

NUCLEAR NETWORK AFRICA

THE WORLD OF NUCLEAR

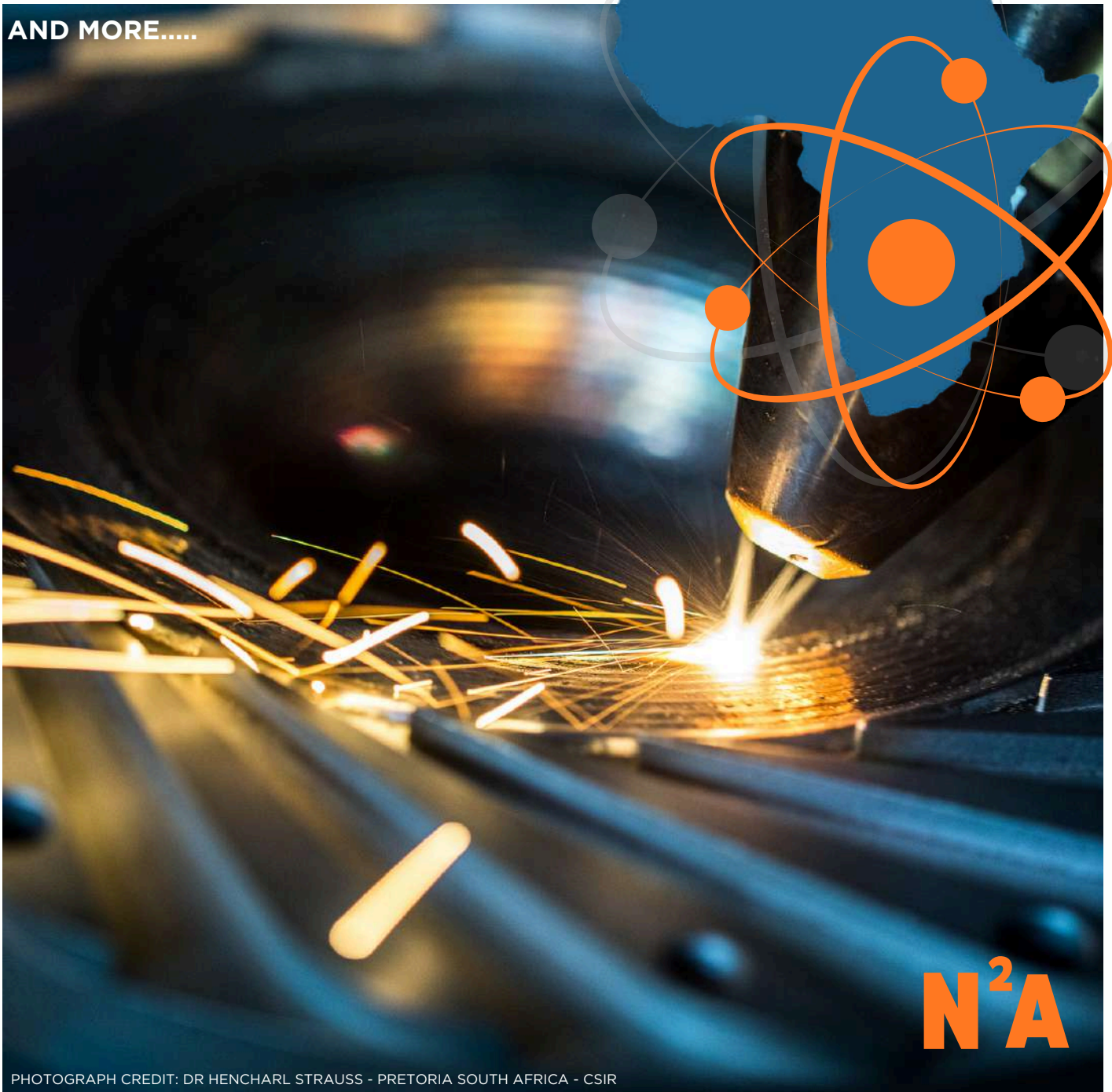
LASER TECHNOLOGY IN NUCLEAR DEVELOPMENT

DR HENCHARL STRAUSS

NUCLEAR SUPPLY CHAIN READINESS

DES MULLER

AND MORE.....



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Heather Veldhuis
HEATHER VELDHUIS
EDITOR

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The Vital Role of Diverse Technologies in Building SMR Plants

Building Small Modular Reactors (SMRs) requires the integration of multiple advanced technologies. At its core, nuclear physics and reactor engineering ensure safe power generation, but the success of SMRs depends on more. Materials science develops components that can endure extreme conditions, while innovations in cooling systems improve safety and efficiency.

Digital technologies like AI-driven monitoring systems allow for real-time oversight and predictive maintenance. Modular construction and 3D printing help streamline the building process, cutting costs and time.

By leveraging a range of technologies, SMRs can provide safer, more efficient, and economically viable clean energy solutions for the future.

Our writers in this edition share with us their insights to their specialist technologies.

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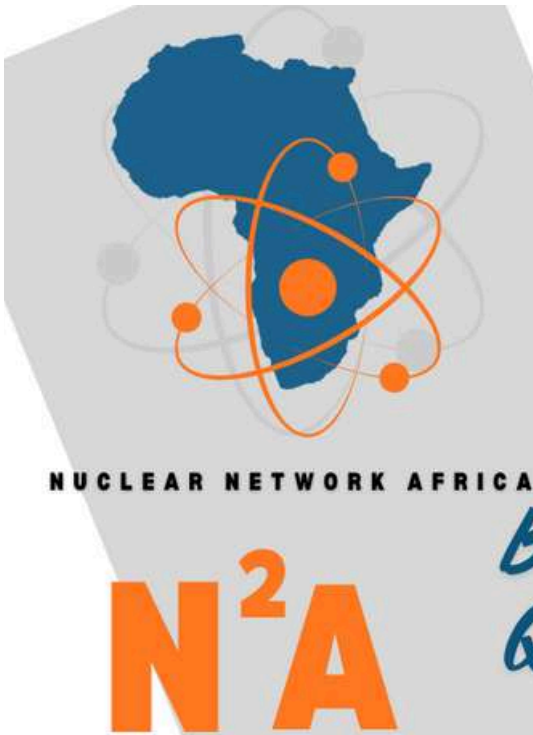
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LASER TECHNOLOGY IN NUCLEAR DEVELOPMENT

DR HENCHARL STRAUSS

Laser technology has been central in South Africa's nuclear ambitions over several decades. The country's high power/energy laser capability was developed at the Nuclear Energy Corporation of South Africa (Necsa) and the CSIR, which is one of the leading scientific and technology research, development and implementation organisations in Africa. These capabilities were combined in 2000 with the formation of the National Laser Centre which was incorporated into the CSIR in 2003. The National Laser Centre was modelled on the Fraunhofer ILT in Germany, with a strong focus on high-power laser manufacturing. The Centre develops advanced photonic and laser technologies, processes, products and services which serve a wide range of industries.

The Centre has developed a range of high-power manufacturing technologies to provide a competitive edge to local nuclear power plant development. All of these laser-based processes, and the equipment required for these processes, have been developed at the CSIR Photonics Centre, with many of these technologies now at high technology readiness level. The CSIR Photonics Centre has an established track record in industry, in the provision of laser-based processing services, most accredited by existing industry standards, under appropriate ISO certification.

The most relevant services and products use advanced laser welding and surface treatment technologies. Laser Cladding is a process in which metal powder is blown through a nozzle with low pressure Argon gas, and then intersects a high-power laser beam. The process creates a well-defined melt-pool whose position is guided by an industrial robot. The centre developed a patented process to use this technology to repair leaks in large, borated water tanks at the Koeberg power plant. The repairs which were carried out in 2012 extended the lifetime of these tanks by several years. Subsequently the technology was further developed to repair turbine components for Eskom Rotek.

The CSIR now routinely repairs large turbines for Eskom through a dedicated services group. This includes; repair of turbine journals, tenons, seals, blade tips, and leading edges. Laser cladding has also been successfully applied to increase the lifetime of parts in corrosive, high temperature environments by adding custom-developed metal-alloyed coatings to their surfaces. High power laser beams are also used to heat up areas of high-wear components and then selectively harden these areas, thereby significantly increasing their lifetime. Closely related to the cladding technology is selective laser sintering 3D printing. A large metal 3D printer, called the Aeroswift machine was developed at the CSIR. It uses a process that builds up complex parts layer by layer, by melting a thin layer of powder with an accurately directed, high power laser beam. This produces large final use metal parts.

The benefits of this manufacturing process to nuclear builds are that complex integrated geometries can be produced with internal cooling features, and that designs can be rapidly modified, thereby decreasing overall development time. The technology is also suitable to process difficult-to-machine materials. A new large industrial metal 3D printer is currently being developed at the CSIR that will be able to print parts in a wide range of metals up to 600x600x 700mm in size.

Stress corrosion cracking is a severe problem in the power generation sector. This problem occurs when three criteria are present: high tensile stresses, within a corrosive environment, on a susceptible material. A process called Laser Shock Processing (LSP) has been proven to significantly reduce this problem, and increase the lifetime of critical components and welds within a corrosive environment. LSP works by firing successive short pulses of high energy laser light across the surface of a metal component, each pulse creating a mini explosion and shock wave.

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LASER TECHNOLOGY IN NUCLEAR DEVELOPMENT

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A layer of water absorbs the pressure of the shock wave, which then travels into the material creating permanent (plastic) deformation, resulting in compressive stresses on the surface of metal parts, which then counteracts the tensile stresses and effectively removes one of the three criteria for crack growth. The process can also improve the fatigue life of components, including components with complex geometries. Internationally this technique has been successfully demonstrated to stop crack formation on nuclear reactor shroud welds, and in various aircraft components.

The CSIR is currently developing several industrial machines to apply this technique to steam turbine root structures, to stop crack formation. These state-of-the-art, locally-developed, laser manufacturing technologies are poised to enable and accelerate the development and competitive edge of new nuclear power plants.



Dr Hencharl Strauss is the Manager of the CSIR Photonics Centre, as of 1 March 2022.

The Photonics Centre was established at the CSIR in 2000, as an acknowledgement of the importance of advanced laser technology to industry.

The Centre carries out a spectrum of Research and Development programs in advanced laser technology. However, the Centre also carries out contract work for industry in a number of important industrial applications.

Dr Strauss has a PhD from Stellenbosch University. He joined the CSIR in 2009.



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DR HENCHARL STRAUSS AT THE CSIR PHOTONICS CENTRE



Dr Hencharl Strauss showing the body of a drone created entirely using a laser.



This is a shaft for an industrial customer, which had just been refurbished by means of a laser system. The diameter of the shaft was increased using a laser to lay extra metal onto the outer surface.



Dr Hencharl Strauss examining the leading edge of an industrial turbine blade, which is being refurbished using a laser system.



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NUCLEAR SUPPLY CHAIN READINESS

MR DES MULLER



Over the last 40 years, Koeberg Nuclear Power Station on South Africa's south-west coast, has delivered the cleanest, cheapest and most reliable electricity to South Africa's economy. It not only created an abundance of jobs during construction, but also continued to create thousands of jobs during its 40 years of operation and maintenance, which is now being extended to 60 years.

South Africa needs a balanced and sustainable electricity system that delivers energy security, as a priority, plus access to affordable energy, with environmental sustainability and provides an abundance of local jobs. Nuclear energy is the only technology that delivers all four of these objectives.

Because of the top quality and safety standards of nuclear energy it is one of the safest generation technologies on the grid. The spent fuel and eventual decommissioning of plants are both accommodated in the electricity tariff. Koeberg's spent fuel is safely stored in pools inside its containment building, and the older fuel is transferred into dry storage casks, which are stored on the property. Instead of long-term storage, another option is that spent fuel can be recycled into new fuel for advanced reactors, reducing the waste to about 10%.

The Renewable Energy sector, which produces mountains of toxic waste, can certainly learn a few valuable lessons from the nuclear industry concerning waste management.

Considering these nuclear energy issues for South Africa, it's totally reasonable that the Minister of Energy is driving a procurement process for new nuclear capacity. Given the proposed retirement program for South African coal power plants, during the 2030s, the procurement of new nuclear energy needs to commence immediately to ensure future energy security.

The newbuild will likely start with a pair of large-scale reactors on one of two shovel-ready coastal sites, followed by Small Modular Reactors (SMRs) for intensive energy users, municipalities, and, as an ideal replacement for retired coal power stations. A multi-purpose research reactor for Necsa is also planned during the nuclear power expansion program. So, this will provide the local industry with an abundance of major opportunities for the long-term.

Due to the exceptionally high quality and safety standards required by the nuclear industry, the local industry needs to be prepared to participate in the nuclear industry supply chain. There are scopes of work that a company with a good quality and safety culture can take on, but most of the work on a nuclear power plant is safety-class work, requiring approved nuclear industry suppliers with compliant management systems.

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Koeberg's life extension program gave NuEnergy Developments an opportunity to qualify several local companies to the highest standards. They are now delivering safety-class nuclear projects successfully. The procurement and licensing processes for the Nuclear New Build will take some time, but the local supply chain needs to start now, in getting ready to be eligible to join the selected nuclear vendor's local supply chain. The readiness of local industry will determine the degree of localization for the entire project.

In 2008, when the South African nuclear procurement process started, over 40% localisation was achieved on the proposed fleet of nuclear power plants. This figure would have resulted in a R275 Billion spend in the local industry over 16 years, and would have provided about 100 000 sustainable jobs. Unfortunately, the global financial crisis and a couple of other political factors put a hold on that. That project would have grown local industry significantly, and probably would have avoided the subsequent electricity crisis.

A systematic approach to local supply chain readiness is recommend. The first step is to become orientated concerning the opportunities in the South African nuclear industry, so that an effective business development strategy can be implemented. The second step would be a readiness assessment against the relevant nuclear industry standards. The third step would be to establish a planning management team from existing resources and to get an appropriate nuclear management system implemented. The fourth step would be to train and prepare the management teams of the nuclear divisions of companies to succeed in a compliance audit, and to become approved as a nuclear industry supplier.

Des Muller is an Electrical and Thermal Power Process Engineer with over three decades of project development and construction experience in a wide range of power generation technologies. He is Managing Director of NuEnergy Developments.

His energy career started as an engineering and construction contractor during Eskom's 25GW capacity expansion program from 1980 to 2000.

During his corporate construction career, he developed and delivered the full range of energy projects throughout Africa. This platform positioned him as an industry leader in the local energy sector while providing global access to strategic energy partners.

His corporate career included the establishment and qualification of LifeEx programs for Koeberg. This included securing and delivering two major safety-class projects for Koeberg, which set a precedent for local industry.

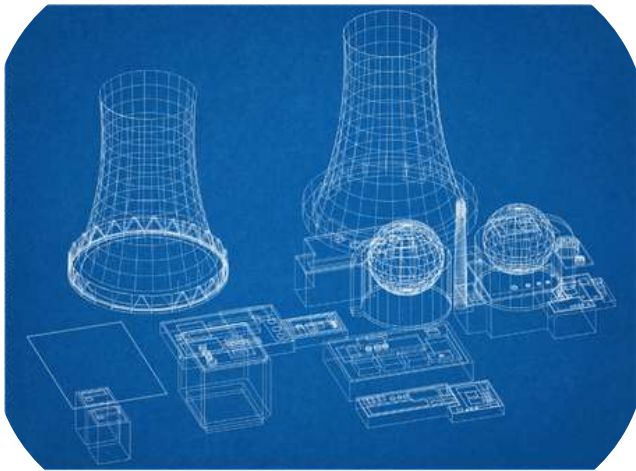


Koeberg, located near Cape Town, South Africa, is the continent's only nuclear power station. Operational since 1984, it generates around 1,800 MW of electricity, playing a critical role in South Africa's energy mix by providing clean, low-carbon power to millions of households and industries.

AI AND SMART TECHNOLOGY IN NUCLEAR ENERGY

DR JACQUES LUDIK

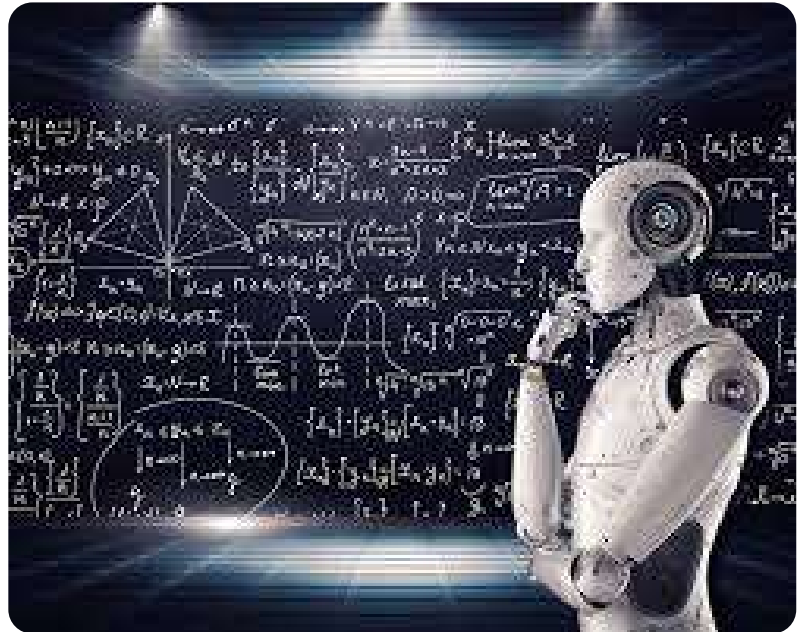
The nuclear energy sector is undergoing a transformative revolution, and at the forefront of this change is the application of Artificial Intelligence (AI) and smart technology. These technological advancements are shaping the future of nuclear energy by improving safety, efficiency, and cost-effectiveness. As Africa seeks reliable and sustainable energy solutions, the role of AI in nuclear energy is becoming more significant than ever.



Smart Technology and Nuclear Safety

One of the most critical areas where AI and smart technology intersect in the nuclear sector is in enhancing safety. Smart sensors, AI-driven diagnostics, and real-time monitoring systems provide unprecedented levels of oversight in nuclear reactors. These systems detect anomalies or deviations from normal operational parameters, allowing for swift intervention before potential hazards develop.

By integrating AI into nuclear safety protocols, we can reduce human error and reliance on manual processes. For example, AI can assist in automating emergency shutdown procedures, improving response times in the unlikely event of a reactor malfunction. This is especially relevant as the global nuclear industry seeks to reassure the public about the safety of nuclear power, given its potential as a long-term sustainable energy solution.



The Role of AI

Artificial intelligence is a game-changer for the nuclear industry. By leveraging AI algorithms, we can enhance the operation of nuclear reactors, reduce human error, and optimize maintenance schedules. One of the key applications of AI in nuclear energy is predictive maintenance. AI systems can analyze data from sensors in real time, predicting equipment failures before they occur. This minimizes downtime, enhances safety, and extends the lifespan of nuclear reactors.

Moreover, AI has the potential to enhance reactor design and operational efficiency. By simulating complex nuclear processes, AI enables engineers to optimize reactor performance and fuel use. This leads to safer, more efficient reactors that generate more energy with less waste, contributing to the global push for sustainable energy solutions.

In the African context, where energy needs are growing rapidly, AI's ability to manage energy distribution more efficiently is crucial. Through AI-powered grid management, energy generated from nuclear power plants can be more effectively distributed, ensuring that remote and underserved regions have access to consistent and reliable electricity.



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Pioneering Nuclear Solutions

In Africa, the role of small modular reactors (SMRs) is gaining traction as a viable solution to meet the continent's growing energy needs. Stratek's nuclear energy solution, headed up by Dr Kelvin Kemm, is a pioneering approach to the adoption of SMRs in the African energy landscape. These reactors are smaller, more flexible, and cheaper to deploy than traditional nuclear reactors, making them a perfect fit for countries with less established energy infrastructure. Stratek's approach, which emphasizes localized energy solutions using SMRs, is crucial for Africa. These reactors can be deployed in regions where large-scale infrastructure is challenging to build, providing a reliable source of electricity without the need for massive grids or extensive transmission lines. AI's role in optimizing the operation and maintenance of SMRs is a natural fit, offering real-time monitoring, predictive maintenance, and efficiency improvements.

SMR Global and African Energy Needs

Small Modular Reactors are not only poised to revolutionize Africa's energy landscape but also to offer global benefits. These reactors can be mass-produced and deployed quickly, providing a flexible solution to energy needs worldwide. For Africa, where the demand for energy is outpacing supply, SMRs offer a way to leapfrog traditional energy infrastructure and deliver clean, reliable power to millions of people.

AI's role in this energy revolution is critical. With AI-driven optimization, SMRs can be designed, operated, and maintained more efficiently than ever before. This reduces costs, minimizes downtime, and ensures that reactors are running at optimal capacity, addressing Africa's energy deficit while also contributing to the global concern over carbon dioxide emissions.

Cutting Edge is Here

The fusion of Artificial Intelligence and Nuclear Energy holds immense potential for the future. As we strive to meet both Africa's and the world's growing energy needs, AI and smart technologies offer innovative solutions to ensure that nuclear energy remains safe, efficient, and sustainable. With pioneering approaches like Dr. Kelvin Kemm's Stratek solution and the growing role of Small Modular Reactors, Africa has the opportunity to lead the way in adopting cutting-edge nuclear technologies that can transform the continent's energy landscape and contribute to a global energy revolution.

Dr Jacques Ludik has over 25 years' experience in AI, Machine Learning & Data Science. One of his companies, CSense Systems, was Africa's first AI company that was sold to General Electric, in 2011. Dr Ludik is the author of "Democratizing Artificial Intelligence to Benefit Everyone: Shaping a Better Future in the Smart Technology Era" and "Neural Networks and Psychopathology." www.jacquesludik.com

Dr Ludik is also the Founder & CEO of Cortex AI Group, Vive; Founder & President of the Machine Intelligence Institute of Africa (MIIA) focused on transforming Africa through AI, and Co-Founder of Sustainable Technology Venture Capital (STVC); and Bluefin Gold Group which is involved in the implementation of large-scale infrastructure and smart technology driven projects. He was also previously an Executive at Jumo and General Electric, as well as an Academic at Stellenbosch University.

Dr Ludik currently serves on the Advisory Boards of IMCI, TOMARS, Cirrus, Data Science Nigeria, Intelliverse, AI and AICE in Kenya, and Verchool, and member of the AI Africa Consortium,. In 2019, he received the Africa's AI Leader of the Year Award.



SOUTH AFRICA IS A LEADING PRODUCER OF FLUORO CHEMICALS

IVAN RADEBE

Fluorochemicals are little known, but are critical for enriching our daily lives. They are characterised by the presence of fluorine atoms.

How would our world be without all the products which need fluorochemicals. These cover a large spectrum such as; electronics; the lithium-ion batteries found in Electric Vehicles, laptops, cell phones; the plastic materials that don't deform and resist high temperatures; pharmaceuticals; solar panels; nuclear fuel for clean energy; agrochemicals for food production; air-conditioning; non-stick pots; non-crease and water repellent textiles...

Unique properties of Fluorine

The versatility of fluorochemicals is due to the unique properties of Fluorine. Fluorine is the most reactive chemical element, and the lightest member of the halogen elements. Its chemical activity can be attributed to its extreme ability to attract electrons (it is the most electronegative element) and to the small size of its atoms. These fluorine characteristics enable fluorochemicals to have high thermal, chemical, and water-repellent properties.

High barrier to entry

The very same properties which make fluorochemicals very difficult to handle also require high tech material, technology, and operational knowhow. In short, barriers to fluorochemical entry are very high. This explains why only 13 countries globally have mastered the production and processing of fluorochemicals on a commercial scale. All G7 countries commercially produce and processes fluorochemicals, and so do all members of the United Nations Security Council. South Africa produces a range of fluorochemicals, some on a commercial scale and some not. South Africa has the largest reserves of the critical input material, fluorspar, and a 50 year track record of fluorine chemistry R&D.

In many countries, including South Africa, fluorochemical development coincided with nuclear development. Despite South African fluorochemical development being initiated in the 1960s the country has largely remained in R&D and pilot-scale mode, whilst other countries such as China, South Korea, Mexico and Japan, who started way after South Africa, quickly scaled up to a commercial level. Of all major fluorochemical producers, only China and Mexico have large reserves of fluorspar, whilst all others rely on imports.

Fluorochemicals industries

Fluorochemicals are a \$30Bn global industry. South Africa has minimal market share, despite abundant fluorspar and operational knowhow, including some patented fluorochemical technologies.

Recent years have shown an exponential growth in fluorochemical demand, leading to supply shortages. Between 2020 and 2023, there was a worldwide semiconductor chips shortage affecting more than 150 industries. This supply shortfall is expected to persist and increase, leading to a deficit position from 2028.

For years China was a massive exporter of fluorspar but in 2017 the China declared fluorspar a strategic mineral and stopped exports. China's fluorochemical market has passed the \$20-billion mark.

Fluorspar designated a strategic mineral

As the result of its critical nature and limited reserves, fluorspar has been designated a strategic mineral by the US, EU, China, Japan, and recently Australia.

Despite South Africa initiating a Fluorochemical Expansion Initiative (FEI) policy to develop commercial fluorochemical production, it did not designate fluorspar as a strategic mineral. Without the enabling practical policy framework and support structures the FEI did not achieve its objectives, and instead the pilot-scale production of fluorochemicals dwindled, leading to South Africa now importing even the basic fluorochemicals from the new-kid-on-the-block; the UAE, despite the UAE not having fluorspar, nor knowhow. They relied on UK technological support, and Indian operational knowhow.

All countries which developed fluorochemicals had the common thread of strong industrial policy development frameworks, specifically for fluorochemicals. Governments provided strong support. Today the Asian tigers dominate the fluorochemical markets, generating trillions of dollars for their economies.

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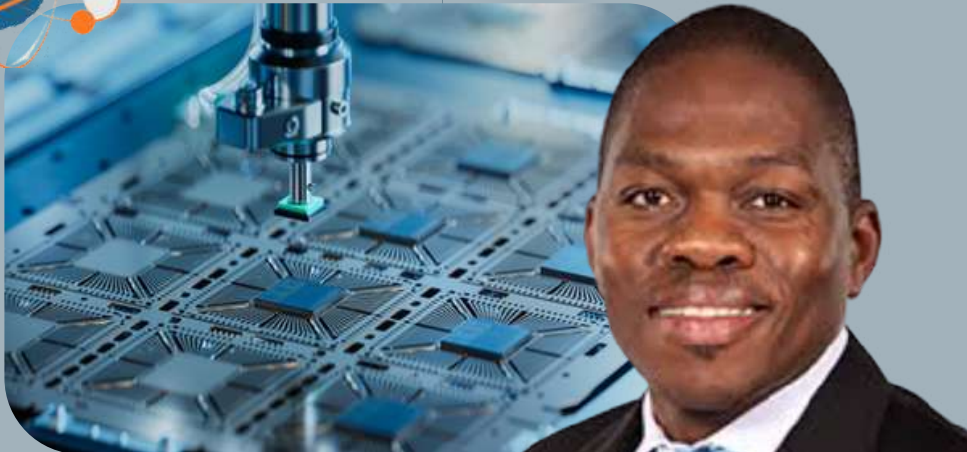
What is the potential?

South Africa, with its more than 50 years of fluorine chemistry experience, large reserves of fluorspar, deep capital markets, and operational knowhow, is very well poised to develop a commercial-scale operation.

South Africa could establish a 300 000 tpa fluorochemical production capability. This would translate into over 2000 direct new jobs, export revenues in excess of R15Bn, taxes exceeding R2Bn, and it would catalyse fluorspar mining developments which would turn the country into a major producer.

The increased demand for Fluorochemicals spurred Fluorochemicals South Africa (Pty) Ltd to partner with various local and international stakeholders to develop a 100 000 tpa commercial-scale fluorochemical plant in Coega, Eastern Cape. The plant will start producing 60 000 tpa of Anhydrous Hydrogen Fluoride (AHF) in 2028, and from 2031 also higher value specialty fluorochemicals. These will include; lithium-ion battery electrolyte, refrigerant gases, and fluoropolymers. The work of FSA has already catalysed the development of upstream fluorspar mining. The project will turn South Africa into the first country in the Southern hemisphere to produce fluorochemicals on a commercial scale.

Ivan Radebe is a director of Fluorochemicals South Africa (Pty) Ltd. He is a former Managing Director of an R&D-based fluorochemical company in South Africa and of a nuclear isotope manufacturing company in Belgium. Ivan has extensive executive experience in the Petrochemical, Power & Energy, Fluorochemical, and Nuclear Isotope manufacturing sectors
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Bright Nuclear Nexus

BY PRINCESS MTOMBENI

*Poor infrastructure
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And inequality raises curiosity
If we ever take responsibility
And it make it a priority
To create equality*

*The hope to a bright future
Seems so unclear
But lend me your ear
As I present to you NUCLEAR*

*Don't let old news
Bring you fear
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Used to save lives
Creating solutions
Reducing pollution
Bringing revolution*

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*An essential response
To climate change and greenhouse gas emissions
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And economic growth*

*Load shedding will be a thing of the past
This change is a must
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Based on inclusive growth
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Youth employment
Improvement of inhabitants
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Unity within Africa
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DID YOU KNOW??



In the beginning...

In 1895 Wilhelm, Roöntgen discovered some strange rays. He was experimenting with Cathode-Ray tubes from which the first TVs were made. He noticed that some photographic plates, which were inside paper packets on the side, were exposed when he processed them. He realized that something must have gone through the paper packets.

He then did what today is illegal, and he told his wife to put her hand on a photographic plate, still in its packet, and he passed the strange rays through her hand. (Today it is illegal to use people in experiments.) When he developed the plate, he was amazed to see a picture of the bones in his wife's hand.

Roöntgen did not know what the strange rays were, so he called them X, and so X-Rays were discovered. Just a year later, in 1896, Henri Becquerel discovered some other strange rays coming out of Uranium salts. They were definitely not X-Rays because you needed to 'make' X-Rays using some equipment. Becquerel merely put the Uranium salts on a photographic plate, still inside it's packet, and they left an image on the plate. This strange phenomenon interested the husband and wife team of physicists Pierre and Marie Curie. They studied the salts and isolated two new elements which they described as 'radioactive.' They had detected Radium and Polonium.

In 1899, the New Zealander, Lord Ernest Rutherford, discovered that there were two different types of radiation coming out of the radioactive material. He did not know what they were, so he labelled them; A and B. They were then named, Alpha radiation, and Beta radiation. So that is how the whole nuclear drama started.

A physicist had a summer job as a beach lifeguard.

He noted that the best tanned girls flirted the most throughout the summer, but they never found steady boyfriends.

He therefore theorised that: A body in lotion tends to stay in emotion.



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NUCLEAR NETWORK AFRICA

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Any person who has influence and a role to play in representing any Nuclear-Related Developments to advance nuclear power in Africa. or in any international entity, which can contribute to the development of Africa's nuclear energy capability is encouraged to be part of this great journey.

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