, to £29.7bn in March 2016" (NAO, 13 July, 2016), an increase of over 400% in only 3 years.

In addition, the HPC has been facing financing difficulties due to the high capital and overrun costs of the nuclear build project. These financing difficulties have not only resulted in delays of the planned progress of the project, but have also caused concerns over the economic viability of the project for EDF Energy itself. Amid rising concerns for the financial stability of the company, related to the HPC project, Moody's rating agency published a credit opinion, which stated that EDF's "rating could be downgraded if Hinkley Point C were to go ahead" and that "the outlook could return to stable provided that EDF decides not to proceed with Hinkley" (Moody's 17 May, 2016, as cited in Schneider et al., 2016).

In an attempt to secure investments for the HPC project, in 2015 EDF entered into a strategic agreement with China General Nuclear Power Corporation (CGN) for a joint investment in the construction of two reactors at HPC (Scheider et al., 2016). The agreement guaranteed CGN a 33.5% share in the project. This in turn raised worries over China's influence on energy infrastructure developments in the UK. Amid such fears, as well as rising concerns over the cost and financing of the plant, the project was halted and a comprehensive review was ordered in the beginning of 2016. After an agreement was reached that the UK government would have the right to veto any future changes in the ownership structure, at the end of 2016, the project was given a go-ahead and the guaranteed price of £92.50/MWh was kept, despite concerns about it being significantly higher than the current market price in the UK (Mason and Goodley, 15 September, 2016).

Global growth in energy is on the decline

International agreements to mitigate climate change, alongside technological breakthroughs in renewable energy, are the main reasons for the decline in the global growth of energy demand as well as in the demand for fossil fuels. Solar energy is receiving an increasing amount of attention around the world, and oil and gas producers (Saudi Arabia and the UAE) are preparing for a future where oil demand is much lower than today, through diversifying their economies. The World Energy Council expects a peak in demand for per capita energy demand around the 2030s (WEC, 2016). The main scenario of WEO 2016 however contradicts this view, stating that "the world's energy needs continue to grow, but many millions are left behind", also providing nuance to the picture of future global demand. Specifically, WEO predicts a 30% rise in global energy demand by 2040, indicating that this will translate into an increase in consumption of all modern fuels. The scenario also suggests however that the global aggregate masks diversity of trends and fuel switching of significant levels. Notwithstanding this scenario, the forecast is that the current situation of hundreds of millions of people having limited access or no access to basic energy services will continue into 2040 (WEO, 2016).

To continue the discussion of how this demand will be supplied, WEO 2016 forecasts that RE will see, by far, the greatest growth, with natural gas emerging as the preferred fossil fuel, while demand for oil will slow. Coal is predicted to be the hardest hit, with growth in demand coming to a standstill, relative to the rapid growth experienced in recent years. Nuclear is also predicted to play a role in supplying this demand, stimulated by rapid growth in China.

Experts and global research puts forward the collective view that global energy consumption trends will align with the trajectories of the most intensively industrialising and urbanising global economies, particularly India, Southeast Asia and China. Parts of Africa, Latin America and the Middle East are also integral to these trends, while OECD countries are on a declining path (WEO 2016, WEC 2016).

C I Situational analysis - South Africa

To some extent, emerging global energy and global climate response commitments and trends are at play in South Africa: The future energy mix is under scrutiny, largely through the national long term energy planning process (see Box 3, the Draft IRP 2016), but also through developments in the sector. The South African energy market has seen some levels of deregulation and unbundling, evident in the progress of the RE Independent Power Producer Procurement Programme (RE IPPP) which now involves a number of wind and solar IPPs, totalling an investment of R192,6 billion as at June 2015 (DOE, 2015). Changes are also afoot in the small scale renewable market, with the City of Cape Town for example having secured a tariff from the energy regulator that enables the municipality to purchase excess power generated by small scale owners (e.g. rooftop solar) thus creating an incentive for further installations at the same time as slowly reducing demand on the national grid.

Additionally, South Africa is in a unique position for an emerging but developing economy, in the global climate change arena. On one hand, South Africa is categorised as a developing economy; and is therefore recognised as needing help with adapting to the impacts of climate change (and has some leeway in terms of reducing its CO_2 emissions). However, on the other hand, it is also an emerging, industrialising economy and a high emitter of CO_2 (the highest by far in Africa), as a result of numerous coal-burning power stations. South Africa therefore needs to both reduce CO_2 and adapt to the impacts of global warming. This, along with the water threats associated with coal (water is required for coal mining as well as in coal-fired power stations), has brought current and past levels of burning coal into sharp focus. Furthermore, global price trends for RE have become highly relevant to South Africa, with prices for procuring wind and solar energy having gradually dropped, and now being far lower than for any other energy resource. South Africa is a recent investor in wind and solar energy, and the above situations send strong growth signals to the RE sub sector. This is against the backdrop of the 2014-2015 episode of costly energy insecurity in the country. This strengthening case for RE also comes in the face of serious questions as to the financial and strategic viability of Eskom. These are some of the trends and questions coming together at a time of economic stagnation in South Africa, with much uncertainty as to future growth trajectories – and the best energy mix going forward.

South Africa is among the few African countries that has robust and wide reaching electricity transmission and distribution infrastructure, meaning that as much as 90% of the population can be connected to electricity supply, receiving power through the national transmission line system, which in turn feeds into a local distribution system, together known as the national grid. Most of the country's electricity is supplied from centralised energy generation, or sale of electric power capacity, which is dominated by coal, at around 85% of total generation capacity. Since the recent inclusion of supply of electricity into the grid by RE Independent Power Producers, the share of coal generated electricity in South Africa has been reduced. Since the start of the IPP Procurement Programme, 3 GW of generation capacity has been added through renewable energy projects, which have contributed over 8 000 GWh of electricity to the national grid (48% wind, 47% solar PV, 4% Concentrating Solar Power (CSP) and 1% Hydro) (DoE, 23 August, 2016). Following the introduction of the IPP programme, which aims to reduce the generation capacity owned by ESKOM to 70%, coal generation capacity in South Africa has come down to 77.6%, while the generation capacity share of IPPs, made up mainly of RE producers, has increased to 6.8% (ESKOM, 31 March, 2016). As mentioned earlier, the electric power industry comprises these three components (transmission, distribution and generation) and in South Africa, Eskom, the state-owned national utility, owns and controls all three. Thus, the utility is vertically integrated, with state control of all aspects of the sector, and the power sector in SA is highly centralised.

This section of the report synthesises what are considered to be the primary components of analysis of South Africa's current energy situation, thus framing the assessment of the need for and viability of potential nuclear investments in this country. The overarching question is what should South Africa's energy future look like, given the geography, socio economic environment, affordability and politics of the country? Specifically, what comprises a feasible energy mix to secure energy for the country, taking account of uncertain economic growth and affordability? What are the political priorities? What can the consumer and national fiscus afford? Is nuclear a viable option to supplement coal for baseload power? Is South Africa following global nuclear trends and can it afford to do so? Does the country have a history and credible track record of operating nuclear power plants? These and other questions and issues explored in the situational analysis aim to provide a succinct overview of the political economy of the energy sector in South Africa, and the place for nuclear within that.

South Africa's primary Energy Drivers

Since the advent of democracy just over 20 years ago, South Africa's energy sector has undergone a massive transformation. During this period, the government has pursued a policy of providing universal energy access as a priority, and has managed to achieve 92% delivery, an extraordinary accomplishment given the relatively low baseline inherited in 1994. However, this has come at some cost; delivery has come at the cost of planning which, coupled with institutional mistakes internal to institutional decision making, resulted in demand overtaking generation capacity, leading to two periods of energy supply crisis (2007-08 and 2014-15), with great cost to the country's economy. In response, two new coal-fired generation plants were commissioned, Medupi and Kusile, the building of which has overrun budget at a time when demand has slowed in line with no/low economic growth. RE capacities started to come on line at a time of greater energy demand, providing some relief to the energy crisis. Since then, the costs of RE have come down significantly, so much so that they effectively compete with the projected cost for nuclear energy and the costs for coal. Indeed, they are substantially below the costs of the latter. Against this backdrop, a number of drivers are at play in the energy sector, not least of which is policy, politics and governance.

Policy, Politics and Governance

The national policy and regulatory framework provides insight into what drives South Africa's energy decisions and investment environment. This framework includes the National Development Plan (NDP), the Integrated Energy Plan (IEP) which in turn draws on occasionally updated versions of the country's Integrated Resource Plan (IRP), and the Medium Term Strategic Framework (MTSF). Since the power sector is highly state controlled, it follows that political interests have significant influence over policy making and implementation. An overview of the current policy environment and recent political processes with respect to energy decisions therefore follows. This sets the scene for the ensuing discussion on the remaining national energy drivers, which also include cost, security, global interests, economic growth, and the socio-economic circumstances of the country.

The National Development Plan (NDP) (2013): The NDP envisages that by 2030, the country will have an energy sector that promotes economic growth and development. The NDP emphasises the need for sufficiently enabling energy infrastructure, suggesting that investment is needed to ensure this. The NDP further highlights a requirement that the country have sufficient electricity and liquid fuels so as to avoid disruption of economic activity and social welfare. An important target is that 95% of the population will have access to electricity. The NDP suggests a shift from fully centralised supply in that it states that the 95% access target could be attained through both on and off grid solutions (an example of an off grid solution is rooftop solar on private property for own use, and is thus a decentralised energy solution). This shift is supported by other NDP recommendations that involve diversification of power sources and ownership in the electricity sector, alongside the target for at least 20,000 MW of electricity coming from RE resources (wind, solar, hydro) and gas by 2030. This amount is included in the additional 29,000 MW of electricity envisaged as being required. The NDP was drafted and approved in 2013. It is based on the version of the IRP that was never approved by Cabinet, as highlighted in the section below on the IRP.

The Integrated Resource Plan (IRP): The Department of Energy (DoE) is the official custodian of the IRP and is mandated to drive the process of its development and approval. DoE relies heavily on Eskom support in developing the IRP. Following a discredited first attempt at an IRP in 2009 (IRP1), an accepted and well-respected version of the national IRP for 20 years – the so-called IRP 2010-2030 – was promulgated by the DoE in March 2011, based on work done in 2009 and 2010. This IRP was intended to be updated annually (or at the very least, every two years), based on new economic data, revised technology costs, actual electricity demand growth in previous years, and a revised electricity demand forecast for the subsequent years ahead.

A Draft IRP 2013 as an update to IRP2010-2030 was prepared and published in 2013 by the DoE, but was never approved by Cabinet. The generally accepted reason for lack of approval is that the Draft IRP2013 recommended a reduced and delayed nuclear new-build for South

Africa, over IRP 2011. Specifically, the IRP 2010-2030 update made statements such as "demand may not reach the levels required which raises the risk of overbuilding generation capacity", and "...uncertainties suggest ...a more flexible approach taking into account different outcomes based on changing......scenarios and......in making key investment decisions" The IRP update further suggests a delay in the nuclear build programme to mitigate the risk of South Africa being left with redundant technology.

In 2016, the DoE, with Eskom, developed and launched what is currently known as Draft IRP 2016, for public comment in early December 2016 – still a work in progress at the time of writing this report. The overview of the Draft IRP 2016 (see Box 3), particularly the underlying process, is instructive as to the political influences at play in major energy decisions currently being undertaken in South Africa, with nuclear energy being at centre stage. This insight was augmented by interviews with key players in the energy sector (drawn from the Ministerial Advisory Council for Energy (MACE) members, National Treasury, DoE and ESKOM staff).

A brief assessment of the Draft IRP 2016 scenarios highlights the politicised nature of the decisions behind the models (the assumptions). The assumptions are characterised by misuse of available and reliable data (for example load factors, costs of renewable energy, etc.) and the Draft IRP 2016 is being criticised for its lack of transparency concerning critical information, preventing the public from fully interrogating the results. Importantly, running the model to establish the least-cost case for electricity provision to 2050, tells South Africa to increase its build of wind and solar photovoltaic capability, supplemented by gas. Under this scenario, the model makes zero provision for nuclear technology, which is estimated by experts to cost in the region of R100 billion (for build and operation). See Box 4: Future demand for electricity generation.

From the analysis in Box 3; Draft IRP 2016, it seems clear that although the IRP is a rational process, irrational decisions underpin it. An examination of the institutional arrangements in the DoE and Eskom reveals that both institutions have been structured to promote the nuclear agenda, albeit in different ways.

Box 3. Draft IRP 2016: The Energy Planning process and implications for nuclear and RE targets

The Draft IRP 2016[1] was released in December 2016 for public consultation, as an important subset of the Integrated Energy Plan (IEP). The modelling process and decisions behind the Draft IRP 2016 are instructive, indicating the level of influence Eskom has over energy decision making in South Africa. The process is briefly as follows: DoE is the official custodian of the IRP and the modelling process; they are responsible for the overall development for and modelling behind the IRP, for driving the public consultation process, for taking the IRP through a Cabinet approval process and for its implementation and monitoring.

[1] Available online: http://www.energy.gov.za/IRP/2016/Draft-IRP-2016-Assumptions-Base-Case-and-Observations-Revision1.pdf

Eskom has depth of skills and experience in electricity modelling and owns the preferred modelling software licence (PLEXOS). DoE outsources the modelling activities to Eskom, not having these capacities in-house. DOE grants this crucial role to Eskom despite an obvious conflict of interest since Eskom is both a key player in the field and has much to gain or lose from any adopted Plan. This is an historical relationship as Eskom has been doing the modelling since the IRP process started in 2009. At that stage, Eskom both developed the assumptions behind the model and modelled electricity scenarios for South Africa.

The development of the Draft IRP 2016 saw a slight shift in the process; DoE and Eskom jointly developed the assumptions, while Eskom conducted the modelling, producing two scenarios: the "least-cost unconstrained scenario" and the "policy-adjusted scenario". DoE relies significantly on the public consultation process to interrogate the modelling results and proposed energy scenarios.

Public consultation is a central feature of the development process for all major government policies and plans and the public consultations for the Draft IRP 2016 commenced on 7 December 2016. Further consultation workshops were held around the country until mid-December, following a tight timeframe at a time of year when South African public and private sector is typically in the process of entering the country's official holiday season. On request of the public, the consultation process was extended until the end of March 2017 and a number of public consultations are taking place around the country at the time of writing this report.

A Working Group (WG) was set up by the Energy Minister under The Ministerial Advisory Council for Energy (MACE) to review the Draft IRP 2016 prior to its release for public consultation. The WG made a number of recommendations, including that the least-cost scenario be used as the base-case scenario. This would mean that the least-cost scenario would be the point of departure before any constraints or policy adjustments (the policy-adjusted base case) are applied. *This crucial assumption, and all other MACE WG recommendations were ignored by the DoE.*

The DoE and Eskom have taken the view that the base-case point of departure be taken after constraints are applied, requiring that the model constrains the annual build of renewable energy to 2010 IRP levels – resulting in a policy constrained scenario. This is a decision taken despite the fact that the renewable energy programme has exceeded all expectations on price reduction, deployment, job creation and foreign investment in South Africa. Moreover, information about the additional costs imposed by the application of constraints have not been made available to the public and to taxpayers. The estimated annual cost by experts to the country of nuclear build and operation is R100 billion – in perpetuity (nearly 7 billion Euro at today's exchange rate).

One of the DoE/Eskom justifications for the policy constraints choice is that it will be more beneficial for the people of South Africa, noting poverty, inequality and unemployment challenges. However, there is no demonstration as to how the policy constraints will positively impact on these challenges. More importantly, neither the national Fiscus nor Eskom's balance sheet can support the substantial additional costs, raising reasonable questions about the trade-offs and public sacrifices necessary to support the roll-out of the desired 20 GWe of nuclear capacity by 2050. The costs of these trade-offs, such as reduced social spending on public health and food security, can only be borne by the public and taxpayers (on a small tax base). Such trade-offs are unlikely to enhance social inclusion or increase employment in the country.

A critical contradiction noted between Draft IRP 2016 and the commencement of the Eskom-led procurement process for the nuclear build programme is timing. IRP 2016 indicates that the programme should be delayed until 2037, noting demand and other existing generation capacity as the primary reasons. Eskom however, while the public consultations were still in motion, immediately commenced a procurement process for 2025, stating that this is the best option for the economy of South Africa, given aspirational economic growth requirements and the intermittent, therefore risky nature of renewables (as discussed elsewhere in this report).

The nuclear agenda is also evident in the political actions, approach and structure of the primary actors and decision makers in the public energy sector in South Africa: The DoE, Eskom and the President. The individuals concerned also feature as an integral part of the analysis (i.e. lead figures in DoE and Eskom, in addition to the President himself). Note that the analysis below is supported and substantiated as far as possible, by informant interviews. As such, it is analysis and not speculation but since South Africa is still in the early stages of the new nuclear build programme, some of this analysis cannot be fully substantiated. Time is likely to tell as to whether or not this political analysis is fully accurate, and it is for this reason, that the precautionary principle is integral to the recommendations made in Section E to this paper.

It is important to note that changes in the political landscape in South Africa in the last few years have had an institutional impact on the energy sector, and a political economy approach therefore underpins this analysis, with the emphasis on decision making capacities and on the nuclear agenda visible in each institution.

This necessitates a review of the two institutions central to South Africa's energy sector as well as the Presidency, which demonstrates that whilst a renewable future has become increasingly viable, an expensive and large-scale nuclear agenda has come to dominate the political and institutional discourse on energy, to the extent that the development of renewable energy, despite its recent success and diminishing costs, is being constrained. An "either or" situation is emerging (suggesting that RE is getting in the way of nuclear decisions), with the nuclear agenda showing potential of derailing the substantial progress made in RE in South Africa over recent years.

Department of Energy (DoE)

There is some robust capacity and structure within DoE. The Deputy Director General (DDG) for policy, planning and clean energy is widely recognised as being an astute operator in a complex energy environment, who has been building strong capacities around him in Electricity, Energy Planning and Clean Energy. These divisions, or units, are resourced by 100 people, covering three programmes: clean energy, RE policy, and electricity planning (hydrocarbons). The planning capability is the youngest in this Directorate, now eight people strong, including a Chief Director of Energy Planning and a team of specialists, for example covering modelling on liquid fuels and gas and forecasts for demand-side sectors and IRP forecasting for overall energy demand, which is partially outsourced to the CSIR. Planning is noted by the DDG as being "very thin", creating the need for a "big balancing act" within DoE (DOE pers. comms., December 2016).

Thus, on paper (or for example on the DoE's website), the department's organisational structure seems to support the drive to realise RE targets, and even to accelerate these. A senior person is in charge of policy, planning and clean energy, implying that the responsibility for all energy policy and planning, as well as clean energy resides with one person, allowing for fully integrated energy planning that is rational. This person has a team with strong technical skills, who express commitment to neutral energy planning while realising RE targets. However, closer analysis reveals an alternative reality.

South Africa's Minister for Energy, Ms Tina Joemat-Pettersson, was appointed to the post by President Jacob Zuma in May 2014 in a cabinet reshuffle at the time. Since then, her official statements have consistently indicated that RE is firmly on the country's energy agenda and that the nuclear procurement process will be above-board and transparent. However, there have been substantial delays in recent rounds, including the current round, of the Renewable Energy Independent Power Producer Procurement Programme (RE IPPP), alongside which the nuclear procurement process has been under development. However, both took place ahead of the finalisation of the Draft IRP 2016, suggesting a foregone political conclusion. Furthermore, Minister Joemat-Pettersson's close relationship with President Zuma, who is known to be engaged in entrepreneurial activities (well documented in the October 2016 State of Capture Report published by the Office of the Public Protector), is widely acknowledged. It has also been recognised that the Minister supports the proposed nuclear deal, which is strongly backed by the President. She is currently engaged in a related court case[2].

Within DoE, the Director General (DG) is known to be in support of the nuclear programme and a Chief Operating Officer has been situated between the DG and the Deputy Director Generals (DDGs), purportedly to facilitate the acceleration of nuclear decisions and the delay of others. This is the understanding of many, including National Treasury's State Owned Enterprise (SOE) unit. Of the three DDGs (Policy Planning and Clean Energy, Energy Programmes and Projects, and Nuclear Energy), two report to the DG and the Energy Minister, while the third, the DDG for nuclear energy, is said to report directly to the President. Again, this is a view supported by the SOE unit of National Treasury.

Eskom

Before examining the institutional aspects surrounding Eskom's functioning, it is worth noting that the utility has been suffering from high levels of indebtedness, delayed build programmes at significant overrun cost, and ongoing delays to its transition to cost-reflective tariffs. It is for these reasons that the international credit rating agency, Standard & Poor downgraded Eskom's rating to level BB in November 2016 and kept its outlook negative, citing the imminent expiration of Eskom's government guarantee of R350bn (due in March 2017, with no decision to renew it) and legal costs associated with the Utility's ongoing court case against the national energy regulator.

Eskom states that it supports the integration of RE into the grid but is unwilling to do so at its own cost. RE generation in this country is mostly independent of Eskom (based on IPPs and

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[2] Ms Joemat-Pettersen has been asked to account for missing documentation on the nuclear energy programme in Parliament, also identified in a related court case, brought about by two South African non-governmental organisations (NGOs). In Parliament, the official opposition claimed that the Minister failed to disclose approximately ten important and identified documents in justifying its decision to enter an intergovernmental agreement with Russia. The two NGOs, SAFCEI and Earthlife Africa, are challenging Government in court to prove that the nuclear agreement is not in fact a "done deal". The Minister was called by the courts to submit the documents referred to by the opposition party. Delays in doing so suggest a lack of transparency in the nuclear procurement process.

expanding, unregulated small-scale generation capacity such as rooftop solar). However, the state-owned utility expresses the expense of RE in terms of i) connection costs (passed on to the IPPs from Round 3 of the RE IPPP); ii) reduction of kWh sales of coal-fired generation in times of low economic growth, resulting in decreased demand for electricity, and; iii) the threat posed to the country's baseload generation capacity, also central to Eskom's survival. It is evident from the preferred scenario proposed in the Draft IRP 2016 that Eskom is seeing the proposed nuclear build programme as replacing a significant component of the country's existing coal-fired baseload capacity (much of which needs to be shut down well before 2050). This of course raises the question of how much generation capacity the country really needs – with a brief analysis provided in Box 4.

Eskom is also tainted by the lack of transparency that surrounds the nuclear build programme. Since the appointment of Mr Brian Molefe as CEO in March 2015 (initially as acting CEO, and six months later, permanent), the flow of information to important partners such as National Treasury (NT) has been slow and opaque. Notably, Mr Molefe was a strong proponent of the nuclear build programme. NT specifically states that Eskom "battened down the hatches", indicating also that the teamwork that used to characterise decision-making between Eskom, its parent, the Department of Public Enterprises (DPE) and NT, has all but disappeared. According to the State of Capture Report, published by the Public Protector on 14 October 2016, (in which Eskom is cited on 207 out of 355 pages), Mr Molefe used internal relationships to promote certain agendas and contracts, including development of a nuclear programme. The State of Capture report is explicit about the extent of corruption in the utility, implicating senior management and procurement. Mr Molefe, who recently left Eskom under the cloud of the implications of the State of Capture Report, has a long history of alleged corrupt practices that date back to his leadership of Transnet, South Africa's rail, port and pipeline SOE, where he was previously CEO; and prior to that, the Public Investment Corporation (PIC) (State of Capture Report, 2016). His successor at Eskom (acting CEO), Mr Koko, is widely recognised by energy experts in the country as following closely in his footsteps in promoting a nuclear build programme, delaying RE, obstructing partnerships with NT and in a lack of transparent flows of information. National Treasury support this view and find themselves in a position of no longer being able to obtain reliable information from Eskom.

Opaqueness has also characterised the execution of Eskom's role in recent energy planning. The institution conducted the modelling for Draft IRP 2016, after having co-developed the underpinning assumptions. As noted, significantly incorrect costs for RE have been applied in the model, and the true costs for nuclear have not been made fully visible to anyone interrogating the Draft IRP. The resultant outputs of the preferred scenario open up the potential for nuclear significantly.

Three primary drivers appear to be behind Eskom's apparent increasing distance from RE: i) the alleged corruption behind the intended nuclear build programme (supported by related implications in the State of Capture Report) and discussed further with relation to the agreement with Russia, below; ii) the need to protect Eskom's future through securing baseload capacity to replace coal; and, iii) the threat an increasing amount of power generated from IPPs on the utility's ability to monopolise generation capacity; Eskom has traditionally been able to eliminate competitive alternative generation capacity in the private sector through its ability to obstructively control connectivity to the grid, despite regulatory policy to the contrary.

An examination of the relevant structures and decision-making pathways in Eskom is instructive. Eskom's website states: "The organisational structure is currently in process of being revised to incorporate the recent appointments and changes" (as at 15/01/2017). The site refers the reader to the Leadership page for more information. Information is available from other sources, for example Eskom's Reports. In as early as 2011, the Eskom Integrated Report showed that nuclear generation is separated out from other types of electricity generation within the generation business unit, implying, as in the case of DoE, that nuclear is given special focus. This has been on the website for some time. Until the departure of Mr Molefe, decisions were known to be made between the then-CEO, the now-current CEO, Mr Koko (previously Group Executive for Generation) and Mr Singh, the Chief Financial Officer. Decisions are evidently now being made in a similar manner.

Mr Koko released the Request for Information (RfI) for the proposed nuclear build in mid-December 2016, effectively launching the nuclear procurement process. This immediately followed a surprise move that saw the DoE giving the nuclear procurement process to Eskom through a new Section 34 court Determination. A revised nuclear determination published in the Government Gazette, replaced the 2013 version of the Determination, which was only published in 2015. The 2016 Determination confirms Eskom as the procurer, owner and operator of any new nuclear reactors to be built in South Africa. The previous determination had the DoE as the procurer of nuclear capability, flowing from the fact that Eskom was not considered to be in a financial position to procure new nuclear capacity, as noted earlier. The new 2016 determination is based on the outdated IRP (2010). It points out that the nuclear programme will target connection to the grid, as outlined in the IRP 2010-2030 or the updated version. The determination was gazetted just as the roadshows for the public consultation on the Draft IRP 2016 were supposedly drawing to a close (although they were subsequently extended till March). Nonetheless, the Determination was signed by the Minister for Energy on 5 December 2016, just ahead of the public consultation process. The new Determination was however only revealed at the nuclear court hearing on the 13th December 2016, causing the case to be adjourned to the 22 February 2017.

In October 2015, a case was brought by the South African Faith Communities' Environment Institute (SAFCEI) with EarthLife Africa (ELA), against the President and the Minister of Energy challenging the lawfulness of the Government's nuclear, energy decisions, raising explicit concerns that the procurement is being geared toward a deal with Russia. In adjourning the case after the announcement of the surprise Section 34 Determination, the Court ordered the Minister of Energy to pay the applicants' costs on a punitive scale, including the costs of four members of counsel.

As mentioned, the RFI was released within a few days of announcing the new Determination, a few months ahead of the closure and approval on the DRAFT IRP 2016.

In parallel, key actors, such as NT and big business in South Africa, are deeply concerned as to the future viability of Eskom, noting its weak balance sheet. This is expected to weaken further with the necessary closure of all of Eskom's older coal-fired power plants and the Koeberg nuclear plant between 2025 and 2043, potentially leaving the entity with only Medupi and Kusile, SA's newest coal generation plants (comprising around 9,600 MW of SA's total installed capacity).

Eskom is considered by many experts as being unable to provide a coherent, affordable strategy for the future; its employees are afraid of or prohibited from discussing the future in a decisive way, and staff are uncertain about their own futures. At the same time, Eskom routinely promotes the view that RE is expensive (because of the cost of connecting IPPs to the grid, and because renewables purportedly cannot supply electricity close to 100% of the time), and is an unreliable means of securing power 24 hours a day, seven days a week, 365 days per year (a view given by staff and official representatives alike). This view, which talks largely to two key issues, i) the so called hidden costs of RE (costs of connecting more remote stations, e.g. in the Northern Cape) to the national grid; and ii) desired grid stability, described as being a traditional and central component of a country's energy security (Section B, Global Energy Trends), is being challenged by many of the country's top energy experts, yet supported by others.

The reality, in both cases, is not clear cut. For instance, the national utility passes the grid connection costs on to the RE developer, meaning that a solar plant in the Northern Cape for instance, must, and does factor the costs of connection into their project finance (ACED, pers. comms., February 2017, IPP Office, December 2016). However, Eskom officials point out that there are additional associated costs, citing as a prime example the relatively meagre grid backbone in existence in the Northern Cape, which is not densely populated. According to Eskom, in remote locations such as these, the utility has to build new sub-stations (whereas these are already typically in existence in more densely populated parts of the country). Thus it is not only grid connection fees that are incurred, but also the costs of new infrastructure, which has to be borne by the utility (Eskom, pers. comms., February 2017). In addition, and as seen in section B, the approach to grid stability is shifting around the world, but Eskom is pushing against this trend as well.

Eskom argues that it has an unaltered mandate, which is to is to provide electricity in an efficient and sustainable manner, including its generation, transmission, and distribution and sales. As such, Eskom considers itself to be a critical and strategic contributor to the South African government's goal of security of electricity supply in the country as well as economic growth and prosperity (http://www.eskom.co.za/OurCompany/CompanyInformation/Pages/Business_Vision.aspx). The utility therefore sees its primary functions as unchanging, thus opposing moves to unbundle its various sectors (as happened in Germany for example). At the same time, the utility is aggressively growing regional and domestic markets, in order to mitigate the risk of building new bulk capacity at a time of uncertain present and future demand.

In gauging future domestic markets, the utility holds the view that it is obliged to plan for aspirational economic growth in South Africa, stating that it would be irresponsible to assume that current (low to zero) economic growth levels will continue, potentially placing the country at significant risk of energy insecurity. The utility is applying the growth rate experienced in South Africa between 1980 and 2007, of 3.5%, to the country's economic future. The resultant planning considers: related load growth projections, the life of the current fleet of base load and peaking power stations (and when these will either need to be decommissioned or reinvested in, at apparently considerable cost, to prolong their life). Planning also considers the relevant socio economic impacts across the country (for example, displacing coal will significantly cost the country in terms of jobs, as the coal mining industry is the biggest, low skills employer in South Africa) (Eskom, pers. comms., February 2017). At the same time, as a state-owned enterprise, Eskom is bound by Government climate change policy, therefore also factoring in the need for a low carbon future in South Africa.

With all these factors in mind, the utility's view is that a nuclear build programme is not only necessary, but critical.

The President of SA

Mr Zuma's political agenda has become highly visible. The corruption surrounding his relationship with the Gupta family is well documented in the State of Capture Report and his propensity for surrounding himself with likeminded support has come to characterise his Presidency. As mentioned, and in this context, this includes Minister Joemat-Pettersson, a Zuma supporter and appointee, as was Mr Molefe, who political analysts have said was set to become the next Minister of Finance until the publication of the State of Capture Report ostensibly halted that process. Having a supporter in the Ministry of Finance is an important factor in Mr Zuma's continuation of state capture activities, a process he accelerated in December 2015 with his short-lived appointment of Mr van Rooyen to the post of Minister of Finance, in a surprise political move that saw the departure of the nationally and internationally respected Minister Nene. The resultant backlash from the market and business (local and global) saw a quick response from Mr Zuma, who was forced to move Minister van Rooyen to a portfolio better suited to his skills and experience. Minister Gordhan was then brought back into the role after having been replaced by Mr Nene at the same time as the current Minister for Energy was appointed in May 2014. The so-called battle for the Treasury has continued, including the recent charges brought against Mr Gordhan, apparently in a bid to legitimise his departure and replacement; although these charges were subsequently dropped.

Political analysts concur that Mr Zuma's tactics aim to support his vested interests and that he has to secure the National Treasury to succeed. Gareth van Onselen, columnist for the Business Day and other media, analysed Mr Zuma's numerous Cabinet reshuffles (BDlove, 1 February 2017), suggesting that there are only two possible reasons behind the ten reshuffles that have occurred since he took over the Presidency in 2009: either Mr Zuma has extremely poor judgment, with "woeful" ability to choose ministers and create departments and ministries that can deliver on mandate; or, Mr Zuma routinely puts his own political interests ahead of ensuring service delivery, using turmoil to create a state of chaos in which his political appointees are beholden to him. The same newspaper published a political commentary on Mr

Zuma's attack on the NT at the ANC lekgotla (held at the end of January 2017), for frustrating the economic transformation agenda by not availing funds for certain projects. The publication suggests that this attack could be in preparation for another Cabinet reshuffle, and that it renews tensions between Mr Zuma and his backers, and NT, ahead of the ANC Conference in December 2017. The article states that "Gordhan and the Treasury are seen as a stumbling block to implementing projects favoured by the president, including the nuclear-build programme" (Marrian, N. 2 February, 2017).

It is evident that the political powers have prioritised a nuclear build programme and that relevant state organs have been set up to enable and drive this priority. It is probable that the main driver is corruption, with much personal financial gain to be made by the political participants. Corruption experts share the view that the scale is that of "grand corruption" as outlined in detail in Political Risks in section D to this paper.

The International Agreement with Russia

A further important facet of the political agenda discussion, is the existence of an international agreement on the supply of nuclear plant, with Russia. Although South Africa also apparently has agreements in place with other countries, such as China and France, the Russian agreement is more specific and is a central component of the court case against the Minister of Energy, discussed earlier. On the 22 September 2014, an agreement was signed in Vienna, on the margins of the International Atomic Energy Agency Conference. Specifically, the DoE signed an intergovernmental agreement with Russian Nuclear entity, Rosatom State Atomic Energy Corporation, in an internationally binding agreement, to buy a fleet of nuclear reactors from Russia in a $50bn strategic partnership. (One reactor costs around $5bn, with eight reactors expected by 2035.) The agreement includes commitments from Russia to help build the nuclear infrastructure in SA and to train African specialists at Russian universities. Concurrently, the SA nuclear industry lobbied the South African Government to restart the uranium enrichment programme, discontinued during the apartheid period. The nuclear agreement is advisedly of standing in international law (as per interview with the Senior Counsel for Earthlife Africa, who is reviewing the Agreement as part of the nuclear court case brought against the DoE). Following the nuclear agreement, South Africa (represented by the DoE) and Russia (represented by Rosatom) signed two memoranda of understanding (MOUs) on nuclear power. The MOUs call for projects to educate South Africans towards public acceptance of nuclear power, and include programmes for training specialists in SA's nuclear industry.

The above scenario raises tension between domestic procurement law that necessitates a transparent and thorough procurement process for an infrastructure build programme of this nature, and international law, leaving South Africa open to legal risks and potentially substantial costs (discussed further in section D). However, under the procurement process, which Eskom is currently driving, recently announcing that the launch of the Request for Proposals (RfP) for nuclear plant is expected in July 2017, it is likely that Russia may legitimately win the bid, given their current status as the primary supplier of global nuclear technology, currnelty with the largest number of reactors sold to countries around the world over the last 10 years; China (2), Belarus (2), Turkey (4), Jordan (2), India (2), Finland (1), Hungary (2), Bangladesh (2), Egypt (4) (Eskom, pers. comms., February 2017; P Joubert, pers. comms., February 2017).

Arguments that support the nuclear option

Along with the political agenda supporting the nuclear programme, there are also technical and strategic arguments that support the case for nuclear. These are viewpoints of some global power experts, economists and energy analysts, who are apparently independent of the political agenda. In the main, these arguments support Eskom's view on the intermittency of renewable energy, cite the costs of nuclear as being viable and comparable, if factoring in the true costs of renewables (e.g. the costs related to additional infrastructure required to connect remote renewable stations, as discussed) and the true cost of nuclear (reliable, constant) power supply in the equation. These arguments are further discussed in the assessment of the remaining energy drivers in South Africa, below.

Energy Security and Eskom

As discussed in section B on global trends, energy security is an important driver of energy decision making and South Africa is no exception. South Africa has relied on coal for most of its power supply (in 2015, around 85%), including baseload power, for decades. The country continues to demand reliable and predictable supply, having enjoyed relative energy security for many years. The installed capacity in the country is around 44,000 MW and in 2007/2008 and again in 2014/2015, demand exceeded supply, plunging the country into an energy crisis that damaged the economy. Sustained power cuts, caused by under-investment and a shortage of generation capacity, resulted in a belated push for more power supply, from a combination of coal-fired power plants, oil and gas, wind and solar, and a fleet of new nuclear power stations. Since then however, economic growth in the country has stagnated, reducing the demand for energy significantly, as evidenced by the drop in power sales around the country. The related impacts occurred at the same time as Medupi-generated coal power started to come on stream, along with power from wind farms, and more recently, solar installations around the country. This in turn hurt Eskom's revenue, as the utility was forced to sell power from independently produced renewables over its own coal power, while still expending capital on the overrun costs incurred in the building of Medupi. The critical question in this context is how much power capacity does South Africa need in the future? This is a question raised elsewhere in this paper and is discussed and briefly analysed in Box 4.

Thus, both energy security and Eskom's own security have been challenged. National energy security because, should economic growth come back on track, generation capacity may well not be able to generate enough to meet demand, particularly at peak periods between 5 and 9pm. Eskom's security has been challenged because without major energy investments, the utility is unable to generate revenue at the scale to which it is accustomed. According to the Draft IRP 2016, all of South Africa's older coal fired power stations, as well as Koeberg Nuclear Power Station, will be decommissioned as they reach the end of life of plant cycle. While one option would be to increase generation capacity from IPPs across a range of technologies, this approach threatens Eskom's vertically integrated model and its established revenue stream.

Box 4. Future demand for electricity generation capacity in South Africa

A consideration of future demand demonstrates that the country's energy usage and economic patterns are changing:

- As at 2015, actual energy usage was well below the forecasts of IRP2010, even at the lowest growth/demand scenario (in 2015, SA used approximately 248 TWh [TWh: terawatt hours], whereas the 2015 lowest case forecast was for around 270 TWh).
- Electricity demand is also well below 2007 levels.
- SA's electricity demand used to track GDP growth.
- With this, electricity demands used to assume linear forecasts, and successive electricity plans had optimistic growth forecasts.
- But electricity growth and GDP has started to decouple in a trend evident between 2007 and 2015.
- It is therefore clear that new electricity plans must take a different and more realistic view of future demand, noting that less demand means less power than previously planned.

So how much does the country really need?

Even if demand does pick up again, the country will still need substantially less than predicted in both IRP 2010 and the 2013 update. Even if demand growth reached 3% per annum, a figure seen as ambitious by most economists, this would require installed capacity of not more than 50MW by 2030. If demand growth reached 1% per annum, demand for installed capacity would only reach 38MW by 2030. With a good-practice reserve margin of 20% in place, this creates a system requirement for 45MW, which is about what the country has today.

Eskom's existing installed capacity is around 45GW. Not all of this plant is available, with average plant availability having fallen from an historical high of over 90% in 2005-2006, to 73.7% in 2015. Around 16% is unavailable due to breakages and losses that are unplanned (Eskom at times shuts down plants for planned maintenance purposes). A further 10% is unavailable because of planned maintenance activities. Furthermore, some of Eskom's plants are nearing the end of their lifecycle and a total of around 10GW will possibly need to be decommissioned before 2030. Assuming a scenario where about half of the older power stations will be replaced before 2030 (i.e. 5GW), and discount the 7GW of Eskom plant that is, on average, broken, then total new power generation capacity needed by 2030 will be between 12GW and 27GW, corresponding to electricity demand of 1% or 3% per annum respectively. Given recent demand trends, the lower figure is more realistic, and this could be even lower.

(Adapted from Eberhard, 2016)

Energy security and the national grid

Less discussed is the state of the national grid with regard to energy security. During and after the 2014/2015 national energy crisis, it became clear that under-investment in maintaining and enhancing the national grid contributed significantly to both periods of crisis. Hence, securing South Africa's energy future is as much about resolving transmission and distribution issues, as it is about securing adequate levels of generation capacity. Eskom itself has cited grid connection issues as being behind its unwillingness to bring more RE on stream, suggesting that few, if any, plans have been made and implemented to strengthen the grid for flexibility and optimal service delivery.

South Africa's grid has slipped below international grid standards, to the point where an investment of R163bn is needed to get it up to its own grid standard (adapted from SA's Transmission Development Plan, 2014). It is this investment that will prevent grid collapse and allow for new capacity (wind, solar, base-load coal and nuclear) to be added. Eskom produced a revised Transmission Development Plan (TDP) because of inadequate funding, published in late November 2014. The overall required investment of R163bn is made up of R146bn for capacity expansions – new lines, and replacement and additional transformer capacity – and the rest for refurbishments, spares, etc.

Connection issues are frequently raised, primarily because of the delays in round four of the Renewable Energy Independent Power Producer Programme (RE IPPP). Eskom has admitted problems with connecting far-flung RE power plants to the grid, but nonetheless passes the cost on to the developer. Eskom has also stated that connection issues are not limited to renewable energy generation but would include new base load, including the new Medupi plant. Notably, where new power plants are constructed in geographical locations that already have generation capacity of a similar magnitude, the transmission capacity required already exists. This therefore is the problem with some of the new renewable plants. Most of South Africa's older coal fired generation capacity is located in Mpumalanga, close to the coal fields of Witbank; however Medupi, located in Limpopo, is not in the vicinity of adequate transmission infrastructure. Improved grid infrastructure would also be required for connecting nuclear energy into the grid. The sites under consideration in the Environmental Impact Assessment for the first phase for nuclear build are partially selected for grid proximity.

The source of power appears to be shifting in South Africa. By 2040, the expansion of Limpopo's coal-fired plants will make it the largest nett supplier of electricity, while new renewable and gas capacity will make the three Cape provinces nett producers of electricity. As indicated, planners are also having to consider the addition of IPPs to the energy mix and small-scale embedded generation, such as solar PV, as industry and citizens increasingly take energy security and cost management into their own hands. Much of the new capacity is in the form of power that is inherently intermittent (for example wind and solar generated power are not necessarily consistent during a 24-hour period). This necessitates a new, more flexible approach to grid planning.

Electricity generation is thus becoming decentralised, and the line between consumer and producer is beginning to blur. The electricity sector is moving away from a monopolistic model, with new players taking on roles and responsibilities historically controlled by Eskom. The situation is made more complex by the growing number of IPPs, a model that threatens Eskom's security.

In conclusion, energy security is a significant consideration for South Africa and investments are certainly required. However, the answer to the question of which investments can be made at least cost to the country, in an uncertain future, remains unclear.

Global interests that impact on South Africa's energy mix

International Climate change agreements

As discussed, climate change is a significant consideration for South Africa's energy intensive economy. The country is the 32nd biggest economy (in terms of gross domestic product (GDP)), while at the same time it is the 14th biggest emitter of CO_2 in the world (462 Megatonnes (Mt) annually) (Global Carbon Atlas, 2015). South Africa is also a signatory to the Paris Agreement, as it was to the Kyoto Protocol, both global agreements, aimed at reducing CO_2 emissions that destabilise the world's climate. The country has a leading voice in the multilateral climate diplomacy process through its role in some of the key negotiation blocs, the African Group of Negotiators (AGN) and G77+China.

South Africa has released its global climate pledges (voluntary commitments to reduce CO2 emissions), including in the country's Nationally Determined Contribution (NDC) to the Paris Agreement. This policy document goes further than other countries in its approach to climate adaptation in that it quantifies the potential costs of adapting to climate change in light of several possible emissions scenarios. This is indicative of South Africa's relatively unusual position for a country that is not fully developed, of having to both mitigate against and adapt to climate change. The principles of sustainable development underpin the country's climate change policies (adapted from analysis of SA's NDC, DEA, 2015).

A Peak Plateau and Decline (PPD) approach underpins the national emission reduction targets. According to the NDC 2015, national greenhouse gas emissions will peak between 2020 and 2025, then plateau for approximately a decade, and decline in absolute terms thereafter. All 187 countries that were parties to the UN climate talks in Paris in 2015 submitted NDCs, which underpin the PA. South Africa joined China and Mexico in stating intended peaking years for submissions.

Through the NDC, South Africa sent a strong signal to the global community both on its commitments to mitigation and on its view that adaptation to climate change is a global responsibility with quantifiable costs and that all countries bear the responsibility for adequate planning, implementation and financial resources.

International investment and BRICS

Although foreign direct investment (FDI) as the country has known it has declined, South Africa is a significant destination for international energy investment. This has been evident in the RE investments into South Africa, most of which have relied on imported technologies. Similar will be true of the nuclear build programme should this proceed, as the technological solutions will need to be imported, noting though that there are support skills in the country, particularly in nuclear services.

Financing a nuclear build programme is also likely to come from international sources. Russia has purportedly for example suggested that they could enable a 'build now, pay later' solution for South Africa, meaning that they will secure the programme capital expenditure (capex), recovering the costs of investment from the consumer in the future (through electricity tariffs). South Africa is a BRICS country – BRICS being an acronym for an association of five major emerging national economies: Brazil, Russia, India, China and South Africa. Originally the first four were grouped as "BRIC" (or "the BRICs"), before the induction of South Africa in 2011, following China's invitation to the country to join in 2010. This inclusion is in spite of SA's relatively 'small' status. The alliance was formed as the group of the fastest growing emerging economies globally. Goldman Sachs, who originally coined the term "BRIC" suggest that although the alliance is not a political union, such as the EU, or a formal trading association, they have the potential to form a powerful economic bloc. This is also evident in the recent BRICS countries' decision to form the BRICS Bank, a new development bank that intends to mobilise resources for development projects in BRICS countries and developing economies. The first loan issued is for a solar project in Shanghai and reports suggest that energy investments are high on the bank's agenda.

Most informants interviewed are of the view that raising finance for the proposed nuclear build programme will not be difficult, suggesting that finance raised will be blended from debt and equity finance through a mix of project finance, country to country finance, commercial and government debt, including from the BRICS development bank (given that nuclear trends feature in most of the major BRICS economies). It is not expected that the commercial banks in South Africa will invest in nuclear, owing to the magnitude of the public programme along with the risks of corruption highlighted by the State of Capture Report (Standard Bank, ABSA, Yelland, C. Joubert, P. pers. comms, December 2016 and January 2017).

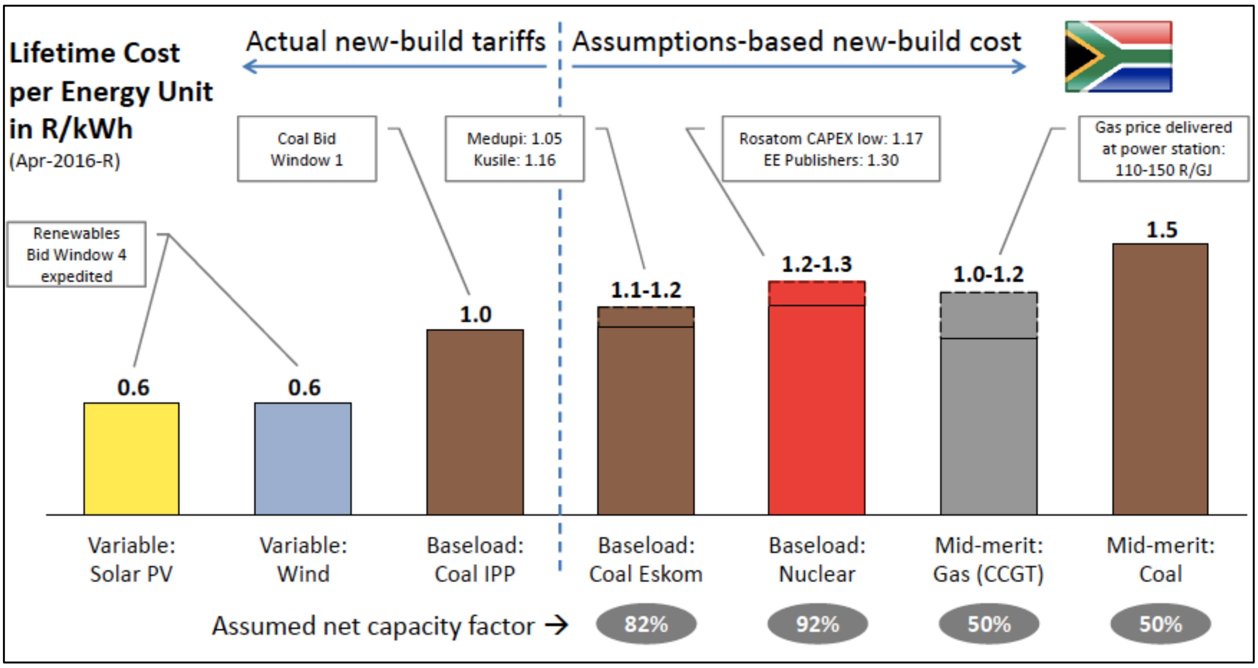
Investment costs and risks of different energy options

Cost and risk (to energy security) are the primary criteria determining the energy mix in most countries, with South Africa being no exception.

National Treasury (NT), an important Eskom shareholder, takes the view that energy investment choices in SA should be made on the basis of the least cost option that does the job properly (NT, Yelland, pers. comms., January 2017). "Properly" includes securing baseload power for the country; energy security is critical to the economy's stability and growth from NT's perspective. According to Draft IRP 2016, NT is expecting a return on public energy investments of 8%. It is further expected that because Eskom is 100% state owned, the shareholder (the State) will have to take the risk and provide the guarantees. This is the jurisdiction of NT, who in an interview in December 2016, stated that they are reluctant to put up any more guarantees for Eskom or to provide the entity with further financial bailouts.

A dominant debate on the current South African energy scene, raised earlier in this paper, is on baseload versus flexible power. As discussed earlier, an "either or" situation has emerged, with some experts and institutions such as Eskom, arguing that RE cannot provide baseload power (due to the intermittent nature of its supply; and in the absence to date of technology solutions such as storage and smart grids in the power sector in South Africa). They further argue that this raises the cost of the otherwise much cheaper RE technology. However, recent analysis by the Council for Scientific and Industrial Research (CSIR) on the scenarios underpinning the IRP, have concluded that not only is renewable energy the cheapest way to generate electricity in SA today, but it also has the potential to provide stable and secure energy supply to the national grid (CSIR, 14 October, 2016 and CSIR, 7 December, 2016). According to CSIR, over the last year, wind and solar have become the cheapest electricity option, at R0.62/kWh, compared to R1.03/kWh for electricity produced by baseload coal. The analysis further concludes that the electricity from all other new build technologies comes at a higher cost, with nuclear expected to come online at a rate between R1.2 and R1.3 (see Figure 2 below). CSIR further suggest that a least cost scenario for South Africa's baseload power, based on a combination of renewables and baseload gas, will save the economy R90 billion per year, compared to the base case scenario, suggested in the draft 2016 IRP (CSIR, 7 December 2016). This least cost scenario is also expected to save 110Mt of CO2 and 24 billion litres of water per year, compared to IRP base case scenario. Hence, there is clear scientific evidence available today that point to the fact that nuclear energy is not the only available option for South Africa's energy future, and far from the cheapest.

Figure 2. Lifetime costs of electricity by type of generation technology (CSIR)



(Source: CSIR, 14 October, 2016)

Proponents of the nuclear energy program have argued that a more holistic approach towards new baseload needs to be taken, as opposed to a least cost scenario. This approach would take into account localisation and job creation opportunities arising from different technologies. As evident from the Timeline of the role of nuclear energy (see Table 1, in the following section, on History of nuclear energy), South Africa has a long history of dealing with nuclear energy and nuclear related research. According to the Nuclear Industry Association of South Africa (NIASA), Koeberg Nuclear Power Station has a very successful safety record and the National Nuclear Regulator (NNR) is a strong and independent institution, which is held directly accountable to the IAEA (Msebenzi and Muller, pers. comm., 19 January, 2017). In fact, in December 2016, the NNR hosted an Integrated Regulatory Review Service (IRRS) mission of the IAEA. The purpose of the visit was to conduct an evaluation of South Africa's nuclear regulatory system and its alignment with IAEA safety standards and international best practice. By the end of the first quarter of 2017, the IRRS will provide South Africa with a final report from the comprehensive evaluation, which will help guide reforms to the relevant regulatory system (Engineering News, 16 December 2016). The South African authorities have said that they will make this report public.

According to the proponents of nuclear energy as a solution for South Africa, the project has significant potential to stimulate the economy, a role Eskom sees as integral to its mandate. This is especially in terms of indirect benefits related to the construction of additional infrastructure, such as roads, schools and hospitals, which would be a necessary prerequisite for the completion of the nuclear power project (Pereira, pers. comms., 16 January, 2017; Eskom pers. comms., 6 February 2017). Due to South Africa's experience with Koeberg, where Lesedi Nuclear services has completed more than 150 modifications to date, proponents suggest that the country already has the necessary skills and expertise to develop and operate new nuclear power stations. Eskom's belief is that South Africa can achieve very high levels of localisation of the new nuclear built programme, given the fact that building eight nuclear power reactors in stages would stimulate local industry growth, as the industry gradually learns from experience and the industry achieves economies of scale. In fact, South Africa would have the opportunity to follow South Korea's best practice and potentially become an exporter of nuclear power equipment itself (Eskom, pers. comms., 10 February, 2017).

Proponents of nuclear energy also state that nuclear is the only viable option to provide baseload generation capacity for South Africa. Some go so far as to state that "…including nuclear in South Africa's energy mix would be very sensible" (P Joubert, pers. comms., February 2017). In light of plans for decommissioning the country's older coal fired power stations, which currently provide more than 80% of South Africa's electricity, nuclear is arguably the only technology able to provide a stable, reliable source of clean energy (i.e. low CO2 emitting) for the country's baseload demand. Those that support this view, further argue that South Africa's economy cannot be further industrialised on the back of renewable energy supply, citing the argument of the intermittence of renewables, as do Eskom and others (Msebenzi and Muller, pers. comms., 19 January, 2017). It is often argued by nuclear proponents that Germany has been confident in making the shift to a 30% renewable capacity in its energy mix, due only to the fact that it can rely on its neighbours to provide energy on cloudy days and when there is no wind. In Ireland, for example, the share of electricity from renewable energy was 25.3% in 2015, while the country only relies on imports from other countries for a mere 1.4% of its electricity (SEAI, 2016a and SEAI, 2016b). South Africa, it is further argued, is not in a position to follow Germany's lead, as few of its neighbours are able to provide it with back up energy supply, and those that can (e.g. Mozambique, with its hydroelectric power from Cahora Bassa) are not able to supply enough. This would change completely were Grand Inga, a massive hydroelectric plant planned for development in the Democratic Republic of Congo (DRC), drawing on the Congo river, to go ahead. However, although this project has been well studied and is widely considered as welcome, it is equally widely considered as unviable, primarily because of the prevailing political climate and barriers in the DRC. Other hydro energy generation, is also not the best choice, given the region's experience with the negative impacts of climate change on its hydro energy generation capacity, as experienced recently by Zimbabwe and Zambia, both reliant on hydropower from Lake Kariba.

Arguments in support of nuclear energy's advantages in securing supply and stabilising the grid have also been countered by scientific evidence. CSIR analysis shows that a mix of solar PV, wind and a flexible power source can provide for baseload demand in the same reliable manner as a base-power generator, such as nuclear energy (CSIR, 9 March 2016). In fact, renewable energy is increasingly providing a larger share of the energy mix in many countries around the world today.

Major baseload investments such as coal and nuclear, are expected by investors to run all the time in order to validate the cost of investment, particularly the high, upfront capital costs (capex). This locks countries into long term energy solutions based on tariffs that are determined upfront, creating an inflexible cost base, as seen in the case of Hinkley Point C (see Case study 2). Given that South Africa faces an uncertain economic future, long term energy solutions of this nature are considered by many experts to be too costly, further suggesting that the precautionary principle be applied. Although large scale hydropower is not a possibility within South Africa (it is possible to import it from the region), and generating further coal power places the country at even greater risk to national water security, there are other, cheaper options to nuclear in South Africa, and many experts suggest that these should be explored, along with a more flexible energy system.

A further factor to consider in assessing cost is the ability of South Africa (and the world generally), to build large scale energy infrastructure within budget and on time. Globally, China and Korea are purportedly building current nuclear power stations within these parameters, but there is little transparent information available to support these allegations. The rest of the world has a consistent track record of significant delays and overrun costs, in building nuclear. Current examples of this internationally are the Watts Bar Nuclear Station in the US, where the cost changed from US$2.5 billion in 2007 to US$4.7 billion in 2016 (Schneider et al., 2016), as well as the Sanmen project in China, where budget overruns of US$385 million and US$401 million were booked during the second and third quarters of 2013 (Schneider et al., 2016). Moreover, South Africa's recent track record in building coal fired power plants, a technology the country has substantial knowledge and experience of, is instructive. Construction at Medupi has already seen a three-year delay with substantial overrun costs, suggesting a much higher tariff than published by Eskom. In its 2016 Integrated Report, ESKOM published information that its Investment and Finance Committee projected an increase of Medupi financing of R40 billion over the previously approved R105 billion (ESKOM, 31 March, 2016).

Although the debate continues, there are strong suggestions that nuclear will be expensive, and that the country cannot afford this expense. Experts suggest that a country that wants to embark on a nuclear build programme at the scale proposed for South Africa, should routinely experience 5% per annum economic growth rates, with certainty around forecasts that this will be sustained (WWF, pers. comm., 2017, Frost & Sullivan 2016). Furthermore, the traditional model for the power sector is already showing signs of changing in South Africa, with suggestions that the magnitude of change that Eskom is avoiding, is inevitable (NT workshop, November 2016, Anton Eberhard pers. comm., December 2016; NT, pers. comms., January 2017). Inevitable change would include the introduction of greater flexibility into South Africa's energy mix, at much lower cost.

Socio-economic context and implications for the energy sector

The socioeconomic context in South Africa inevitably has implications for the structure of the country's energy sector, thus also driving future development. Although South Africa is classified as an upper middle-income, or emerging economy, it is also in many ways a developing country, which faces critical economic and social challenges. Poverty, inequality and unemployment levels, known as the triple challenges, remain high, while the HIV/AIDS epidemic continues to severely undermine people's wellbeing. Currently 54% of people in South Africa live below the upper bound poverty line of R779 per month, while 37% fall below the lower bound poverty line of R501, which means that they are forced to make trade-offs between food consumption and obtaining essential non-food items. At the same time, it is estimated that the wealthiest 20% of South Africans earn 61% of total income in the country, which is also mirrored in the country's high Gini coefficient of 0.65 (StatsSA, 2015 and 2014). In the third quarter of 2016, South Africa's unemployment rate rose to 27.1%, from 26.6% in the second quarter, increasing the number of people without jobs, and therefore no source of income, to a total of 5.873 million (StatsSA, November 2016). Unemployment and poverty challenges are exacerbated by slow economic growth, averaging an annual rate of 1.85% since 2012 and expected to fall to 0.5% in 2016 (SARB, September 2016, and NT, October 2016).

In the context of the persisting triple challenge in South Africa, the costs of electricity are most difficult to bear for the poorest households. As a percentage of their income, poor households often spend a larger share on their energy needs than rich households. According to a 2012 study, households which earned R1500 or less per month spent on average 26% of their income on energy, compared to 4% for households, which earned more than R5500 per month (Swart and Bredenkamp, as cited in StatsSA, 2013). The burden of electricity costs on poor households has been rising in parallel with the steady rise of electricity tariffs in South Africa over the last decade. A 2010/2011 income and expenditure survey found that a significant increase in household expenditure in the period between 2005/6 and 2010/11 was largely driven by increasing electricity tariffs, which increased by 111,4% in the same period (StatsSA, 2013). In the period between 2003 and 2016, residential electricity tariffs have seen an increase of 195% from R 0,366/kWh to R 1,08/kWh (ESKOM, 2016). Given this trend, more than two thirds of households in the same survey reported that they would not continue using electricity at the same rate as they had before, as they would not be able to afford the extra costs.

As stipulated in the Constitution of 1996, one of the South African government's main priorities has been to provide access to energy at affordable prices to all of its residents, irrespective of geographical location. According to the Constitution, the government needs to ensure that the generation and distribution of energy are sustainable and create potential for improvement in the population's standard of living. Although rapid progress has been made in electrifying households and South Africa's electrification rate has increased from 54% in 1996 to the highest rate in Southern Africa at 86% in 2014 (IEA, 2016), 8 million people remain without access to electricity, while many cannot afford to use electricity for all domestic chores and thus still resort to using alternative sources of energy, such as wood and coal (StatsSA, 2013). A 2003 study showed that 56% of households, connected to electricity in ESKOM-licensed areas, consumed less than 50 kWh of electricity per month (Prasad and Ranninger, 2003 in Winkler, 2006, as cited in StatsSA, 2013).

While it is estimated that a significant proportion of the South African population are living in conditions of extreme poverty, women, children and young people, as well as people with disabilities, are disproportionally overrepresented within this group (StatsSA, 2014). Poverty, and energy poverty in particular, renders women and children most vulnerable to socio-economic challenges and health risks. In the lack of access to reliable and affordable energy, women and children are often responsible for the chore of providing other sources of cooking fuel, which places a disproportionate physical and time burden upon them, often to the detriment of their health, security and educational progress or income earning economic opportunities" (Modi et al. 2006, IEA 2010, as cited in StatsSA 2013). Therefore, improved access to electricity would relieve women and children from the health and security risks, involved in such chores, and it would also provide them with the opportunity to pursue education and income generating activities. What is equally important is that there are significant potential benefits for the South African economy from reducing women's vulnerability with regards to energy poverty. The UNDP's recent Africa Human Development Report (2016) estimates that gender inequality is costing sub-Saharan Africa on average $95 billion a year or 6% of the region's GDP. All this means – as the UNDP emphasises – that proactive strategies are needed that actively seek to break down the barriers that perpetuate this vulnerability and exclusion and create the conditions for sustainable participation by all in South Africa's growth and development.

The energy sector holds much potential for improving the current conditions of poverty, inequality and unemployment in South Africa. A study on the job creation potential of the energy sector found that by following an emission reduction agenda and pursuing policies to boost South African renewable manufacturing capability, an additional 33,700 jobs could be created by 2030. This is 28% more than the number of jobs which can be created by continuing on a business as usual path (Rutovitz, 2010). The South African DoE has estimated that 24,965 job years (full time employment opportunity for one person for one year) have already been created since the start of the IPPP programme at the end of 2013 (DoE, 23 August, 2016). Based on an additional 21,448MW of energy being procured, the DoE has projected that by 2023 this number will reach close to 371,000 job years (DoE, 23 August, 2016). It has also been estimated that in the period since the beginning of the IPPP programme until March 2016, R30 billion in local content has been generated through the development of local manufacturing capacity (DoE, 23 August, 2016).

However, uncertainty over the IPPP process since the end of 2016 has raised concerns among industry stakeholders and has put this potential at risk. As ESKOM has delayed signing power purchase agreements with independent power producers from bid window 4.5 of the IPPP programme, several component manufacturers are under risk of closing down their facilities in South Africa. SAM Solar, one of the world's biggest solar technology companies, closed its factory in Cape Town in 2016, due to a lack of commitment to green energy by the government. The three largest companies, which are at threat of closing down their factories are Jinko Solar, Sunpower and GRI, which invested close to R400m in manufacturing steel wind turbine towers in Atlantis (Speckman, 30 January 2017).

Despite the fact that South Africa has one of the most well developed energy sectors in the region in terms of infrastructure and rates of electrification, the structure of its consumer base and thus its overall energy demand is currently compromised by rising unemployment, and persisting poverty and inequality. These challenges are in turn exacerbated by low economic growth projections for the medium term. Therefore, it is important that prospects for future energy demand and decisions about new baseload generation capacity are modelled in the context of South Africa's socioeconomic challenges, in order to ensure the sustainability of new infrastructure investments.

History of nuclear energy in South Africa

Nuclear is by no means new to South Africa. A brief history of the nuclear timeline, that started in 1948, demonstrates knowledge of technologies, the skills base in the country, South Africa's safety record, and South Africa's international relations and agreements around nuclear. A nuclear timeline for South Africa is outlined in table 1. In the interests of completeness, this includes recent nuclear related decisions and activities, discussed elsewhere in this report. Because of the typically close links between nuclear power generation for electricity, and nuclear uses for the military, the timeline outlines the history of both in South Africa (SA).

Table 1. Timeline of the role of nuclear energy in South Africa

Date	Event
1948	SA establishes the Atomic Energy Board, the precursor to the Atomic Energy Corporation, to oversee the development of the country's uranium mining and trade industry.
1957-1967	1957 SA signs a 50-year nuclear collaboration agreement with the US, resulting in SA's acquisition of a nuclear reactor and an accompanying supply of highly enriched uranium (HEA) fuel. Under this agreement, US company, Allis Chalmers Corporation delivered the 20MW SAFARI-1 (South African Fundamental Atomic Research Installation) nuclear reactor and 90% HEU fuel to South Africa. SAFARI-I was commissioned the same year, located in Pelindaba, outside Pretoria. SA constructed its own reactor by 1967, as part of a plan to produce plutonium, the SAFARI-2, a also located in Pelindaba. This heavy water reactor project was abandoned in 1969 as it was draining resources from the uranium enrichment programme launched in 1967.
1971	SA Minister of Mines approved a research project on peaceful nuclear explosions (PNEs), publicly stating the objective of using PNEs in the mining industry. At some point between this date and 1974, the PNE was transformed into a nuclear weapons programme
1974-1990	1974, SA started a uranium enrichment plant at Valindaba, known as the "Y-plant,". During the period 1974-1990, SA pursued a nuclear weapons programme as a deterrent to counter the Soviet threat perceived in the southern African region. In 1976, the Soviet Government became sufficiently alarmed as to SA's progress on the nuclear programme that it sought US cooperation in ending the programme, a request purportedly rejected by the US. Through this period, SA developed dual-use nuclear capabilities (meaning that it has civilian and military applications), making it possible to both export nuclear technology and expertise, and be a target for state and non-state actors seeking nuclear materials. During this period, in the 1980s, SA constructed six gun-type nuclear weapons and was in the process of constructing the 7th when the process of ending the programme commenced.
September 1988	SA Government sent a letter to the International Atomic Energy Agency (IAEA) expressing willingness to accede to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), if certain conditions were met; primarily that SA be allowed to market its uranium subject to IAEA safeguards.
1990	SA Government, under de Klerk, terminated the nuclear weapons programme and all nuclear devices were dismantled and destroyed.
10 July 1991	SA joins the Non Proliferation Treaty (NPT) as a non-nuclear weapons state. Subsequently, the IAEA begins inspections of South Africa's nuclear facilities to verify the scope and history of the program and its dismantlement.
1991-1996	SA becomes a champion of nuclear non-proliferation efforts. SA Parliament passes the Non-Proliferation of Weapons of Mass Destruction Act, which committed South Africa to abstaining from the development of nuclear weapons. In 1995, SA diplomats play a critical role in building consensus among member states to adopt a set of "Principles and Objectives for Nuclear Non-proliferation and Disarmament" and to extending the NPT indefinitely. 11 April 1996, SA signed the Pelindaba Treaty (the African Nuclear Weapon-free Zone Treaty) with 44 other Africa states; the Treaty came into force in 2009. June 1996, SA is admitted to the UN Conference on Disarmament in Geneva and in September 1996, SA signed the Comprehensive Nuclear Test Ban Treaty, ratifying it into legal force in 1999.
1986-2012	SA companies are allegedly engaged in illicit transfers on controlled dual-use technologies (Pakistan, 1986-1995; Libya, 1999-2003) and SA faces questions about the security of its nuclear facilities (2007, break ins at Pelindaba, 2012, break ins at the adjacent student facility). SA invests millions of USD to improve on-site security and to enhance the regulatory framework.

1991-2016	SA is a recognised producer, possessor and exporter of nuclear technologies and materials and is a growing producer of nuclear energy. SA enters bilateral partnerships to this effect. In 1999, Presidents Yeltsin and Mandela establish their Declaration on Principles. In 2006, SA and Russia recommit, in the Treaty of Friendship, to the principles of relations of partnership. The Putin-Zuma Joint Declaration of March 2013 acknowledges that the two states' strategic partnership was consummated with the Treaty of Friendship and Partnership of 2006, effectively upgrading the 2006 strategic partnership (SP) to a "comprehensive strategic partnership". *["As regards the formative aspects of their SP, it is instructive that South Africa and Russia share concerns over a variety of threats to internal and international security and stability. Another striking feature is their normative commitment to human rights and fundamental freedoms in the two societies. At the global level, Russia and South Africa agree to an agenda that combines progressive ambitions (such as "a more just and democratic multipolar world order") with conservative notions (like sovereignty, territorial integrity and non-interference). Whether ….mutual economic advantage is probably the (unexpressed) driving force".* – p140 in http://www.up.ac.za/media/shared/85/Strategic%20Review/Vol%2037%20(2)/geldenhuys-pp118-145.zp74595.pdf]
1991-2016 (contd.)	In September 2009, SA signs a nuclear cooperation agreement with the US. As at 2016, the national utility, Eskom, still operates two nuclear power reactors (Koeberg 1 and 2), producing 1800MWe, or 5% of the country's energy supply. According to President Zuma, the country expects to build 9,600MW of nuclear generation capacity by 2030, with the intention to take a fleet approach, building multiple plants at once rather than ordering one reactor at a time. Several international companies have expressed interest in investing in this programme (Areva, China General Nuclear Power Group, EDF, Rosatom, Toshiba, Westinghouse and KEPCO).
2010	Cabinet approves the DoE Integrated Resource Plan (IRP 2010-2030) which provides for, inter alia, 9,600 MWe of nuclear for SA's future energy mix
2013	DoE revises IRP 2010-2030, which discards the importance of nuclear, but fails to take this through cabinet, leaving IRP 2010-2030 as the official energy plan for SA.
22 Sept 2014, Vienna, on the margins of the International Atomic Energy Agency Conference	DoE signs an intergovernmental agreement with Russian Nuclear entity, Rosatom State Atomic Energy Corporation – an internationally binding agreement to buy a fleet of nuclear reactors from Russia in a 50bn $ strategic partnership (one reactor = $5bn; 8 reactors expected by 2035) and includes commitments from Russia to help build infrastructure in SA and to train African specialists at Russian universities. Concurrently, the SA nuclear industry lobbies the Government to restart the uranium enrichment programme, discontinued during the apartheid period.
8 July 2015. Ufa Russia, BRICS Summit	SA (DoE) and Russia (Rosatom) sign 2 memoranda of understanding on nuclear power, calling for projects to educate the people of SA so as to encourage public acceptance of nuclear power and include programmes for training specialists in SA's nuclear industry
October 2015	SAFCEI and ELA launch a court application against President Jacob Zuma and energy minister Tina Joemat-Pettersson in an effort to stop the nuclear programme
21 Dec 2015	DoE publish a nuclear determination (nuclear section 34 determination made in 2013) in the Government Gazette allowing them to legally proceed with 9.6GWe nuclear build. The determination sets the amount of generation capacity and specific technology that government will procure for 9 600MW of nuclear energy, in line with government's 2010 Integrated Resource Plan. SAFCEI request the courts to set aside the determination
August 2016	SAFCEI/ELA prepare for a court case against DoE, calling for ten documents referenced in the Government's legal response to their founding affidavit. The Government refuses to release the documents. In October, SAFCEI/ELA note Cabinet's statement that it will delay the nuclear requests for proposals (RfP), until the energy plan (IEP) and its subset, electricity plan (IRP) have been completed, welcoming this as a step toward good governance
Oct-Dec 2016	Minister Tina Joemat-Pettersson gazettes the Draft IRP 2016, as an update and revision of IRP 2010-2030 for

	public comment. The Ministerial Advisory Counsel for Energy (MACE) advises the Minister against the policy constrained scenario and make a series of recommendations, all of which are ignored in the launch. Roadshows to roll-out public consultations for the IRP take place in Johannesburg, Durban, Cape Town and Port Elizabeth between 7th and 15th December 2015, followed by additional roadshows in January. Consultations will go on until the end of February 2017.
14 Dec 2016	A revised nuclear determination is published in the Government Gazette, replacing the 2013 version, published in 2015, confirming Eskom as the procurer, owner and operator of any new nuclear reactors to be built in South Africa. The previous determination had the DoE as the procurer; flowing from the fact that Eskom was not considered to be in a financial position to procure new nuclear capacity, owing to its high levels of indebtedness, its junk status, delayed build programme and ongoing delays to its transition to cost-reflective tariffs. The 2016 determination is based on the outdated IRP (2010). The new determination points out that the nuclear programme shall target connection to the grid as outlined in the IRP 2010-2030 or the updated version. The determination was gazetted as the roadshows for the public consultation on the Draft IRP 2016 drew to a close but was signed by the Minister for Energy on 5 December 2016, just ahead of the public consultation process. The case by SAFCEI/ELA, challenging the determination, has been adjourned for hearing on February 22 to 24. The Court ordered the Minister of Energy to pay the applicants' costs on a punitive scale, including the costs of four counsel.
Dec 2016	Mr Koko (acting CEO Eskom), announces the intention to launch the nuclear RfP following the Government gazette nuclear determination. He cites urgency for base load capacity, protection of the people of SA and economy and the inability of Renewable Energy (RE) in SA to meet baseload requirements to supply energy 24/7/365 to SA as among the primary reasons. The RFI is launched on 16th December 2016 and Eskom has indicated it expects to launch the RFP mid 2017, with evaluations of bids concluded by close of 2017.

Apart from the interest value of this timeline, the history demonstrates a lengthy process of building skills and capacity around nuclear energy in South Africa. For example, Lesedi Nuclear Energy Services is a company that was spawned from French investment in the Koeberg nuclear plant. (Areva was initially, and until recently, the major shareholder. Group Five, a South African construction company, is now the majority shareholder.) The company currently employs 150 permanent and 110 contract workers (Pereira, pers. comm., 16 January, 2017), including highly skilled employees such as design engineers. Lesedi is also partly responsible for safety at Koeberg, which ostensibly has a strong safety track record (measured statistically in terms of the number of directly caused deaths per year), although designs for and implementation of waste management infrastructure is lagging, with the nuclear fuel ponds allegedly holding three times the amount of waste that they were originally designed for.

The history also speaks to South Africa's international relations, which diplomatically and economically are linked to the country's nuclear energy relationships. It is evident that Russia is a significant partner and that there has been a shift away from relations with France, the USA and the UK.

D I Risks and potential for nuclear energy investors in SA

An overarching theme emerging from the global and situational analyses is uncertainty: uncertainty as to SA's economic future, the related demand for energy and the country's ability to afford expensive, if reliable energy; uncertainty as to a 'good practice' model for the future of the power sector; uncertainty as to the viability of fast emerging technologies that could enable a cheaper, more flexible alternative to the lock ins created by nuclear build; uncertainty for future generations left with plants to decommission and nuclear waste and uncertainty around the success rates of other large-scale nuclear build programmes taking place in countries such as China. In the case of the latter, as well as some of the other uncertainties, it is too soon to tell.

Measuring risk

The level of risk is measured as the probability of the event occurring, multiplied by the level of impact the event is expected to have. This approach to measuring risk is visually represented in the matrix in Figure 3.

Risk = Probability x Impact Figure 3 provides a populated matrix, illustrating risk, made up of probability and impact.

Figure 3. Matrix used to represent risk. Risk = Probability x Impact

Probability of the Event Occuring			
High	Medium Risk	High risk	Extremely High Risk
Medium	Low Risk	Medium Risk	High Risk
Low	Low Risk	Low Risk	Medium Risk
	Low	*Medium*	*High*
	Expected Level of Impact		

There are nonetheless, several risks to discuss with some certainty, associated with investing in the proposed nuclear build programme in South Africa. These include political, financial, socio-economic, environmental, safety and security, and legal risks, each of which is discussed below. There are also identified opportunities, discussed briefly after the evaluation of the risks.

Political risks

Deemed the biggest risk for SCI, this is discussed first. The level of uncertainty outlined above raises an obvious question: Why, in the face of unpredictable electricity demand, in a declining economy with numerous, competing socio-economic priorities, and where there is so much controversy, including around disruptive technologies, is the nuclear deal a top political priority? The nuclear deal has been, and continues to be challenged for being shrouded in a veil of secrecy, with a pending court case that challenges the governance of the matter. While all of this remains to be proven in the courts, allegations of corruption have dogged the proposed nuclear deal from the outset. At the time of writing this paper, enough evidence is available to point in the direction of large-scale, systemic corruption to give cause to put pen to paper on the matter.

Based on expert interviews for this report, the nuclear deal is considered to be grand corruption. Grand corruption is defined by Transparency International (TI) as the abuse of high-level power that benefits the few at the expense of many, and causes serious and widespread harm to individuals and society. TI further states that it often goes unpunished. Grand corruption is a term that refers more to the level at which it occurs, rather than to the amount or scale of money involved, taking place at the policy formulation end of politics – where policies and rules may be unjustly influenced. The types of transactions are usually large in scale. TI states on its website, that "grand corruption is a crime that violates human rights and deserves adjudication and punishment accordingly. This ranges from stealing from public budgets used to build hospitals and schools, to constructing dangerous facilities as the result of underfunding caused by corrupt actors" (TI, 21 September, 2016 and pers. comm., H van Vuuren, economic corruption expert, Institute for Justice and Reconciliation, January 2017).

The manner in which the nuclear build programme and related policies have evolved speaks to the key components of grand corruption: i) manipulation of facts to push toward large-scale procurement (see the IRP process, Box 3); ii) the complicated technical nature, confusing officials and the public alike, and; iii) related security issues, allowing politicians to create a veil of secrecy in the interests of national security (interview with H van Vuuren, Economic corruption expert, Institute for Justice and Reconciliation, January 2017). Furthermore, political dependency is said to often be created through this level of corruption, since grand corruption usually involves group activities that are global in scale. In this case, there is evidence of this agenda in the Russian agreement, which for example stipulates that if South Africa wishes to sub-contract part of the build programme, it must get Russia's approval. Russia has also alluded to its intention to manage the nuclear waste, provide the ongoing fuel requirements and to finance the upfront capex.

The Institute also supports the view that there are many parallels here with the case of South Africa's arms deal, only this is potentially much bigger; South Africa would be buying large-scale technology it does not need, while promising the economy jobs and socio-economic spin-offs that are beneficial, and will be financed through the international finance system.

What evidence is there for grand corruption?

Evidence and process surrounding the nuclear court case brought by SAFCEI/ELA against DoE):

- The Minister of Energy arrived in court with five agreements, implying that with so many, none could be binding; one each from Russia, France, China, Korea and the USA. On examination, the Russian agreement is specific and detailed, relative to the others, and scrutiny by Senior Counsel says that it has the potential to be upheld by international law (D Unterhalter, SC, pers. comm. December 2016). The specificity of the agreement points to the Government already having a preferred vendor in mind, despite the open Request for Proposals estimated to be launched mid 2017.
- The Minister repeatedly delayed providing information called for ahead of the court case, often ignoring set dates and calls for information.
- On the date of the court hearing, the case was adjourned to February 2017, following a surprise court order, on the same day, giving Eskom the Determination required for them to front the procurement process for nuclear. Not only did this delay the court case, it also allows the procurement process to continue without the lead institution being bogged down in a legal process (Eskom is not part of the court application).

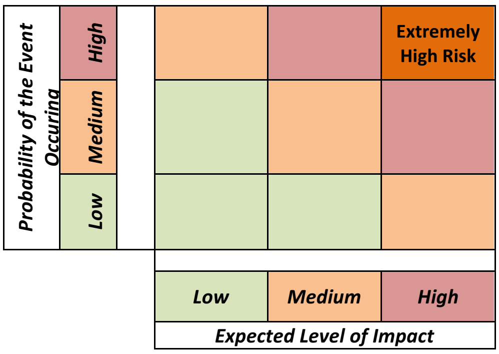
Contradictory statements from Government:

- "South Africa's nuclear programme is non-negotiable and the National Development Plan (NDP) supports it." (Department of Energy Director-General, Parliament, 15.04.13)
- "South Africa needs a thorough investigation on the implications of nuclear energy, including its costs, financing options, institutional arrangements.... a potential nuclear fleet will involve a level of investment unprecedented in South Africa. An in-depth investigation into the financial viability of nuclear energy is thus vital." (National Development Plan)
- "South Africa needs an alternative plan – 'Plan B' – should nuclear energy prove too expensive, sufficient financing be unavailable or timelines too tight. All possible alternatives need to be explored." (National Development Plan)
- "South Africa's nuclear power plant planning process is at an advanced stage and the multi-billion dollar procurement process should be completed by the end of this financial year." (President Jacob Zuma, 11 August 2015)
- "The nuclear energy expansion programme remains part of the future energy mix. Our plan is to introduce 9 600 megawatts of nuclear energy in the next decade. We will test the market to ascertain the true cost of building modern nuclear plants. Let me emphasise that we will only procure nuclear on a scale and pace that our country can afford." (President Zuma, State of the Nation Address, 11 February 2016)
  (adapted from Anton Eberhard, March 2016).

The presence of corruption in the SOE

- The SOE (Eskom) is responsible for energy planning, (IRP) modelling and for the procuring, owning and operating of the nuclear build programme.
- The SOE's recently departed CEO, Mr Molefe, has a long history of allegations of corruption, including allegations against him while at Eskom.
- The SOE's Acting CEO (previously Head of Generation) and the Finance Director are widely understood to be tainted with allegations of being corrupt officials (also implicated in the State of Capture Report).
- Eskom is seriously implicated in the State of Capture Report.

Figure 4. Risk of grand corruption



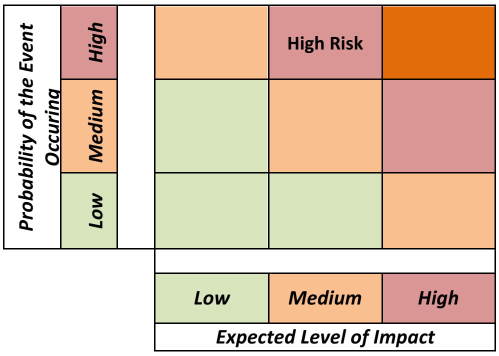
Why is grand corruption a significant risk for SCI?
Soul City is a renowned NGO with a sustained and robust track record for promoting social justice. ***The probability and impact of this risk being realised are both high***; Soul City's reputation surrounding its core business could be severely compromised, while participating in a programme associated with grand corruption is against the principles of ethical investment embedded in the SCI Investment Charter.

Financial risks

Two primary financial risks are considered:

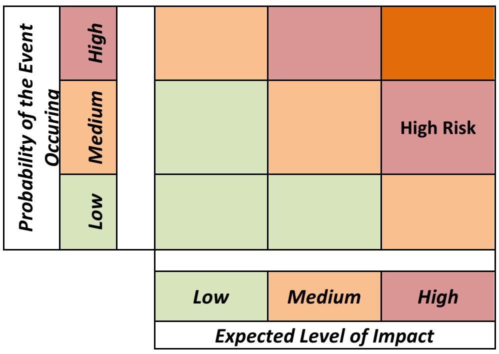
i) The inflexible nature of large scale nuclear build programmes means that investors are locked into agreements and prices before the plant has begun to be built. There is no room to adapt to market conditions as these evolve, for price or for energy market structure. This means for example that if RE becomes less intermittent because of evolved storage technologies that have been tried and tested and for which capacity has been built, it would be difficult, or even impossible, to downsize the use of nuclear and upscale the use of RE, unless the demand for energy increased substantially. While this is a risk for the country more than a small investor, *the associated risk of increasing or spiralling costs associated with nuclear build does pose a direct risk*. Experience from around the world, as well as of Eskom's recent record of building new coal-fired generation plants, shows that *the risk of cost overrun is high and is likely to reduce the return on investment.*

Figure 5. Financial risk (i) Risk of cost overrun



ii) A further financial risk directly applicable to SCI relates to the possibility of *South Africa being left with stranded nuclear assets because of over investment in generation capacity for which there is inadequate demand*, a situation that is expected to continue (see Box 4, section C). Stranded assets are not likely to yield any returns on investment and this is a risk for the country and all investors in a nuclear build programme for which there is insufficient demand.

Figure 6. Financial risk (ii) South Africa is left with a stranded nuclear asset



Direct risks regarding financial issues to SCI

i) High probability, medium impact

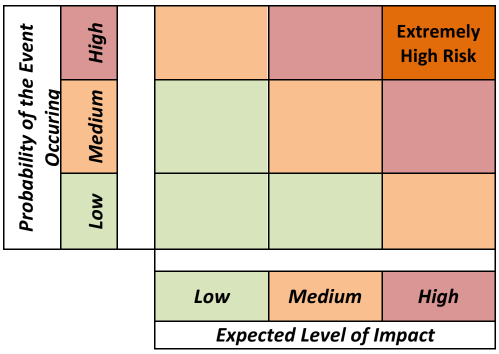
ii) Medium probability, high impact

Socioeconomic implications of nuclear energy

Modelling developed by the Energy Research Centre (ERC) at the University of Cape Town shows a 94% chance that South Africa's electricity price will be greater with a commitment to nuclear power, by 2030, with a 20% chance that the price will be at least 10% higher. Under their worst case scenario for nuclear, which assumes an average rate of economic growth at 2.7%, the ERC model forecasts that 75,000 jobs will be at risk in the economy, with consumers being hit directly both by high electricity prices and by overall decreased economic growth (ERC, 2015).

National Treasury's position on nuclear energy is noteworthy here: in two reports they have presented to Cabinet on the topic, Treasury has made it clear that the nuclear programme is not viable and that unless South Africa can guarantee 70% local finance, the programme is unaffordable. The trade-off costs for socioeconomic programmes such as public health are likely to be significant, as the national fiscus does not have these levels of reserves or capacity. Should the Russians do as they promise, which is to finance the upfront capex, they will recoup from the future consumer and the country would still have to produce adequate finance for operational expenditure (opex). In this scenario, electricity prices would increase significantly, raining questions as to consumer affordability, ultimately, reducing the return to the investors.

Figure 7. Risk of nuclear pushing up electricity prices



Risks to SCI

This is primarily a reputational risk in that SCI could be seen to be gaining returns on investment at great cost to the consumer, raising questions of ethics. Ultimately though, if the consumer cannot afford the increasingly expensive electricity, the investor's returns would be at risk.

High probability, high impact

Environmental, safety and security implications of nuclear energy

Three types of risk are considered:

i) Waste management risks in the medium and long terms

ii) The risk of a nuclear accident and disaster

iii) Risks to national security

These are interrelated and therefore discussed briefly together.

The management of nuclear waste has posed problems for the industry for decades. New technologies, designed to 'eat' the waste, have been tried and failed (to date); and the lifespan of the waste material is thousands of years. This means that decisions taken today have implications for many generations to come and the associated risks of disasters will have a similar lifespan, long after the energy generating reactor has reached the end of its lifecycle. The risk is exacerbated by current levels of design and planning. While the nuclear industry has among the highest standards known in the energy sector, precisely because of the safety and security hazards of nuclear, research has highlighted that typically, plants are designed for five years of waste management, with the expectation that the next phase will be designed during the five-year period and the plant upgraded accordingly. It is evident however that this has not been the case at Koeberg, which nonetheless has high ratings for safety. Koeberg's nuclear waste ponds, as a result, carry around three times the waste they were designed for, heightening the impact of a potential accident or disaster.

While disasters, for example of the magnitude of Fukushima, are relatively few, when they happen, the consequences are immense and long lasting, experienced in direct financial costs, socio-economic costs, loss of life at scale, long term health and environment consequences and massive cost to infrastructure. In South Africa's present economic environment, there are few reserves to absorb the related financial costs and the social investment that would be required to restore, or partially restore the country. International aid would be required, creating a new course of dependency, with a possible downgrade in economic status and standing in the international community.

Although dismissed by Government, the USA, along with national and international experts, predict that South Africa is facing an increasing risk of acts of terrorism, not least because of porous borders and known terrorism training that takes place in the country (ISS, 2014, British Peacekeeping Force, 2014, USA Government, 2016). A nuclear plant is a recognised target, potentially triggering a large scale nuclear disaster.

A key consideration is whether or not South Africa has the discipline to mitigate all three risks. The country has been proven to have a poor track record in managing long term environmental risks, despite a relatively sophisticated regulatory environment. The mining industry provides an example of the country's inability to foresee, plan for, mitigate and hold accountability for acid mine drainage. This has become a large scale problem for the country's already scarce water resources and the problem has been allowed to become so big that it is now considered by many as being too late or too expensive to resolve. Figures 8, 9 and 10 below illustrate the risks of waste management, risk of a nuclear disaster or accident and risks to national security.

Figure 8. Waste management risks

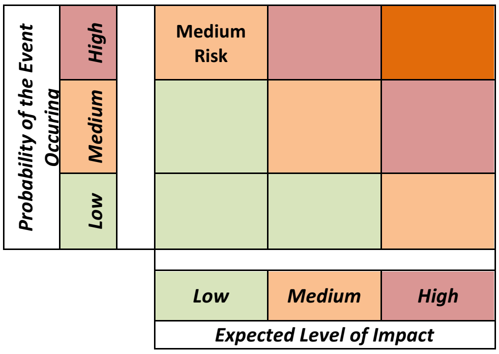


Figure 9. Risk of a nuclear accident and disaster

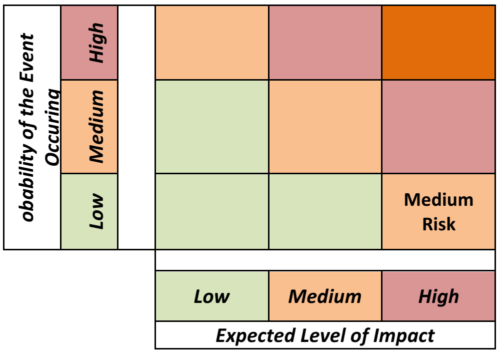
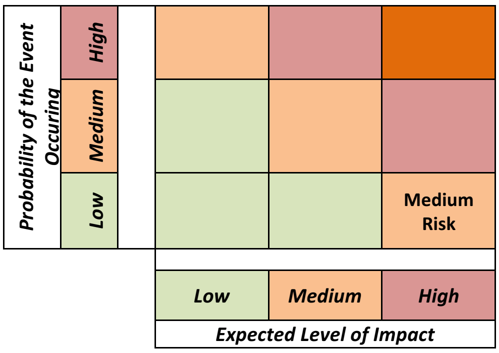


Figure 10. Risk to national security



Risks for SCI

The associated risks are both financial and reputational in nature.

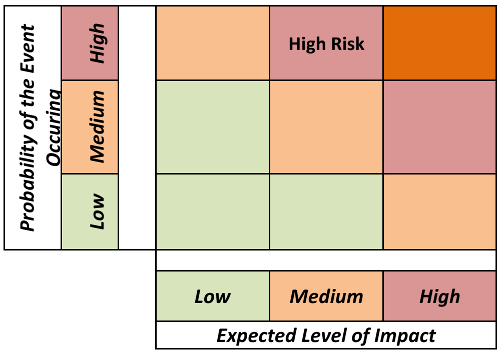
1. High probability, low impact
2. Low probability, high impact
3. Low probability, high impact

Legal risks

Legal risks considered are twofold:

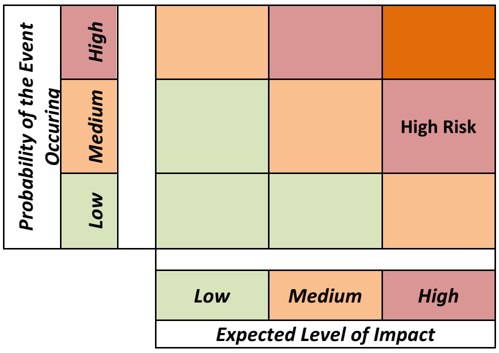
i) *South Africa's domestic regulatory environment is at odds with international law* (the Russian agreement) as discussed earlier. Given the continued robustness of the country's legal and court system, and as already evidenced in the nuclear court case currently underway between SAFCEI and the Government, there is a strong possibility that the nuclear build programme will be challenged by protracted legal processes and court cases. Moreover, although other civil society players, such as Corruption Watch may also enter the fray, the legal battles may not be limited to civil society action, with the private vendors who have much at stake, also possibly challenging the alleged done deal for Russia. As it is, Eskom has been challenged legally by Westinghouse through a procurement process surrounding Koeberg, resulting in recent public statements by Eskom officials that the process damaged their relationship with Westinghouse.

Figure 11. Legal risk (i): Ongoing legal challenges



ii) *International vendors are experts at protecting their interests contractually*. It is to the advantage of those with vested political interests in the nuclear deal to secure this deal quickly, as their returns are not necessarily tied to the longer term process of early plants actually selling power. These financial flows are likely to be available from signing the deal and then commissioning plants. Therefore, should the country subsequently decide not to proceed, because the power is no longer needed, or for reasons of affordability, contractual obligations could be challenged at a much later stage of the process than where the country is today. Bulgaria's recent experience (see Case study 3), is a useful example of what can happen when a country attempts to change its mind after signing a contract with Russia.

Figure 12. Legal risk (ii): Future legal action



Risks for SCI

i) Protracted court cases may raise the visibility of SCI as an investor in the nuclear build programme, potentially damaging its reputation. Furthermore, it is likely that there will be associated financial implications. ***High probability, medium impact***

ii) Russia (and other international vendors) are experienced and well versed at entering into these sorts of contracts, experience that is low in South Africa (with experience only from a relatively small nuclear plant, commissioned and built before the current political regime). Furthermore, the likelihood that SA would decide, under future political leadership, that the planned level of nuclear capacity is not needed, is strong, given analysis in this paper. ***Medium probability, high impact***

Case study 3. Bulgaria and the Belene Nuclear Saga

As the poorest country in the European Union (EU), Bulgaria has experienced modest rates of economic growth and thus only a slight increase in energy demand over the last decade. At the same time, the country continues to be one of the most significant net exporters of electricity in the Balkan region. A third of the country's electricity is supplied by two operating nuclear reactors at the Kozloduy nuclear power plant. The first one of these came into operation in 1974 and since then the country gradually constructed and commissioned a total of six nuclear reactors. However, four of these were closed by 2007 as part of the pre-conditions for Bulgaria to join the EU due to safety concerns over the out-dated technology at the station (Schneider et al., 2016).

Nevertheless, the government's commitment to the future of nuclear energy seems to remain strong. In 2005, Bulgaria resurrected its plans to build a new nuclear power plant in Belene. Construction at the site originally began in the 1980s and the first reactor was partially built (40%, with 80% delivery of equipment), but was abandoned in 1991 due to lack of financing for the project. Since the 1990 there have been on-going attempts to re-start the construction. Negotiations on the project involved nuclear vendors and construction companies from Bulgaria, France, Germany, and Russia. In 2005, the government approved the construction of the plant and in 2006, the Bulgarian National Electricity Company (NEC) chose Rosatom subsidiary Atomstroyeksport (ASE) over a Skoda-led consortium to complete the power plant, which consisted of two 1060 MWe capacity third-generation VVER-1000 (AES-92) units (WNN, 16 June, 2016). In 2008, the Bulgarian government signed a contract for the equipment and construction with an ASE-lead consortium, which included Areva NP, Siemens and number of Bulgarian enterprises.

After a series of unsuccessful attempts to attract foreign investors for the $10.5 billion project, in 2012 the Bulgarian government officially cancelled the project (WNN, 16 June, 2016). In addition to funding challenges, the project also came under pressure from Brussels and Washington, due to the fact that it risked increasing Bulgaria's energy dependence on Russia (Reuters, 9 December, 2016). Following the cancellation of the project, Rosatom took the case to an international arbitration court, which ruled in June 2016 that Bulgaria's NEC needs to pay $620 million compensation for the nuclear equipment it ordered, according to the contract it had signed with ASE in 2006. In return, Bulgaria will receive from Rosatom one fully assembled nuclear reactor and parts of a second one. At the moment, there is not clear plan as to how the government will manage the stranded assets. There have been statements from the energy minister Temenuzhka Petkova that a number of companies, including the China National Nuclear Corporation (CNNC), have expressed interest in picking up the project. However, non of these have so far been confirmed and in case negotiations fail, Bulgaria will have to seek a buyer for the nuclear equipment it bought from Russia (Reuters, 9 December, 2016).

The arbitration case is seen as Rosatom's biggest success of 2016, according to an analysis by Russian agency Interfax. The analysis also lists on-going negotiations between Rosatom and a number of countries internationally – in Turkey, Iran and India. However, only the ruling for Bulgaria to pay Rosatom a compensation of $620 million is seen as a positive achievement of the Russian company in 2016 (Interfax, 26 December, 2016).

Potential for nuclear investment

The nuclear build programme is likely to follow a similar route in terms of BBBEE requirements as the recent new coal fired generation capacity did, which required a 51% BBBEE shareholding structure. This immediately presents an opportunity for SCI, who could co-invest in the BBBEE component.

Should the nuclear build programme proceed, the investment itself is potentially an attractive one in that the programme is large scale and long term. The reactors are likely to be built in pairs, and not in parallel, meaning that it could take a few decades to complete the build programme, with potential returns on investment each time another module of the build programme is commissioned. Assuming the entire build programme is realised, which would mean that the financial guarantees are in place, the possibility of a sustainable and longer term revenue stream for the investor is strong, provided that energy demand grows and stabilises and the electricity does not become unaffordable.

Given the financial rewards at stake and the involvement of political players and state institutions in the process thus far, the possibility that the primary BBBEE investor has already been identified by upper echelons in government, is very strong. This would not necessarily mean that there is no room for a smaller investor such as SCI. Rather, SCI's involvement could be viewed by political actors as an opportunity to legitimise the investment structure and players. SCI would therefore need to conduct an extremely thorough due diligence of the investment structure and players, under circumstances that are likely to be difficult and not fully transparent. The reputational and financial risks for SCI are considered to be significant, with high probability of these risks occurring.

It is possible however that events could play out differently in the future: the feasibility and technology evaluation studies that have been called for, could be produced by neutral experts, validating the technology choice, energy demand scenarios and the viability of the programme. A more accurate analysis of future demand scenarios (and the need for nuclear, as well as affordability) may be forthcoming. Noting that to date, these studies do not exist and many of the country's energy experts are not in support of the nuclear build programme, although there are voices, globally and locally that promote the nuclear solution as part of the country's future energy mix. Should these studies be produced, credibly validating nuclear investments, the energy programme would become decoupled from the political agenda, creating a much more attractive and less risky investment environment that is founded on solid rationale and the support of National Treasury, civil society and energy experts.

In conclusion, the risks appear to outweigh the opportunities for SCI by a significant margin. Much is at stake for a few players in an uncertain and fraught political environment in South Africa. A massive infrastructure programme of this nature is unavoidably a politically driven programme, because it is clearly located within the global energy environment and its politics – which are also uncertain, changeable and politically fraught. Thus, the key question for SCI is, is it worth risking the robust reputation of a highly credible organisation*, under the circumstances outlined in this document?*

E I Recommendations

Recommendations to the SCI as the sole shareholder of the SCBBEC, are framed by the information outlined throughout this paper, the risks considered in section D, and importantly, by the prevailing atmosphere of uncertainty in global and local energy politics and economics. Furthermore, note is taken of the investment strategy of the company in relation to potential for its investments in the energy and nuclear sector; whatever the technology, energy investments are critical to South Africa's long term development. This is true in terms of securing South Africa's socio-economic future, to which a secure energy environment is integral, and is articulated in the SCBBEC Investment Charter.

The Soul City Broad-Based Empowerment Company (SCBBEC) is mandated to:

- acquire an equity portfolio that will contribute to the long-term funding, and hence the sustainability, of the SCI
- acquire stakes in companies operating in South Africa as their broad-based empowerment shareholder (or as part of a group of such broad-based shareholders), and feed the returns on these investments back to the SCI.

The nuclear build programme, at face value, ignoring the political and cost-related/affordability discussion outlined above, may appear to present a sound opportunity for SCI to acquire a sustainable source of funding. As a BBBEE shareholder, SCI is well positioned to play a role in the programme. As indicated, SCI is likely to be an attractive shareholder given its robust reputation and legitimacy.

Two pathways are available to SCI. The first, preferred in terms of the evidence outlined in this paper, is to completely and permanently close the door on investing SCI's finances and reputation in South Africa's nuclear build programme. The second pathway, is to take note of the possible uncertainties in how the future could play out, and to track the opportunity closely, with a view to possible investment, should there be a change in the politically driven and therefore skewed agenda.

The preferred (first) option is recommended on the basis that the stakes are high, the political links are strong, and South Africa can ill afford to enter another Arms Deal-like scenario, with a nuclear build programme being set by all accounts to be on an even greater scale.

The second pathway is that the critics are wrong and more specifically, that there is the possibility that South Africa requires a large-scale energy infrastructure investment programme, where nuclear is the only option. Were this to be proven beyond reasonable doubt (not the case today), then the energy programme could become decoupled from the political agenda. Of course, this would not necessarily mean that grand corruption is no longer at play. A legitimised energy programme of this scale is likely to feed into the vested interests of the political players in the process.

Applying '**the precautionary principle'** is therefore highly recommended for SCI, should the organisation choose to pursue the alternative pathway of a nuclear investment option. The precautionary principle is widely applied in the global financial environment, when dealing with risk. The principle states that when there is an apparent but not yet scientifically proven threat to society or to the environment, scientific uncertainty should not prevent prudent actions to prevent potentially large damage. Thus, the precautionary approach is applied in order to protect society and the environment. Fundamentally, where there are potentially grave or irreversible threats, lack of full scientific consensus should not be used as a reason for postponing cost-effective action. The precautionary principle is often found in relevant legal treaties and dates back to early law, for example in Justinian's statement in 527 AD, that "the maxims of law are to live honestly, to cause no harm to others, and to give everyone his due" (Thomas, 1975).

In other words, should SCI choose to pursue this opportunity, the organisation would greatly benefit from proceeding with caution. This approach requires close scrutiny of the nuclear procurement process, paying attention to the relevant aspects of politics, socio economics and energy economics, locally and globally. At a subsequent, although later stage, it would require a thorough due diligence of the unfolding investment and financing structure proposed for the programme, the investors and the preferred Vendor, and thus the technology supplier and the contractual arrangements. At each stage, a detailed risk assessment would be critical, accompanied by a cost benefit analysis that is done in consideration of the precautionary principle.

The pursuit of the nuclear investment opportunity is likely to be expensive and difficult for SCI. This is a fraught pathway, with many obstacles to resolve before signature is put to any agreement, of either intent or full commitment.

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Annexures

Annex 1. Schedule of interviewees

Name	Role	Institution	Contact details	Date of Interview
Philippe Joubert	Senior Advisor and Special Envoy Energy and Climate; ex President of Alsthom Power	World Business Council for Sustainable Development (WBCSD)	Phjoubert54@gmail.com	23 December 2016; 29 January 2017
Nicky Prins	Senior Analyst	National Treasury, State Owned Enterprises Unit	Nicky.prins@treasury.gov.za	21 December 2016
Andre Kruger	Advisor	NEPAD Business Foundation: Africa Investment & Integration	Andre.kruger@thenbf.co.za	22 December 2016
Shane Pereira	Business Development Manager	Lesedi Nuclear Services	shane.pereira@lesedins.co.za	16 January 2017
Peter Becker	CEO	Koeberg Alert Alliance	peter@koebergalert.org	17 January 2017
Chris Yelland	Managing Director	EE Publishers	chris.yelland@ee.co.za	19 January 2017
Knox Msebenzi	Managing Director	NIASA	Knox.Msebenzi@vdw.co.za	19 January 2017
Des Muller	Supply Chains	NIASA	dmuller@groupfive.co.za	19 January 2017
Ellen Davies	Policy and Futures Unit: Nuclear and Mining	WWF	edavies@wwf.org.za	21 January 2017
Mary Waller and James Cumming	Manager and Project manager	African Clean Energy Developments (ACED)	Mary.waller@aced.co.za James.cumming@aced.co.za	22 January 2017
Saliem Fakir	Manager, Energy and Urban Futures	WWF	sfakir@wwf.org.za	23 January 2017
David Nicholls	Chief Nuclear Officer	ESKOM	david.nicholls@eskom.co.za	10 February 2017
Mandy Rambharos	Climate Change and Sustainable Development Manager	ESKOM	mandy.rambharos@eskom.co.za	7 February 2017