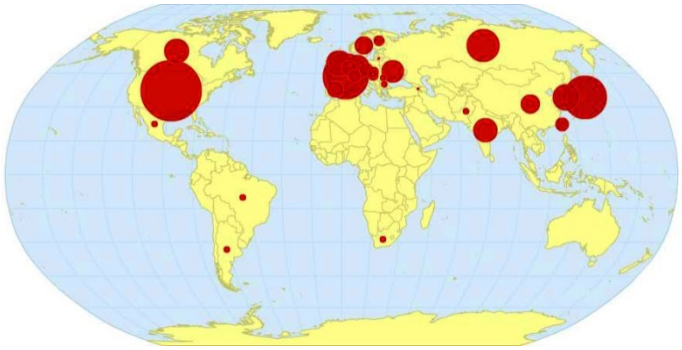
Is Africa ready to grow a nuclear power market?

In 1984 South Africa took the lead in synchronising Africa's first nuclear power plant to the grid. Nothing has changed since then, until now. South Africa is due to officially announce the nuclear new build roadmap and countries such as Kenya, Egypt, Ghana and Nigeria are actively pursuing nuclear options.

The ever growing demand for electricity generation across Africa and the necessity of developing and using safe, reliable and economical sources of energy are encouraging African countries to consider both renewable energy options in solar, wind and hydro as well as adding nuclear to their long-term base-load generation roadmaps. Globally, there are 436 civil nuclear power reactors that are currently under operation and 68 nuclear reactors were in construction stages in 14 different countries, as of July 2013. 1 Nuclear energy is used to generate around 11% of the world's electricity, with almost zero greenhouse emissions.

South Africa's nuclear future
With an over reliance on coal fired power stations (96% of power in RSA generated by coal) and the fact that many of these stations are to retire in 2022, a viable base load alternative is required to prevent power outages and achieve the economic growth forecast. When the former Minister of Energy, Ms Dipuo Peters, announced the appointment of Dr Bismark Tyobeka to the position of Chief Executive Officer of the National Nuclear Regulator of South Africa, she stated that "Dr Tyobeka brings a wealth of nuclear expertise to the NNR and is suitably poised to guide the NNR at a challenging and exciting time." In the following exclusive interview we tap into this vast knowledge and examine the possible future of nuclear in Africa.

Dr Tyobeka, what will your core focus areas be in terms of the role you are taking up in October as the Chief Executive Officer of the National Nuclear Regulator of South Africa?
My role and focus will be to carry out the core mandate of the National Nuclear Regulator (NNR). This is to monitor and enforce regulatory safety standards for the achievement of safe operating conditions, prevention of nuclear accidents or mitigation of nuclear accident consequences, resulting in the protection of workers, public, property and the environment against the potential harmful effects of ionizing radiation or radioactive material. In order to achieve that, my focus will be to ensure that NNR is properly resourced both financially and in terms of human capital. My vision is to create a fully independent regulatory body, with world-class expertise. We should be able to declare without fear or favour, that we have the calibre needed to execute our mandate to the letter. In anticipating the nuclear new build in South Africa, I think the focus will be to up the NNR's readiness level to handle the daunting task of licensing new nuclear power plants, a process which South Africa has not gone through in almost 30 years.



436 Nuclear Power Reactors in operation worldwide - total net installed capacity of 372,900 MWe. Source: World Nuclear Association, Reactor Database

What are your thoughts on developing a nuclear power generation industry in Africa?
With all the realities of ensuring security of energy supply and less reliance on fossils, reducing the greenhouse emissions as well as creating hi-tech industries for job creation and economic prosperity, nuclear is an attractive option for African countries, and any other country in the world for that matter. However, it should be noted that a nuclear power programme is a life-time commitment for the country and it needs extensive infrastructure preparation before it is launched. Starting from legal and legislative framework, to having an independent regulatory body, developing the necessary human capital as well as the industrial capacity to handle a project of that magnitude, construction, operation and up to decommissioning a nuclear power plant can take a commitment of 80 years or more. So, it is very important to make sure that a country becomes an intelligent customer, before engaging in a nuclear project. Moreover, nuclear projects are capital intensive projects, so, for African countries who are developing countries with many socioeconomic challenges, the issues of financing should be closely examined. Assuming that all these have been given a green light, I think nuclear power can be a boom for Africa and South Africa. As regulators, our task will always be to make sure that operators of nuclear installations take all the necessary steps to ensure that they are safe and secured.

How different could a future (30-50 years ahead) African nuclear sector look compared to the global market?
A number of African countries have indicated and indeed expressed their interest in going nuclear. Despite what we see happening in Japan and what happened in Germany, there is still a future for nuclear globally. If the world has to continue modernising and bringing about a better life for its citizens through economic development,

energy needs will continue to grow, and no single source of energy will be sufficient. A sound energy generation mix will increasingly be called for, and nuclear will be part of that mix.

In South Africa power generation is predominantly reliant on coal, and the new nuclear build envisaged in the Integrated Resource Plan is set to increase it by 9,600 MW. However, would our abundant resources in renewable energies (solar, wind and hydro) not be a more viable option?
I am not sure if I should label our renewable energy resources as “abundant” but yes we have enough sunshine, maybe not too much wind, and not really too much water. As the climate change becomes a reality, we see a lot of droughts and these can affect our rainfall patterns and hence our hydro power resources become constrained. On top of that, we must also keep in mind the cost of renewable energy which is not as cheap as people continue to advocate it to be. So, a healthy balance must be struck, taking into consideration that renewables are not base-load and cannot always be available. On the other hand, whilst nuclear power plants may be too expensive, there is a good return on investment on these plants, given the fact that the lifetime of nuclear power plants is now increasing up to a possible 80 years.

There are a number of countries in Africa that have expressed keen interest in nuclear power generation; what will it take to get to a level of readiness?
Strategic partnerships between African countries and nuclear operating countries will be necessary to get these African countries up to speed with understanding the challenges of the nuclear business and understanding what it takes to get a nuclear power programme up and running from scratch. Increasingly, financing models must also be explored with supplier countries to ensure mutual benefit from these nuclear programmes. For this to happen, more and more government commitment will be necessary, because nuclear, as I said, is a very long term commitment for any country. One big challenge that we have in Africa is that, for example, there are no nuclear power engineering schools or training programmes. We need more of these to make sure that we develop our own crop of nuclear scientists and engineers who are well versed in global nuclear design and safety standards. We must leverage the assistance from international organizations such as the International Atomic Energy Agency (IAEA) and the Organisation for Economic Co-operation and Development/ Nuclear Energy Agency (OECD/NEA) as well as the European Atomic Energy Community (EURATOM) to advance the level of preparedness needed to kick off nuclear projects in Africa.

Africa’s only nuclear power plant, designed with two uranium pressurised water reactors, was synchronised to the grid in 1984. What new technologies have come about since then that impact positively on the life span, safety, and generation capacity in nuclear plants?

African Utility Week 2013 offered an exclusive behind the scenes tour of Koeberg Nuclear Power Plant in Cape Town.

Soon after 1984, we had the Chernobyl accident in 1986 and that brought about a new culture in how we deal with nuclear safety. More safety requirements were brought into play, and the IAEA Safety Standards also came into being. As a result, nuclear vendors and design organizations began to look into more inherently safe systems and reactor designs that incorporate passive safety systems. To-date, most of the designs available for the market such as the Westinghouse AP-1000, AREVA’s EPR, the Russian VVER-1200, the Korean APR1400, the Japanese ABWR, APWR 1000, ESBWR etc. All incorporate extraordinary passive safety systems, including the provision of a core-catcher in the case of a core melt, design for a big aircraft crash on the containment and many diverse safety systems. Additionally, the market abounds with Small and Medium Sized Reactors, so-called SMRs. These are the reactors that have been designed to be small in size and can be added incrementally in modules. This gives customers with smaller power requirements economical, reliable, and carbon-free power in their portfolio and act as a good fit for process heat and steam applications, such as refining, desalination and district heating. The innovation in these reactors, apart from size, is the integral design, which incorporates all systems inside the vessel and have passive safety features too. Safety improvement is mostly due to a relatively small source term and these passive safety features which do not need any human intervention in the case of an accident, so the reactor shuts itself down and heat is removed through passive means. The leading SMRs are the NuScale, MPower and Hyperion, from the USA, and there is the KLT-40s design which is already under construction in the Russian Federation. This is an interesting one because it is actually a barge-mounted nuclear power plant, so-called floating NPP, which can operate off-shore. The technology was adapted from the Russian nuclear submarines and ice-breakers.

Will technologies such as thorium and pebble bed modular reactors become more prevalent?
The pebble-bed type reactors are a good innovation with intrinsic safety features due to the TRISO (Tristructural-isotropic) fuel design, which ensures that in the case of an accident, there is virtually a complete confinement of fission products in the coated fuel particle. Currently there is an HTR-PM (High Temperature Reactor - Pebblebed Module) which is a pebble-bed type reactor being constructed in China and is planned to put the first electricity on the grid by 2017. If the progress in China continues and the project is completed successfully, the

market can potentially see a flood of these reactors as they promise much more than producing electricity. The high outlet temperatures can actually be leveraged for other process heat applications such as coal gasification, sea water desalination, fertilizer industry applications and many more industrial processes that require the use of high temperature steam.

Full name: B&W mPower reactor
Reactor type: Integral pressurized water reactor
Coolant/moderator: Light water
System pressure: 14.1 MPa
System temperature: 320°C
Thermal capacity: 500 MW(th)
Electrical capacity: 150 MW(e)
Fuel material: UO2
Fuel enrichment: 5%
Fuel cycle: 4 years
Distinguishing features: Internal once through SG, pressurizer and control rod drive mechanism

Reactor type: Pressurized water reactor
Coolant/moderator: Light water
System pressure: 12.7 MPa
System temperature: 316°C
Thermal capacity: 150 MW(th)
Electrical capacity: 35 MW(e)
Design life: 40 years
Fuel material: UO2
Fuel enrichment: <20%
Fuel cycle: 28 months
Distinguishing features: Floating nuclear power plant

Full name: High temperature gas cooled reactor, pebble bed module
Reactor type: High temperature gas cooled pebble bed reactor
Coolant/moderator: Helium/graphite
System pressure: 7 MPa
System temperature: 750°C
Thermal capacity: 500 MW(th)
Electrical capacity: 211 MW(e)
Design life: 40 years
Fuel material: UO2, UC2, UCO
Fuel enrichment: 8.9%
Fuel cycle: Open
Distinguishing features: Prototype for commercial sized HTGR

Nuclear build programmes are lengthy projects with challenges around financing; what are the options to consider?
There are several financing options available for new nuclear projects which include full financing by the state; however this is not very feasible for most developing countries. Then there is the possibility for loans by utilities, where the state may have to provide some loan guarantees, and as you would know, that is also a difficult undertaking by the state because of a relatively high risk in nuclear projects. The most interesting financing model is the one that the Russians have just completed with the Turkish, where they will carry the entire cost of the nuclear power plant and the Turkish government has to provide the land and provide guarantees for power purchase from these plants. Over a number of years the Russians will own and operate these plants and then get paid back through selling electricity, but the Turks will get a certain percentage of the electricity sales. Eventually, the plants can be bought by the Turkish government. This is an adjusted Build-Operate-Own (BOO) turnkey financing model. I am of the opinion that this model is the most attractive to many newcomer countries.

What are the engineering skills and supply chain management challenges that need to be overcome in this sector?
Human resources development is a challenge for newcomer countries because as I mentioned, there are no nuclear education programmes there. Additionally, there are few engineering schools at African universities, mostly concentrated in South Africa. Efforts must be made to adequately staff these universities and resource them properly so that when the nuclear programme takes off, there are almost enough skills available to tap from. Supply chain challenges are also daunting, especially for critical components that need nuclear stamp certification. There are no facilities as yet to do the manufacturing of these components and some of these are very long-lead components. The supply chain challenges cannot be easily overcome until the nuclear renaissance takes off in earnest, because companies cannot invest in heavy-component industries to produce steam generators or reactor pressure vessels for only two or three plants. It would not be cost effective. However, for the nuclear new build to be beneficial to African countries, a sizeable percentage of localization must be envisaged and realized. So, it is important to develop industry to supply at least 40% of the materials needed in the construction of a nuclear power plant.

There are countries that are decommissioning nuclear power plants in view of the immense safety risks; is this a realistic plan to follow?
In this day and age, the world has become very democratic and citizens determine the direction they want the country's policy to take. My view is that due to higher cost of energy when nuclear has been switched off, some of these policy decisions may be revisited, and indeed revised. To satisfy the world's energy needs, we cannot simply discount the role of nuclear. Nuclear still remains one of the reliable options for energy generation, but the onus lies with the operators and designers to make sure that the safety of their plants is assured and that public confidence can be improved. The role of independent nuclear regulatory bodies hence becomes more and more important to protect the public, property and environment from nuclear damage, by holding the operators to their word.

In conclusion
With innovative nuclear technologies coming to the fore this base load generation is here to stay having proved itself to be safe in the right circumstances, virtually carbon free, reliable, and affordable in the long term. At the 14th annual African Utility Week the potential of nuclear to offer Africa so much more than just energy will be discussed in the context of skills, job creation, and economic growth for all. According to the Nuclear Industry Association of SA, EDF France, Ministry of Energy Kenya, and Eskom South Africa, who were amongst the attendees of this year's Nuclear Roundtable discussion at the 13th annual African Utility Week conference and exhibition session sponsored by Bureau Veritas, it takes 6-8 years before the start of operation, around 2,300 different contractors and approximately 7,000 workers on a single site, demanding very high quality standards.

To learn more, download ROSATOM's Nuclear Operator Organisations Forum paper, and the World Nuclear Status Report 2013 at www.african-utility-week.com/whitepapers.

Dr Bismark Tyobeka, the CEO of the South African National Nuclear Regulator is a nuclear engineering specialist with experience in the fields of nuclear reactor design, nuclear safety analysis, advanced nuclear reactor designs and fuel cycles, including generation IV nuclear systems. Visit www.africanutility-week.com/advisoryboard for Dr Tyobeka's complete biography.

Dr Bismark Tyobeka was interviewed by Nicolette Pombo-van Zyl, Programme Director of the 14th annual African Utility Week which will take place from 13 – 14 May 2014 at the CTICC in Cape Town, South Africa. Talk to the experts, gain intelligence.