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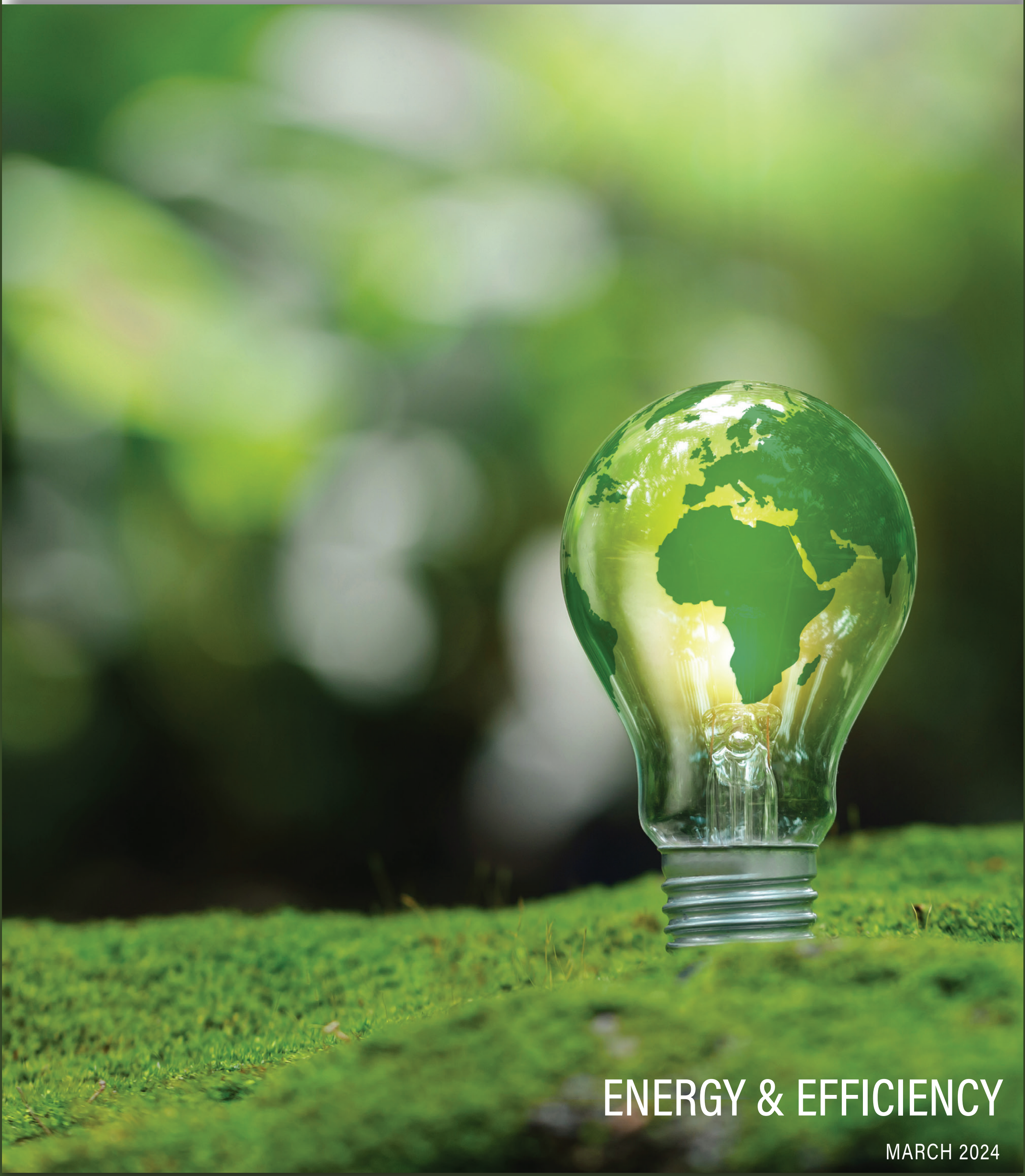

ENERGY & EFFICIENCY

MARCH 2024

SAIEE

CONTENTS

SAIEE @SAIEE SAIEE

Dear **watt**now reader

In the effort to decrease carbon emissions and tackle climate change, energy efficiency has become a crucial focus for countries around the world. This is especially true in Africa, where the need for sustainable energy solutions is urgent. In South Africa, a plan for Just Transition is being implemented to reduce the country's carbon footprint and promote a more sustainable energy sector.

Experts in electrical engineering have stressed the importance of energy efficiency in achieving these goals. By optimizing energy use and reducing waste, countries like South Africa can decrease greenhouse gas emissions, save on energy costs, and enhance energy security. In this context, the issue at hand is energy and efficiency.

Our first featured article takes us through a report on Electricity in 2024, providing an analysis and forecast for 2026. You can read it on page 24.

On page 38, you will find an article on "Accelerating an Equitable Transition," which explains how the green transition, driven by the growing urgency of accelerated climate action, is a transformative economic shift that affects the production, distribution, and consumption of goods and services. It has far-reaching and complex implications for equity, fairness, and justice.

The April issue features Electrical Technologies, and the deadline is 11 March. Please send any article/news contributions to minx@saiee.org.za

Herewith the March issue; enjoy the read!

Minx

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How SAUPEC started and still prevails

Dr Koos Holtzhausen and Prof John van Coller at SAUPEC2024. Both attended the first one in 1990.

During the seventies and eighties of the previous century, electronic engineering enjoyed a heyday due to extensive military research, while power engineering and machines were sorely neglected. Towards the end of the ninety, things changed when research funding by the National Energy Council (NEC) became available.

By: Koos Holtzhausen, with inputs from Prof Ron Herman.

This was initiated by the High Voltage Coordinating Committee (HVCC). All instances having high voltage facilities were represented on this body: The South African Bureau of Standards (Kees van Alphen), the CSIR (Dr Rob Anderson and Dr Andy Eriksson), Wits (Prof Jan Reynders), University of Natal (Prof. Ron Harley), University of Cape Town (Colonel Webster) University of Pretoria (Prof. Heymann) and the University of Stellenbosch (Prof. H.O. Reuter and Koos Holtzhausen).

At the meetings of the HVCC, the absence of research in high voltage and power engineering in general was often discussed. This was a severe situation in light of the envisaged expansion of the power network and the electrical industry.

The outcome was that the NEC was approached to make funds available for power engineering research at the major universities' electrical engineering departments. The results of this funding were soon evident in research results, and researchers could present their results at international conferences.

Ron Herman commenced a PhD in the statistical analysis of distribution loads, and Ron contacted Dr Bill Beattie at Queens University in Belfast. in 1989, he spent a sabbatical in Belfast. While there, Dr Beattie invited Ron to accompany him to UPEC in Nottingham. Ron got the idea of initiating a similar conference in South Africa. He contacted the late Prof. Mike Case, who was the Departmental Head at that stage, and, in his typical way, he immediately enthusiastically approved of the concept. While Ron was still overseas, he and I started planning. People from the industry, like Roy Macey, immediately pledged their support.

A Call for Papers was sent to the relevant universities, and arrangements were made for accommodation and the conference dinner. Ron and I worked over the December holidays to finalise arrangements and review the received papers. Eventually, 48 papers were included in the Conference Proceedings.

Most papers were printed on dot matrix printers, which was common then. The proceedings document was a cut-and-paste job in the real sense of the word.

The actual SAUKIK90 (SA Universiteite Kragingenieurswese Konferensie) / SAUPEC90 (SA Power Engineering Conference) occurred on 25 and 26 January 1990. The lectures took place in the Auditorium of the Department of Electrical Engineering.

It was attended by 90 persons, students and lecturers (Wits: 20, RAU: 16 and Natal: 10). The Conference Dinner was held in the Blue Room of the Students' Union. Accommodation was provided in university hostels.

The idea of a SAUPEC attracted strong support from leading academics in the field of power engineering, including Prof. Frikkie van der Merwe at Stellenbosch University, Prof. Jan Reynders at the University of the Witwatersrand, Prof. Ron Harley at the University of Natal and Prof. Daan van Wyk at Randse Afrikaanse Universiteit.

In the years to come, SAUPEC moved from one university to another, and 2017 celebrated its 28th year. The SAUPEC fraternity was later expanded by including the Technical Universities.

The Eskom Tertiary Education Support Programme (TESP), aimed at supporting postgraduate research in power engineering at academic institutions, was initiated in 1992 and took over the role of the National Energy Council.

In 2015, SAUPEC became part of the South African Institute of Electrical Engineers (SAIEE), and the 23rd SAUPEC was the first SAUPEC conference organised under the auspices of SAIEE. Through the years, SAUPEC enjoyed strong sponsorship support from the industry. Together with Eskom, companies such as ABB, Siemens, Aberdare Cables, and Schneider Electric have sponsored the conference regularly.

The return of SAUPEC to Stellenbosch from January 24 to 25 this year, after more than 30 years, was indeed a memorable occasion. The proceedings took place in the comfortable STIAS Conference Centre. A total of 70 papers were presented. Keynote lectures were given by Dr Tobias Geyer (R & D platform Manager at ABB) on Challenges and Opportunities for High-Power Converter Systems and by Dr Peter Jan Randewijk, Island Programme Study Coordinator from Energet, Denmark, on The Technical Design Considerations of the Danish Energy Islands. Dr Randewijk is a Stellenbosch University graduate and was previously a Senior Lecturer at the University.

Prof Trevor Gaunt and his team presented a tutorial: Rethinking power systems without reactive power. It was an honour to attend the conference as a guest of honour. wn

SAUPEC 2024 AWARD WINNERS

From left: Prof Jan de Kock (SAIEE President) and Ruan Murray for Best Paper at SAUPEC 2024.

From left: Tariq Rouhani from Stellenbosch University, winner of the SAIEE Rotating Machine Section Award for best Student Paper at SAUPEC 2024.

IITPSA women a powerhouse group

(From left) Prof Lynn Futcher, Ulandi Exner, Joice Benza, Josine Overdevest, Senele Goba, Pearl Pasi and Moira de Roche.

The women members of the Institute of Information Technology Professionals South Africa (IITPSA) are a powerhouse group, particularly when seen gathered in one place at the same time!

At the recent IITPSA President's Awards, some of the IITPSA's leading women in IT had a rare opportunity to network in person.

Among them were IITPSA President Senele Goba and Vice President Pearl Pasi; IITPSA Past President Ulandi Exner who has officially taken over as the Chair of the Africa ICT Alliance (AfICTA), becoming the organisation's first female chairperson; and Moira de Roche, IITPSA past President and Fellow, as well as Vice-president of International Federation for Information Processing (IFIP) and President of IFIP International Professional Practice Partnership (IP3).

Also present were Prof. Lynn Futcher, Chair of the IITPSA Eastern Cape Chapter, SIGCyber Committee member and Professor at the Centre for Research in Information and Cyber Security (CRICS) at Nelson Mandela University; and Josine Overdevest, IITPSA Social & Ethics Committee Chair, winner of the 2023 David O'Leary Award, and newly appointed member of the IFIP IP3 Global Industry Council.

Rounding out the line-up of leading women in IT was the IITPSA's friend and guest, Joice Benza, President of the Computer Society of Zimbabwe and member of the IFIP IP3 Board.

The IITPSA is focusing its efforts on addressing the gender imbalance in the IT sector, and is stepping up the work of its Women in IT (WIIT) Chapter in line with this. WIIT has called for women in IT to join the chapter and become involved in projects to make a positive impact on girls and women in the IT profession.

To learn more and register your interest in joining WIIT, click here. wn

Local procurement should be the top priority in mine-owned solar power projects

Many mines in South Africa are currently in the early stages of planning and obtaining approval for their independent solar power ventures, with the country's ongoing energy crisis largely driving this transition to renewables.

Underground mines typically own large areas of land on the surface that cannot be developed but are ideal for housing solar plants and recent legislative changes have enabled businesses to develop up to one hundred-megawatt energy plants with very little red tape.

As a result, some mining houses have already initiated construction, while others are still in the process of specifying their plant or engaging engineering, procurement, and construction (EPC) companies to go out to tender on their behalf. However, in this journey toward sustainable energy solutions, the significance of local procurement cannot be overstated. Yet, projects of this nature are often outsourced to and managed by an EPC company that must work within a specified budget, with the delivery of a functioning solar plant being their main directive.

Unless the directive from a mine specifies local procurement and aftersales backup, EPC companies might purely focus on delivering the solar plant at the lowest cost and look at short-term criteria rather than the long-term needs of the mine for the plant to remain at full capability.

COMPETITIVE PRICING

While certain components might not be locally available, infrastructure such as transformers, switchgear and substation equipment can be sourced locally. There are multiple suppliers that can supply this at competitive prices and offer after-sales backup.

However, short-term cost savings are often prioritised and products from foreign suppliers are sourced at lower prices. While the equipment might be functional, mines should consider whether they are serviceable and if the equipment has the desired longevity to deliver the expected return on investment (ROI).

On the other hand, the advantages of proximity to local suppliers and service providers for mine-owned solar plants in terms of operational efficiency and reliability are numerous. For example, transformers often sustain damage during transit or fail prematurely due to transport-related movement of internal components. Additionally, foreign suppliers sometimes deliver "throwaway" products that are not designed to last or to be repaired.

This frequently occurs when products are insufficiently specified in the tender process, and there is a lack of effective quality control, often exacerbated by the supplier's distant location and language barriers. With many international suppliers lacking local aftersales support, equipment owners face limited options for recourse in the event of equipment failure.

So, while the choice to import products is largely driven by cost, this cost is very often not explored in terms of a well-defined specification. Mines can thus end up with substandard equipment that costs more in the long run.

SUPPORTING COMMUNITIES

Additionally, choosing local suppliers and labour for a solar plant project fosters economic growth and job creation within the vicinity of the mines. This direct engagement with the community enhances the overall well-being of residents and solidifies mines' position as responsible corporate citizens. If industry is seen to have a desire to involve and upskill local communities, thus creating sustainable employment, it will go a long way to forging better bonds between industry and labour.

Local procurement also supports the Just Energy Transition (JET) initiative, which places a strong emphasis on a smooth and sustainable transition to renewable energy sources. Local procurement aligns with this vision, as it actively contributes to the objectives of reducing carbon emissions and fostering a sense of social and environmental responsibility. Additionally, as mines become more mechanised and shafts reach their end of life, specifying skills transfer to employees during solar plant projects could enable these workers to seek alternative sources of income.

Given the numerous socio-economic advantages of local procurement, there is an absolute obligation on the part of local business owners to support and empower local suppliers. Local procurement also creates employment opportunities at a time when tackling the country's unemployment crisis should collectively be everyone's responsibility. wn

The next big shift in SA's energy infrastructure

South Africans have, sadly, become accustomed to the utter disappointment and dismay of high levels of loadshedding, often after some or other positive promise from political heads. This year's State of the Nation Address was barely over before the well-curated positive outlook was replaced by stage 6 load shedding. While people are accustomed to this, it does not mean they accept it, and this will fuel the next big phase in the country's energy infrastructure.

By Lance Dickerson, MD Revov

High-voltage (HV) LiFePO4 battery energy storage systems, commonly referred to as BESS, which drastically improve the power reliability prospects for businesses, have been around for some time, but expect to see a massive surge in 2024.

HV BESS systems are designed for industrial, commercial and utility-scale applications. If we consider that the lack of power security and insufficient supply is like a giant lead weight sinking the economy, it is no surprise that we are seeing a surge in inquiries from critical players in agriculture, manufacturing, property development, residential and commercial property management, and even the education sector.

Businesses in crucial sectors in the economy realise that they must take control of their own energy security and more and more business leaders are realising that renewable energy storage is a far more viable, and reliable, option than old-paradigm internal combustion generators.

There are three main reasons for this. The first two are commercial. Hauling big loads of fuel to power generators comes at a significant cost, especially for outlying areas, and this doesn't come with absolute security of supply for obvious road-travel reasons. Beyond this, the diesel itself is significantly more expensive than it was pre-Covid, while maintaining and servicing large generators also puts a large financial strain on organisations that may already be operating on tight margins.

In addition to this, the world is demanding a shift towards renewable energy. What was a lofty ideal a few years ago, the shift towards net neutral is front and centre all around the world.

South African businesses have no choice but to accept this, and accept that access to markets such as the EU will become increasingly difficult and restrictive unless businesses, industries, and countries comply with ever stricter carbon targets. In other words, you simply cannot assume that you'll be able to sell a product in the EU if it is made or farmed on the back of internal combustion engines or coal power stations. The days of that paradox are numbered.

Finally, with the weight of overwhelming evidence about the critical state of the climate and our planet, surely no one can justify investing in further harm to the planet? If this moral obligation is not urgent yet, consider that much of our workforce and consumer population is made up of Millennials and Gen Z. While different, both age groups value purpose and actively pressure their employers and brands they support to embrace various environmental, social and governance (ESG) causes. They're also known to reject businesses and brands who don't. Activist shareholders are increasingly demanding accountability and this pressure will continue to grow.

It is abundantly clear that the perfect storm of pitiful electricity supply combined with economic and social factors have combined to create an environment for HV BESS systems to become almost synonymous with electricity security in South African industry.

The technology and benefits of HV BESS has evolved to a point where it is applicable and scalable across sectors, making these systems suitable for larger-scale applications in industrial, commercial and utility settings.
Beyond this, leading suppliers are able to build modular systems, allowing businesses to scale up their investment as needed.

HV BESS systems are either being investigated or being deployed in farming and downstream agricultural contexts, manufacturing, retail centres, and more, to provide power backup capacity for when the inevitable happens and Eskom plunges the country into darkness. Even if there are unexpected improvements in Eskom's generation and distribution, this trend will continue in much the same way that solar PV has transformed large swathes of the residential sector.

Businesses have different motivations, but they all hinge on energy security with cost savings front and centre. Many are interested in renewable power investments where BESS systems store the energy generated from solar panels and in some instances, turbines. Others need uninterrupted power backup power to ensure critical systems such as refrigeration and security are unaffected by protracted power cuts. Businesses are also realising that high-voltage systems enable them to reduce their energy costs by mitigating against periodic demand changes.

Eskom recently announced a battery system in the Western Cape. This is because another crucial application is to improve grid stability as well as to integrate renewable energy sources.

These systems, if built properly and with the right batteries, can help manage fluctuations in supply and demand and reduce transmission losses, while HV BESS systems can also provide additional functions such as regulating frequency, providing voltage support and balancing the grid. There is more than enough capacity and engineering expertise in the local industry to support a shift to a utility of the future.

Modern, modular systems include local and remote monitoring of specific battery telemetry, ranging from individual per-cell visibility, all the way up to data relating to each battery string.

Comparing this type of technology to the hope and a prayer that municipalities and the national utility will finally get their act together, it is obvious that the next big shift in our power landscape this year and beyond will be mass rollout of HV LiFePO4 BESS systems. wn

Lance Dickerson, MD Revov

Evolving Energy Solutions For Business

- THE SOLARSAVER SUCCESS STORY

Amidst ongoing power supply issues, solar power has become a viable, if not essential, option for business in South Africa. With many businesses seeking cost-effective, reliable alternatives to the unstable national grid, SolarSaver has become a major success story. The solar energy company now manages over 650 self-financed installations across South Africa, Namibia and Botswana, the largest fleet of commercial solar photovoltaic ("PV") systems in the Southern African region.

While most of SolarSaver's business was initially in Namibia, substantial investment backing from the Pembani Remgro Infrastructure Fund (PRIF) in 2017, a US$302 million private equity fund established by Remgro Limited and Phuthuma Nhleko, allowed the company to aggressively grow its South African portfolio.

RMB Corvest then came on board in 2022 as the main investor behind Sedgeley Energy, the exclusive provider of engineering, procurement and construction ("EPC") and maintenance services to SolarSaver. "The partnership with RMB Corvest enables us to reach more potential customers and expand our operations," says SolarSaver Managing Director Tim Frankish. "With their support, we have continued to innovate and offer affordable solar solutions to a wider market."

The business has taken a unique approach: offering its clients solar photovoltaic solutions on a rent-to-own basis, eliminating the need for any capital investment on the part of clients and allowing them to pay only for the greener power produced. This 'hassle-free, capex-free' concept has proved extremely popular and addressed the barrier of large capital investment for solar system ownership. SolarSaver effectively operates as an independent power producer, leasing high-quality solar PV systems to clients who seek to reduce their reliance on the grid and harness renewable energy. SolarSaver owns and manages the solar system on a term agreement.

However, with the instability of load shedding and power outages across South Africa, consistent power supply is also a priority. SolarSaver now offers both grid-tied and hybrid solar systems. Existing clients are able to add batteries to their grid-tied systems, and new clients can install hybrid solutions from the outset. Clients have the option of set monthly fees, or outright purchase of the hybrid solar systems.

"We're now providing existing and new clients with 24-hour power solutions through fully-financed, customised solar-battery systems," says Frankish. "We have steered clear of expensive quick-fixes and focused on long-term solutions. We believe that by partnering with businesses and investing with a long-term view, we can provide a real alternative to Eskom."

SolarSaver has a range of clients across various sectors, from retail to manufacturing, fuel to food processing, agriculture to hospitality. Large commercial and residential developments also form part of the portfolio. The majority of these businesses have grid-tied systems, and

SolarSaver installation at Canyon Lodge, Namibia.

most clients have reduced their reliance on grid power by up to 30%.

With South Africa's electricity prices increasing by over 450% in the last decade, installing grid-tied solar has been a 'no-brainer' for these businesses, says Frankish. "SolarSaver tariffs are significantly cheaper than the equivalent cost of grid power, so clients start saving on their electricity bills from day one. Rates then only increase in line with CPI inflation, so clients' savings grow each year as grid tariffs increase significantly beyond that," explains Frankish. "SolarSaver also remains responsible for all ongoing monitoring, maintenance and insurance. It's in our interest to ensure that the photovoltaic systems are operating at peak performance and that translates into better savings for our clients."

Frankish says that even if the cost of a full battery system is prohibitive, businesses are taking a long-term view. Installing a solar solution means businesses reap immediate cost-saving benefits with no capital cost, as well as having the potential to link batteries to the system that is already in place in the future.

SolarSaver is paving the way for a cleaner, greener future, providing tailored grid-tied or hybrid solar installations that make solar power more accessible and affordable for businesses across Southern Africa. wn

Solar & Storage Live Africa & The Future Energy Show Africa to open on 18-20 March

Taking place at Gallagher Convention Centre in Johannesburg, Solar & Storage Live Africa co-located with The Future Energy Show Africa will unite the solar and energy industry, to accelerate Africa's sustainable energy future.

The 27th edition of this multi-brand event, commencing on 18-20 March, provides the ideal platform for the industry to explore a stable, lower-carbon, and digitized energy future.

Gina Bester, General Manager at Terrapinn Middle East & Africa commented: "We're absolutely thrilled to be back this year, with this edition set to be bigger and better than ever before. In these critical times, it's paramount for the energy and solar industry to come together, network, and drive forward towards a more sustainable future, all while exploring innovative solutions."

"Supported by our invaluable partners, sponsors, and exhibitors, we're excited to announce that we're moving to the spacious Gallagher Convention Centre, ready to welcome thousands of attendees this March in Johannesburg.

Not only will we be reshaping Africa's energy sector, but we'll also be fostering crucial connections and collaborations that will propel us towards a brighter tomorrow."

The free-to-attend exhibition will feature over 350 domestic and international brands, providing a range of energy solutions from PV modules and components, energy storage and inverters, generation equipment and critical power, TD and tech components, smart tech and much more.

Other free-to-attend highlights include the Installers University, a new addition to the show that is the ideal opportunity to listen to practical applications in all thing's energy installation related - from home to commercial scale installation projects.

This year's edition includes the launch of the Dealmakers Hub, an exclusive platform designed for sponsors and exhibitors to facilitate the signing of partnerships, finalization of significant sales deals, and the execution of MOUs directly at the event.

The Dealmakers Hub offers a dedicated space to enhance networking opportunities and elevate the visibility of successful collaborations.

The event is supported by Official Partners, The South African Photovoltaic Industry Association (SAPVIA) and Eskom.

Solar and Storage Live Africa co-located with The Future Energy Show Africa will take place at the Gallagher Convention Centre, Johannesburg on 18-20 March 2024. wn

For more information click here.

Register for free click here.

Government's Integrated Resource Plan 2023 spurs call for sustainable energy investment

The recent release of government's Integrated Resource Plan 2023 highlights the reality that South African organisations will need to invest heavily in alternative energy if they are to meet their sustainability goals, ensure a reliable supply of power for their operations and bring their energy costs under control.

That's according to Chris Kruger, MD at Nashua Kopano, who says that the current plan approved by cabinet makes allowance for businesses to self-generate a substantial portion of the country's energy in its 2030 and 2050 horizons. In the scenarios modelled in the plan up to 2030, companies are expected to produce about 6,000 megawatts for their own use.

Says Kruger: "An updated energy plan is welcoming news for businesses, but it doesn't offer the prospect of relief for their energy woes in the shorter term. Progress in bringing new capacity on stream remains slow. With a current estimated 6,000 megawatt shortfall in power generation capacity, it's clearly up to large businesses to fill the gap."

SUSTAINABILITY CONCERNS AT THE FOREFRONT

Another factor that businesses should consider is that the new blueprint envisages extending the lifespan of existing coal-fired plants as well as adding more gas power to the mix. While it is important to have a diverse mix of energy sources and protect jobs as we transition to sustainable power, over-reliance on legacy sources could compromise the drive towards net-zero, says Kruger.

"Sustainability is a hot topic around the world, with the International Energy Agency highlighting that least $4 trillion a year needs to be invested in renewable energy until 2030 to allow the world to reach net-zero emissions by 2050," says Kruger. "This will be a major international effort that will require public and private sector cooperation.

"Supply chain partners, investors and commercial customers are carefully scrutinising the environmental credentials of companies they do business with. South African organisations that invest in clean alternative energy sources rather than depending on grid power may gain a competitive advantage. Indeed, export-focused businesses that don't will be at a disadvantage in the global market."

The new integrated plan offers no clear pathway to reduce grid power costs, says Kruger. The commercial case for achieving cost-savings through renewable energy is compelling, with companies able to build solar panels and battery storage in phases. With today's financing offers, it is viable to start small and use ongoing cost savings to fund expansion of one's alternative energy installation.

FROM GRID DEPENDENCY TO ENERGY INDEPENDENCE

"The price of grid power is increasing at a rate far higher than inflation and can be expected to continue to do so for the foreseeable future. Companies can shift to solar power without making large capital outlays and they can harvest the savings they achieve from using less grid power to help fund the installation," says Kruger.

"With frequent power cuts still costing enormous amounts of time, money and opportunity, companies can benefit from smarter power consumption and alternative energy solutions. In the longer term, energy independence is key for cost control and sustainability - but the short-term payback comes from business continuity and uninterrupted productivity during load shedding."

SAIEE Student Chapter's Impact Role on University Registrations

The Central University of Technology, Free State, SAIEE Student Chapter was instrumental in improving the registration process for both first-year and senior students. Our hardworking registration team helped students from January 24 to February 2, 2024, while actively seeking new members to join our group.

Written By: Motlaloe J Moeketsi

Our involvement's main goals were to make the registration process more efficient and to make the campus feel more friendly to students. We also wanted to bring in new members who are passionate about electrical engineering to grow the SAIEE community.

ACTIVITIES AND CONTRIBUTIONS

1. GUIDANCE FOR FIRST-YEAR STUDENTS

- We strategically positioned our registration staff to assist first-year students with the registration process.
- They received help with comprehending course requirements, navigating online platforms, and asking any questions they had.

2. SUPPORT FOR SENIOR STUDENTS

- Seniors received assistance with any problems with schedule conflicts, course modifications, or other registration difficulties.
- Our group collaborated with university personnel to guarantee an efficient and effective procedure for senior pupils.

3. PROMOTION AND RECRUITMENT

- We assisted with registration and actively informed all students about the SAIEE Student Chapter, providing information about SAIEE's mission, activities, and membership benefits.
- Interactions with potential members revolved around the benefits of joining our vibrant group.

ACHIEVEMENTS

1. POSITIVE FEEDBACK FROM STUDENTS

- Many students appreciated SAIEE's help during the registration process.
- Several times, our crew members' kind and personable manner was evident.

2. INCREASED AWARENESS AND MEMBERSHIP INTEREST

- There has been a noticeable surge in interest and questions regarding joining the SAIEE Student Chapter as a consequence of the recruitment efforts. We were able to recruit 156 new members.
- Many students strongly desired to participate in the forthcoming events and activities.

CHALLENGES FACED AND LESSONS LEARNED

1. COMMUNICATION CHALLENGES

- Some pupils had trouble communicating because of language barriers. We discovered how crucial it is to modify our communication approaches to engage various audiences.

2. IMPROVEMENTS FOR FUTURE INITIATIVES

- We can improve our approach in future registration drives and recruitment initiatives with the help of feedback from this experience.

- Keeping open lines of communication with university personnel will enable us to handle any unforeseen obstacles more skillfully.

CONCLUSION

The latest registration session was a great success for the SAIEE Student Chapter. We have increased our visibility on campus by actively seeking out new members and offering vital help to first-year and senior students. This effort has grown the SAIEE community and improved the registration experience for students. We hope to build on this accomplishment in upcoming activities and keep improving the university community. wn

SAIEE NWU Student Chapter launched

The SAIEE Northwest University Student Chapter Office Bearers.
From left: Andrew Geldenhuys (Activities Coordinator), Franco Coetzee (Public Relations) , Leshendra Munian (Vice Chairperson), Jonathan Solomon (Chairperson), Anchen Gerber (Treasurer) and Zanele Mdhluli (Secretary).

In February, Northwest University (NWU) students launched the SAIEE NWU Student Chapter at the Potchefstroom campus. The purpose of the chapter was to encourage NWU Potchefstroom campus students to become involved in SAIEE and reap the long-term benefits.

During the launch, the Chairman of the NWU Student Chapter, Jonathan Solomon, hosted an information session for potential student chapter members. They were joined by Professor Albert Helberg, a senior lecturer in Computer & Electronic Engineering and an SAIEE member, and the SAIEE President, Professor Jan de Kock. The students were treated to a social media competition and a talk by Prof Jan de Kock, followed by an interactive Q&A session.

According to Jonathan, "The launch was a huge success, and we anticipate having more events in the future, such as Membership Drives, Seminars, Socials, and Industry Visits. We also actively participate in all campus recruitment events, such as Engineering Days and Open Days."

The SAIEE NWU Student Chapter aims to partner with numerous stakeholders to prepare students for the industry and ensure their community engagement continues growing. wn

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Robotics labs equip a next generation with future-fit education

As NASA retires Ingenuity, the little robot helicopter that completed 72 flights on Mars, a next generation of Grade 8 and 9 South African learners is beginning its robotics journey.

A R1,6 million investment in robotics infrastructure, equipment, course work and teaching is speeding their mission, with the Shoprite Foundation facilitating two fully equipped robotics laboratories at Mountview and Verulam High Schools in KwaZulu-Natal. The initiative is the first phase of technology support for various schools around the country.

Speaking at the opening of the Mountview Robotics Laboratory, Maude Modise, the managing trustee of the Shoprite Foundation, explained the two schools were selected to launch the robotics initiative as the Department of Education is piloting coding and robotics as a subject.

"The groundwork was in place and importantly there was interest and enthusiasm, so we saw an opportunity to help by providing training and equipment and adapting the existing computer rooms into fully functional robotics laboratories."

To deliver the laboratories, the Shoprite Foundation commissioned SIFISO Edtech, a South African company which specialises in delivering turnkey robotics hubs, providing everything from infrastructure, robotics kits, teaching material and training.

The kits come with over 10 models each and include everything the learners and teachers need, from microcontrollers and actuators to gyroscopes. They are modular, allowing learners to create their own builds. Face-to-face and online training for teachers and lesson plans, presentations and worksheets are also provided. As well as funding the laboratory set up, kits and teaching aids, the Shoprite Foundation donated laptop computers and tablets.

"AI is already part of our everyday lives. At the Shoprite Group, we're using AI to get the freshest products on the shelves and reduce food waste. By investing in future-fit education we aim to ensure that these learners leave school able to participate and contribute in a modern economy," explains Modise.

While robotics may currently be the cutting edge of maths and science education, she says that the Group's efforts to unlock educational opportunities and encourage entrepreneurship among young South Africans extend substantially beyond this.

At Mountview, it has also provided a bespoke consumer-studies laboratory – funded by the Shoprite Foundation, to encourage entrepreneurial endeavour amongst learners. This facility was formally opened at the same event as the robotics laboratory, with a former learner telling guests how consumer studies had led him to start his own catering company. wn

Royal Academy of Engineering's Africa Prize for Engineering Innovation marks 10th anniversary

The Royal Academy of Engineering is investing over £1 million this year in alumni of the Africa Prize for Engineering Innovation programme through grants, prizes and accelerator programme awards, to facilitate long-term success of innovations addressing local challenges.

The programme is Africa's biggest prize dedicated to engineering innovation and supporting entrepreneurs to maximise their impact and marks its 10th anniversary this year.

Outstanding alumnus of the Africa Prize, Neo Hutiri from South Africa, was awarded an anniversary medal and £50,000 to further support his business, Technovera. His product, Pelebox Smart Lockers, is designed to improve access to chronic disease medication. The award was presented by HRH The Princess Royal, the Academy's Royal Fellow, at a ceremony that celebrated some of the most successful innovators and businesses from the past 10 years. wn

Neo Hutiri

How Tech is changing University

- DIGITAL REVOLUTION'S IMPACT ON THE WAY WE STUDY

The landscape of higher education is undergoing a profound transformation, driven by the relentless advances in technology. Educational technology, often referred to as EdTech, has become a powerful force reshaping traditional approaches to teaching and learning in Higher Education institutions. This disruption brings both challenges and opportunities as institutions strive to adapt to the rapidly evolving educational landscape, an expert says.

"The emergence of the digital revolution within higher education marks a pivotal shift, granting unprecedented access to information with just a tap or click. This transformative wave challenges conventional educational paradigms by elevating online platforms, interactive tools, and virtual classrooms into positions of prominence," says Dr Mario Landman, Head of Educational Technology, and Innovation at The Independent Institute of Education, SA's leading private higher education provider.

He says a key focal point of this new era is the democratisation of knowledge as educational resources become more accessible to a global audience and, resultingly, faces greater scrutiny.

"The rise of tech in ed is having a profound impact on seven key areas of study, and it is important for higher education institutions, as well as parents and prospective students, to understand how the environment has changed, continues to change, and where it is headed," he says.

GREATER ACCESS VIA ONLINE LEARNING PLATFORMS

"Educational technology has notably revolutionised how education is delivered, as evidenced through the dramatic ascent of education providers utilising online learning platforms for programme delivery. The seismic impact of educational technology has been further underscored by the COVID-19 pandemic, catalysing the rapid rise of education providers leveraging online learning platforms for program delivery. This newfound flexibility is particularly beneficial for non-traditional students, working professionals, and those in remote or underserved areas," notes Dr Landman.

BEST OF BOTH WORLDS VIA BLENDED LEARNING ENVIRONMENTS

Educational technology has paved the way for blended learning, combining traditional face-to-face instruction with online components.

"This hybrid approach allows for a personalised learning experience, leveraging the strengths of both in-person interactions and digital resources. Institutions are increasingly incorporating learning management systems (LMS) to empower educators to create engaging, personalised learning experiences while streamlining administrative processes and fostering collaboration," Dr Landman says.

ADAPTIVE LEARNING SYSTEMS MEANS NO MORE 'ONE-SIZE-FITS-ALL'

Adaptive learning systems use data-driven insights to tailor educational content to individual student needs.

"By analysing a student's performance and learning style, these systems can

dynamically adjust the difficulty and pace of lessons. This personalised approach enhances student engagement and comprehension, addressing the diverse needs of a student population with varying learning abilities."

PERSONALISED LEARNING PATHS CATER TO SPECIFIC STUDENT NEEDS

Dr Landman further says that personalised learning in higher education offers a range of benefits that cater to the individual needs, preferences, and abilities of students.

"As educational institutions increasingly recognise the diverse learning styles and backgrounds of their students, the implementation of personalised learning becomes crucial.

"There are some key benefits to providing personalised learning paths in higher education that includes tailored instructional approaches, adapting teaching methods to suit the individual learning styles and pace of each student. This will also include individualised support for struggling students by providing targeted interventions and additional support, addressing specific areas of difficulty, and preventing students from falling behind."

By recognising and responding to individual needs of students, institutions can foster a culture of continuous improvement and better prepare students for success in both academia and the professional world.

While advances in EdTech come with substantial opportunities, it does not come without challenges that must be navigated, says Dr Landman.

ELIMINATING DIGITAL EXCLUSION IS PARAMOUNT

The digital divide remains a significant challenge, as not all students have equal access to technology and the internet.

"Higher education institutions, as well as relevant authorities, must address issues of digital inclusion to ensure that all students, regardless of their socio-economic background, can benefit from the advantages of educational technology," says Dr Landman.

FACULTY DEVELOPMENT REQUIRES THAT NO LEADER BE LEFT BEHIND

The integration of educational technology requires faculty to acquire new skills and adapt their teaching methods.

"These initiatives should be designed to empower educators not only to adeptly harness technology within traditional classrooms and online settings, but also to continually stay abreast of emerging advancements," says Dr Landman.

"By nurturing a culture of ongoing learning and resilience in the face of new developments, these programmes should equip faculty members with the skills and agility needed to navigate the ever-evolving landscape of technologically supported and mediated education practices."

DATA MANAGEMENT, SECURITY, AND PRIVACY: SAFETY FIRST

With the pervasive integration of online platforms and data-driven tools in education, institutions face a burgeoning challenge: the management and effective utilisation of copious student data generated through interactions with learning management platforms.

"This influx of data poses a daunting task, demanding efficient strategies to navigate and harness its potential effectively. Also, with increased interaction online, safeguarding student data should also stand as a paramount responsibility for educational institutions. Education providers must not only prioritise but also proactively establish stringent measures to protect sensitive student information. Such measures should not only safeguard personal information but also cultivate an environment of trust and reliability, crucial for fostering a healthy and secure learning environment."

Dr Landman says it is clear that educational technology is fundamentally reshaping higher education in South Africa, as in the rest of the world. wn

Electricity 2024

- ANALYSIS AND FORECAST TO 2026

Electricity is central to the functioning of modern societies and economies – and its importance is only growing as technologies that run on electricity, such as electric vehicles and heat pumps, become increasingly popular. Power generation is currently the largest source of carbon dioxide (CO_2) emissions.

Still, it is also the sector leading the transition to net zero emissions through the rapid expansion of renewable energy sources such as solar and wind power. Ensuring consumers have secure and affordable access to electricity while reducing global carbon dioxide (CO_2) emissions is one of the core challenges of the energy transition.

Given these trends, the International Energy Agency's (IEA) Electricity 2024 is essential reading. It offers a deep and comprehensive analysis of recent policies and market developments and provides forecasts through 2026 for electricity demand, supply and CO_2 emissions. The IEA's electricity sector report, published regularly since 2020, provides insight into the evolving generation mix. In addition, this year's report features an in-depth analysis of the drivers of recent declines in electricity demand in Europe, the data centre sector's impact on electricity consumption, and recent developments in the global nuclear power sector.

GLOBAL ELECTRICITY DEMAND ROSE MODERATELY IN 2023 BUT IS SET TO GROW FASTER THROUGH 2026

Falling electricity consumption in advanced economies restrained growth in global power demand in 2023. The world's demand for electricity grew by 2.2% in 2023, less than the 2.4% growth observed in 2022. While China, India and numerous Southeast Asian countries experienced robust growth in electricity demand in 2023, advanced economies posted substantial declines due to a lacklustre macroeconomic environment and high inflation, reducing manufacturing and industrial output.

Global electricity demand is expected to rise faster over the next three years, growing by an average of 3.4% annually through 2026. The gains will be driven by an improving economic outlook, contributing to faster electricity demand growth in advanced and emerging economies. Particularly in advanced economies and China, electricity demand will be supported by the ongoing electrification of the residential and transport sectors and a notable expansion of the data centre sector. The share of electricity in final energy consumption is estimated to have reached 20% in 2023, up from 18% in 2015. While this is progress, electrification must rapidly accelerate to meet the world's decarbonisation targets. In the IEA's Net Zero Emissions by 2050 Scenario, a pathway that limits global warming to 1.5 °C, electricity's share in final energy consumption nears 30% in 2030.

Electricity consumption from data centres, artificial intelligence (AI) and the cryptocurrency sector could double by 2026. Data centres are significant

drivers of growth in electricity demand in many regions. After consuming an estimated 460 terawatt-hours (TWh) globally in 2022, data centres' total electricity consumption could reach more than 1 000 TWh in 2026. This demand is roughly equivalent to Japan's electricity consumption. Updated regulations and technological improvements, including on efficiency, will be crucial to moderate the surge in energy consumption from data centres.

EMERGING AND DEVELOPING ECONOMIES ARE THE ENGINES OF GLOBAL ELECTRICITY DEMAND GROWTH

About 85% of additional electricity demand through 2026 is set to come from outside advanced economies, with China contributing substantially even as the country's economy undergoes structural changes. In 2023, China's electricity demand rose 6.4%, driven by the services and industrial sectors. With the country's economic growth expected to slow and become less reliant on heavy industry, the pace of Chinese electricity demand growth eases to 5.1% in 2024, 4.9% in 2025 and 4.7% in 2026 in our forecasts. Even so, the total increase in China's electricity demand through 2026 of about 1 400 TWh is more than half of the European Union's current annual electricity consumption. Electricity consumption per capita in China exceeded that of the European Union at the end of 2022 and is set to rise further. The rapidly expanding production of solar PV modules, electric vehicles, and processing-related materials will support ongoing electricity demand growth in China. At the same time, the structure of its economy evolves.

China provides the largest share of global electricity demand growth in volume, but India posts the fastest growth rate through 2026 among major economies. Following a 7% increase in

India's electricity demand in 2023, we expect growth above 6% annually until 2026, supported by strong economic activity and expanding ownership of air conditioners. Over the next three years, India will add electricity demand roughly equivalent to the current consumption of the United Kingdom. While renewables are set to meet almost half of this demand growth, one-third is expected to come from rising coal-fired generation. We also expect Southeast Asia to see robust annual increases in electricity demand of 5% on average through 2026, led higher by strong economic activity.

While electricity use per capita in India and Southeast Asia is rapidly rising, it has been stagnant in Africa for over three decades. Per capita consumption in Africa has declined in recent years as the population grew faster than the electricity supply was made available, and we only expect it to recover to its 2010-15 levels by the end of 2026 at the earliest. Thirty years ago, an average person in Africa consumed more electricity than someone living in India or Southeast Asia.

However, substantial electricity demand and supply increases in India and Southeast Asia in recent decades – which have gone hand in hand with a boom in economic development – have transformed these regions at a spectacular pace. Meanwhile, Africa's per capita electricity consumption in 2023 was half that of India and 70% lower than in Southeast Asia. Our forecast for Africa for the 2024-26 period anticipates average annual growth in total electricity demand of 4%, double the mean growth rate observed between 2017 and 2023. Two-thirds of this growth in demand is set to be met by expanding renewables, with the remainder covered mainly through natural gas.

Electricity demand in the United States fell by 1.6% in 2023 after increasing by 2.6% in 2022, but it is expected to recover in the 2024-26 outlook period. A key reason for the decline was milder weather in 2023 compared with 2022, though a slowdown in the manufacturing sector was also a factor. We forecast a moderate increase in demand of 2.5% in 2024, assuming a reversion to average weather conditions. This will be followed by growth averaging 1% in 2025-26, led by electrification and the expansion of the data centre sector, which is expected to account for more than one-third of additional demand through 2026.

THERE ARE SLIM CHANCES OF A QUICK RECOVERY FOR ENERGY-INTENSIVE INDUSTRIES IN THE EUROPEAN UNION

Electricity demand in the European Union declined for the second consecutive year in 2023, even though energy prices fell from record highs. Following a 3.1% drop in 2022, the 3.2% year-on-year decline in EU demand in 2023 meant it dropped to levels last seen two decades ago. As in 2022, weaker consumption in the industrial sector was the main factor that reduced electricity demand, as energy prices came down but remained above pre-pandemic levels. In 2023, there were signs of permanent demand destruction, especially in the energy-intensive chemical and primary metal production sectors. These segments will remain vulnerable to energy price shocks over our outlook period.

EU electricity consumption is not expected to return to 2021 levels until 2026 at the earliest. Electricity demand in the European Union's industrial sector fell by an estimated 6% in 2023 after a similar decline in 2022. Assuming the industrial sector gradually recovers as energy prices moderate, EU electricity demand growth is forecast to rise by an average of 2.3% in 2024-26. Electric vehicles, heat pumps and data centres will remain strong pillars of growth over the period, accounting for half of the expected gains in total demand.

Electricity prices for energy-intensive industries in the European Union in 2023 were almost double those in the United States and China. Despite an estimated 50% price decline in the European Union in 2023 versus 2022, energy-intensive industries in the region continued to face far higher electricity costs compared with the United States and China in the aftermath of Russia's invasion of Ukraine. The price gap between energy-intensive industries in the European Union and those in the United States and China, which existed before the energy crisis, has widened. As a result, the competitiveness of EU energy-intensive industries is expected to remain under pressure. Policymakers are currently discussing new policy initiatives and financial instruments to enable the European Union to position itself among other global industrial heavyweights. The scope and effectiveness of these measures will likely determine the future of the European Union's energy-intensive industrial sector.

CLEAN ELECTRICITY SUPPLY IS FORECAST TO MEET ALL OF THE WORLD'S DEMAND GROWTH THROUGH 2026

Record-breaking electricity generation from low-emissions sources – which includes nuclear and renewable sources such as solar, wind, and hydro – is set to cover all global demand growth over the next three years. Low-emissions sources, which will reduce the role of fossil fuels in producing electricity globally, are forecast to account for almost half of the world's electricity generation by 2026, up from 39% in

2023. Over the next three years, low-emissions generation is set to rise at twice the annual growth rate between 2018 and 2023 – a consequential change, given that the power sector contributes the most to global carbon dioxide (CO_2) emissions today.

Renewables are set to provide more than one-third of total electricity generation globally by early 2025, overtaking coal. The share of renewables in electricity generation is forecast to rise from 30% in 2023 to 37% in 2026, with the growth primarily supported by the expansion of ever-cheaper solar PV. Through this period, renewables are set to more than offset demand growth in advanced economies such as the United States and the European Union, displacing fossil-fired supply. At the same time, in China, the rapid expansion of renewable energy sources is expected to meet all additional electricity demand. However, the weather and the extent to which the country's demand growth eases remain critical sources of uncertainty for the outlook. The substantial expansion in renewable power capacity must also be accompanied by accelerated investment in grids and system flexibility to ensure smooth integration.

The rapid growth of renewables, supported by rising nuclear generation, is set to displace global coal-fired generation, which is forecast to fall by an average of 1.7% annually through 2026. This follows a 1.6% increase in coal-fired output in 2023 amid droughts in India and China that reduced hydropower output and increased coal-fired generation, more than offsetting solid declines in coal-fired generation in the United States and the European Union. The primary factor determining the global outlook is evolving trends in China, where more than half of the world's coal-fired generation occurs. Coal-fired generation in China is currently on course to experience a slow structural decline, driven by the substantial expansion of renewables and growing nuclear generation, as well as moderate economic growth. Despite the commissioning of new plants to boost the security of energy supply, the utilisation rate of Chinese coal-fired plants is expected to continue to fall as they are used more flexibly to complement renewables. Nevertheless, coal-fired generation in China will be influenced significantly by the pace of the economy's rebalancing, hydropower trends, and bottlenecks in integrating renewables into the country's power system.

Natural gas-fired generation is expected to rise slightly over the outlook period. In 2023, sharp declines in gas-fired power generation in the European Union were more than offset by massive gains in the United States, where natural gas, which has increasingly replaced coal, recorded its highest-ever share in power generation. Global gas-fired output grew by less than 1% in 2023. Through 2026, we forecast an average annual growth rate of around 1%. While gas-fired production in Europe is expected to continue declining, global growth will be supported by significant gains in Asia, the Middle East and Africa amid rising demand for power in these regions and the availability of additional liquefied natural gas (LNG) supply from 2025 onward.

NUCLEAR POWER GENERATION IS ON TRACK TO REACH A NEW RECORD HIGH BY 2025

By 2025, global nuclear generation is forecast to exceed its previous record set in 2021. Even as some countries phase out nuclear power or retire plants early, nuclear generation is forecast to grow by close to 3% per year on average through 2026 as maintenance works are completed within France, Japan restarts nuclear production at several power plants, and new reactors begin commercial operations in various markets, including China, India, Korea, and Europe. Many countries are making nuclear power a critical part of their energy strategies to safeguard energy security while reducing greenhouse gas emissions. At the COP28 climate change conference that concluded in December 2023, more than 20 countries signed a joint declaration to triple nuclear power capacity by 2050. Achieving this goal will require tackling the critical challenge of reducing construction and financing risks in the nuclear sector. Momentum is also growing behind small modular reactor (SMR) technology. The technology's development and deployment remain modest and are not without difficulties, but R&D is starting to pick up.

Asia remains the main driver of growth in nuclear power, with the region's share of global nuclear generation forecast to reach 30% in 2026. Asia is set to surpass North America as the region with the largest installed nuclear capacity by the end of 2026, with many plants currently under construction and expected to be completed by then. More than half of the new reactors expected to become operational during the outlook period are in China and India. Nuclear power has seen robust growth in China over the past decade, with capacity additions of about 37 gigawatts (GW), equivalent to almost two-thirds of its current nuclear capacity. This resulted in China's share in global nuclear generation rising from 5% in 2014 to about 16% in 2023. China started commercialising its first fourth-generation reactor in December 2023, further underscoring its nuclear power advances.

EMISSIONS FROM ELECTRICITY GENERATION ARE ENTERING STRUCTURAL DECLINE AS DECARBONISATION GATHERS PACE

Global CO_2 emissions from electricity generation are expected to fall by more than 2% in 2024 after increasing by 1% in 2023. This is set to be followed by slight declines in 2025 and 2026. The strong growth in coal-fired power generation in 2023 – especially in China and India amid reduced hydropower output – was responsible for the rise in the global electricity sector's CO_2 emissions. As clean electricity supply continues to expand rapidly, the share of fossil fuels in global generation is forecast to decline from 61% in 2023 to 54% in 2026, falling below 60% for the first time in IEA records dating back to 1971. While extreme weather conditions, economic shocks, or changes in government policies could lead to a temporary rise in emissions in individual years, the broader decline in power sector emissions is expected to persist as renewables and nuclear power capacity continue to expand and displace fossil-fired generation.

The CO_2 intensity of global electricity generation is set to fall at twice the rate recorded in the pre-pandemic period. The forecasted average decline of 4% in CO_2 intensity between 2023 and 2026 is double the 2% observed between 2015 and 2019. The European Union is expected to record the highest rate of progress in reducing emissions intensity, averaging an improvement of 13% per year. This is followed by China, with annual improvements forecast at 6%, and the United States at 5%. The decline in the CO_2 intensity of electricity generation means that emissions savings via the electrification of transport, heating and industry will become even more substantial.

WHOLESALE ELECTRICITY PRICES REMAIN ABOVE PRE-COVID LEVELS IN MANY COUNTRIES

Wholesale electricity prices in many countries fell in 2023 from the record highs observed in 2022. This took place in tandem with declines in prices for energy commodities such as natural gas and coal. There are, however, regional differences. Wholesale electricity prices in Europe declined on average by more than 50% in 2023 from record levels in 2022. Despite this, European prices were still roughly double 2019 levels, whereas US prices in 2023 were only about 15% higher than in 2019. Uncertainty about the pace of France's nuclear recovery and natural gas prices are supporting higher future prices in Europe for upcoming winters. The hydropower-dominated Nordics remain the only market in Europe with average wholesale electricity prices comparable to those in the United States and Australia. Wholesale prices in Japan and India also remained above 2019 levels in 2023.

GROWING WEATHER IMPACTS ON POWER SYSTEMS HIGHLIGHT THE IMPORTANCE OF INVESTING IN ELECTRICITY SECURITY

Global hydropower generation declined in 2023 due to weather impacts such as droughts, below-average rainfall and early snowmelts in numerous regions. Canada, China, Colombia, Costa Rica, India, Mexico, Türkiye, the United States, Vietnam, and other countries saw hydropower generation decline. The global hydropower capacity factor, a key measure of utilisation rate, fell to below 40%, the lowest value recorded in at least three decades. In certain countries, diminished hydropower output led to energy shortages, heightened reliance on fossil sources such as coal and gas, and raised concerns about the stability of the electricity supply. The overall trend underscores the susceptibility of hydropower to weather patterns and the potential exposure of countries that rely heavily on hydro to generate electricity. Diversifying energy sources, building regional power interconnections and implementing strategies for resilient generation in the face of changing weather patterns will be increasingly important.

Extreme weather events triggered significant power outages in 2023 in the United States and India. This underlined the need to boost resilience as weather impacts on power systems increase, with both supply and demand becoming more weather-dependent. Insufficient power capacity, fuel supply challenges and grid-related technical issues also continued to cause significant power shortages in many regions. Most of these outages were observed in emerging economies such as Pakistan, Kenya and Nigeria, mainly affected by insufficient electricity supply, infrastructure problems and strained grids in the face of rising power demand. Expanded, stronger grids would ensure reliable electricity and serve as a vital backbone for integrating renewables into power systems. Improving data collection, digitalisation, and greater data transparency regarding outages is also essential to provide better insight into why faults occur and to help develop preventative measures.

Specific operating measures and new markets for ensuring the stability of power systems are becoming more common. Countries with high shares of variable renewable generation are implementing mechanisms to ensure a steady power system frequency. Some regions are

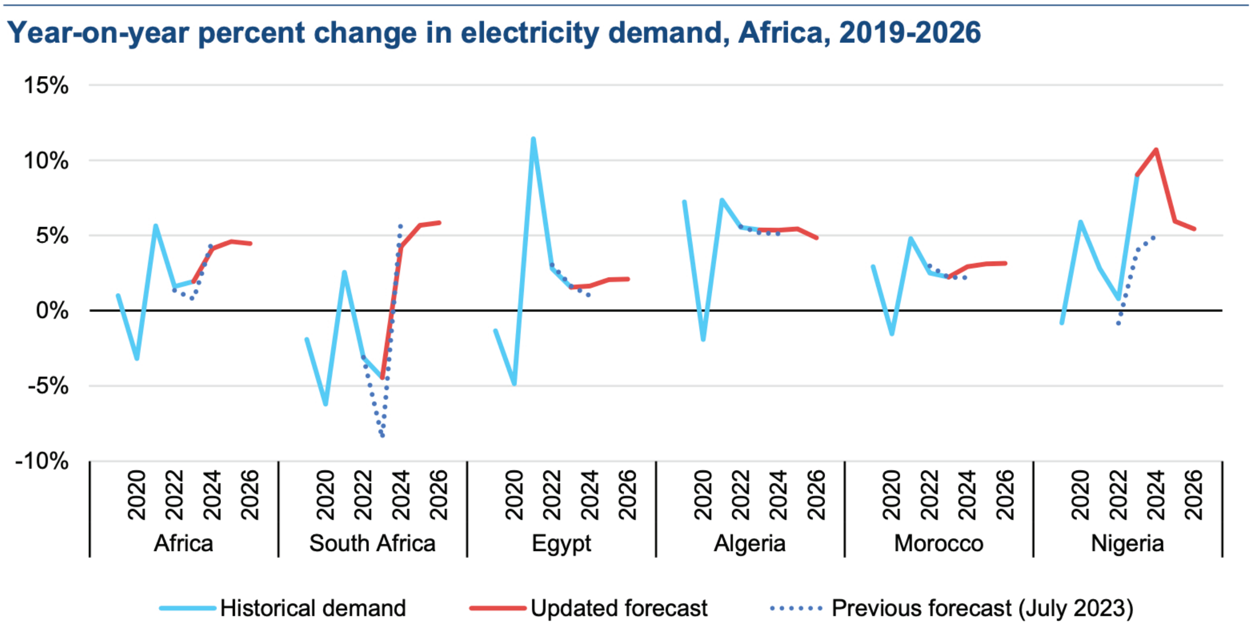

Figure 1

establishing minimum requirements for system inertia, a property typically provided by conventional generators with spinning rotors that helps enhance the power system's resilience during disturbances. Additionally, various countries, including the United Kingdom, Ireland and Australia, have been introducing markets and measures such as fast frequency response and similar services that stabilise the power system rapidly after disruptions. Battery storage systems can provide such services for grid stability while enhancing system flexibility, thus playing a crucial role in integrating renewable energy sources.

REGIONAL FOCUS - AFRICA

INSUFFICIENT POWER CAPACITY AND INFRASTRUCTURE ISSUES CONTINUE TO CURB GROWTH

Electricity demand in Africa increased by 2% in 2023, marginally higher than the year before. Due to chronic power capacity constraints, the lacklustre growth primarily reflects a sharp contraction in demand in South Africa, the continent's largest electricity consumer. Egypt and Algeria, the region's second and third largest consumers, are estimated to have seen growth of 1.5% and 5%, respectively. Combined, these three countries make up 60% of demand in Africa.

The IEA forecast for Africa anticipates much faster growth for the 2024-2026 period, with average annual electricity demand rising by more than 4%. The higher growth rates also reflect a rebound in South African power demand following the restart of shut-in capacity.

We expect per capita electricity consumption in Africa to recover to its 2010-2015 levels by the end of 2026 at the earliest. In our forecast, two-thirds of additional demand growth in Africa is expected to be met by expanding renewables, with natural gas supplying most of the rest.

The emission intensity of electricity generation is expected to fall from 520 g CO_2/kWh in 2023 to 490 g CO_2/kWh in 2026. See Figure 1.

DEMAND SUPRESSED BY EVER-WORSENING POWER GENERATION SHORTAGES IN 2023, AND THE OUTLOOK REMAINS PRECARIOUS

Electricity consumption in South Africa declined sharply in 2023, dropping more than 4% y-o-y due to increased load shedding. This extends the downward trend in demand observed since 2018 when the current power crisis started – except in 2021 when demand rebounded from the COVID-19 shock.

The power sector continues to be plagued by load shedding due to a shortage of power capacity as the availability of its ageing coal fleet has degraded further. At the same time, much-needed new power capacity has struggled to come online to replace this fleet. Most notably, three units of the newly commissioned 4 800 MW Kusile power station suffered critical damage when half of its units were taken out of service when a chimney collapsed towards the end of 2022. This has been further exacerbated by ongoing maintenance at the Koeberg nuclear plant, where one of the two units was restarted in November 2023 after

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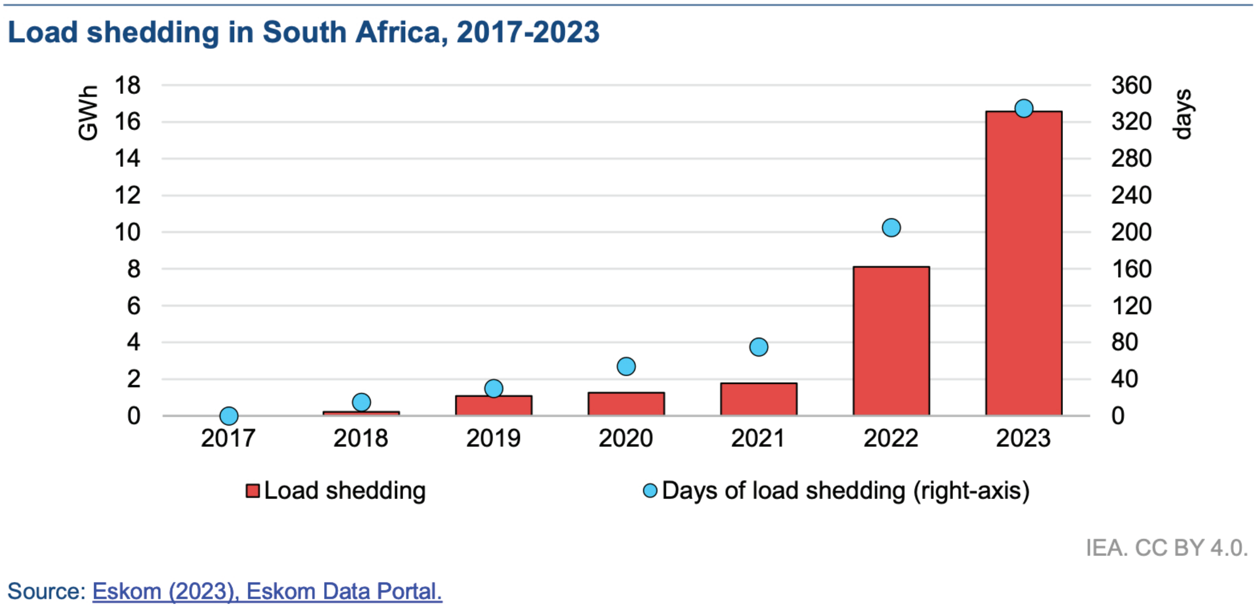

Figure 2

almost a year out of service before the other unit was taken out of operation for similar maintenance a month later.

Meanwhile, the timely procurement of new power capacity through auctions since the COVID-19 pandemic has proven largely unsuccessful due to several issues. Escalating costs due to inflation have prevented successful projects from reaching financial close - see Figure 2.

As a result of these challenges, 2023 will be the worst year to date for load shedding, with the total volume of load shedding up until the end of September already exceeding the total in the previous eight years combined.

The latest renewable auction has fared no better. During the evaluation of the bids, it emerged that the grid hosting capacity in the Eastern and Western Cape (where all wind bids had been received) had been reduced to zero, and so only 860 MW of solar capacity (out of 5 200 MW renewables tendered) was procured. This will further hamper the success of the latest plans for procurement. The government of South Africa announced several new auctions in December 2023 for a suite of technologies, including 5 000 MW of wind and solar PV capacity, 2 000 MW of gas-fired projects and 615 MW of battery storage capacity. The latter comes after the successful procurement of around 500 MW of battery storage capacity last year, the first auction of its kind in South Africa. In addition, the government announced plans to procure 2 500 MW of nuclear capacity. In an attempt to solve the ongoing power crisis, also approved an updated integrated resource plan, although this is yet to be released for public comment.

Despite these critical issues around power capacity, demand is expected to grow by 5%. on average over the forecast period. This is a sharp reversal of the -2% average for the 2018-2023 timeframe. This is based on the return to service of nuclear generation and damaged units at the Kusile coal-power plant. Additionally, we expect renewable capacity to continue to come online from previous auctions through direct procurement via PPAs in the private sector. This will result in the emission intensity of the system decreasing by around 2% y-o-y on average over the forecast period, reaching just under 800 g CO_2/kWh in 2026.

Despite the lack of capacity delivered by the procurement programmes, strong policy is opening up new possibilities for the private sector to respond outside the traditional procurement channels. Following the easing of licensing requirements for private generators, there has been a significant increase in the number of applications for licenses as commercial and industrial consumers have started to invest in renewable generation for their own consumption.

This trend is clear from publicly available data of private projects registered with the regulator. It is equally supported by analysis from Eskom, which estimates that around 4.4 GW (and an increase of

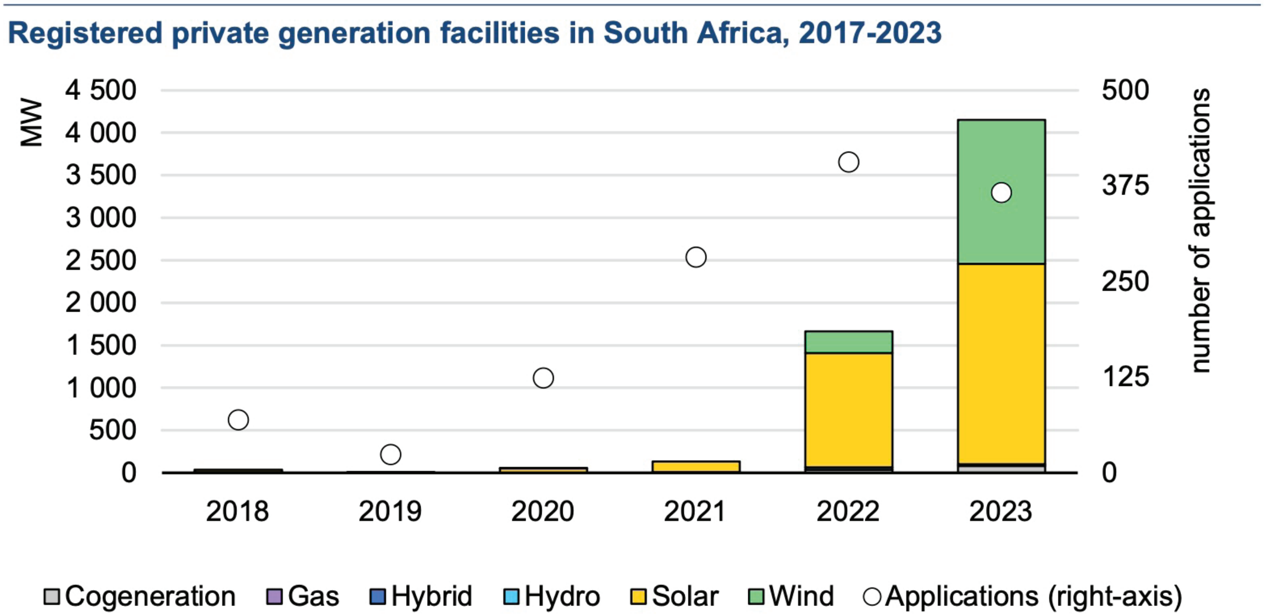

Figure 3

3.5 GW over the calendar year from June 2022 to July 2023) of distributed solar PV was connected to the system - see Figure 3.

The increase in private generation projects may soon be equally aided by a new regulation that allows for the wheeling of power from private projects to multiple customers via power purchase agreements (PPAs). This will be further enabled through the development of a new digital platform by Eskom that can circumvent structural constraints around billing and allow for the wheeling of power from private generators to direct offtakers at the distribution level. The so-called Virtual Wheeling Platform has recently passed from concept to implementation as Vodacom, the largest telecommunications provider in South Africa, signed an agreement with Eskom whereby they will be able to purchase power from renewable energy projects directly to power their operations through the platform. Up until now, private projects for wheeling have been relatively slow to reach financial closure, and so the speed at which they can contribute to the generation mix may be quite limited - see Figure 4.

EGYPT

GOVERNMENT SUPPORT ENABLES GROWTH IN RENEWABLE ENERGY ELECTRICITY GENERATION

Electricity demand in Egypt rose by an estimated 1.5% in 2023. Gas-fired generation is estimated to have increased by around 2%. A decline in the share of generation from oil products versus the previous year in favour of gas resulted in a 1.2% annual decrease in the emissions intensity of the energy mix.

Since 2018, the Egyptian government has taken significant steps to support the electricity sector, attract foreign investments and expand the infrastructure for electricity transmission and distribution. As a result, the sector has become more competitive, with numerous international companies competing for market share and substantially raised investment in the country.

The IEA anticipate sustained growth in electricity demand of an average 2% per year until 2026, supported by higher demand for air conditioning. In addition, Egypt has committed to drastically reduce its energy subsidies as part of a financial support programme with the IMF. Electricity prices will remain unchanged for consumers until January 2024, however after this, rising prices could put downward pressure on demand growth.

Growth in renewable capacity will be supported by the Energy Pillar of Egypt's Country Platform for the Nexus of Water, Food and Energy (NWFE) Program, launched by the government at COP27 in November 2022. NWFE aims to deploy an additional 10 GW of renewable energy capacity (solar and wind) between 2023 and 2028. It also includes the decommissioning of 5 GW of inefficient fossil fuel capacity from 2023 onward. Continued growth of renewables will raise its share in the generation mix from around 11% today to 13% in 2026.

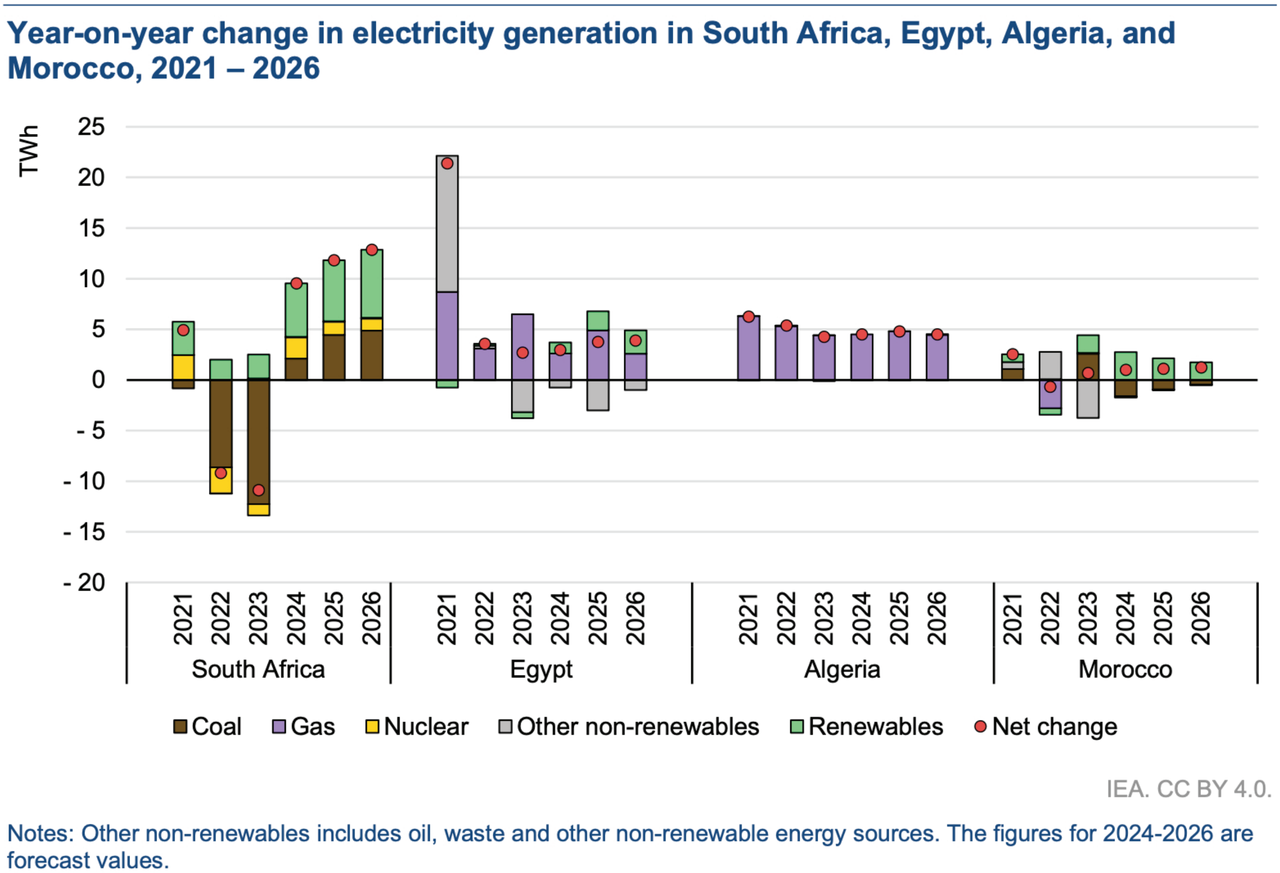

Figure 4

The IEA forecast power generation emissions to remain relatively stable for 2024-2026, as expanding renewables restrain the growth in natural gas-fired power.

Egypt's Vision 2030 plan, which was launched in 2022, targets a 10% reduction in GHG emissions in the energy sector, including oil and gas, by 2030 compared with 2016 levels.

Launched in 2023, the Red Sea Wind Energy project, supported by the European Bank for Reconstruction and Development (EBRD), will contribute to Egypt's green transition with the development of a 500 MW onshore wind farm in the Gulf of Suez region.

ALGERIA

THE COUNTRY'S BOUNTIFUL NATURAL GAS RESERVES PROVIDE ALMOST ALL OF POWER GENERATION BUT RENEWABLES MAKING INROADS

Electricity demand in Algeria rose by about 5% in 2023, largely unchanged from the year before. Over the 2024-2026 forecast period, we anticipate total electricity demand to expand at an average annual rate of 5.2%, mainly driven by economic growth, along with additional consumption coming from water desalination and electric vehicles. Although the electrification of the transport sector remains limited, this will increase over time, with the government aiming to reach 1 000 electric vehicles on the road and 1 000 charging stations by 2024.

Algeria's installed power power capacity is currently around 25 GW. The power mix is heavily dominated by natural gas, representing 99% of generation in 2023. The government is taking steps to accelerate the deployment of renewable energy sources to meet its target of 22 GW of renewables by 2030. Following a tender launched in December 2021 for 1 GW solar PV that did not result in any contracts, in August 2023 the government issued a new tender aiming for a total solar PV capacity of 2 000 MW. Of over 100 bids, 73 from both international and local applicants were accepted as meeting the requirements.

Two additional tenders took place in the following months, the first for 1 GW – reopening the original tender from 2021 – and a second for 3 GW.

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Trans-Africa Projects (TAP) is committed to delivering sustainable solutions that meet these criteria while promoting economic growth, social equity, and environmental stewardship.

CHALLENGES IN AFRICA:

Many African countries face grid infrastructure challenges, resulting in high losses and low supply quality. Trans-Africa Projects recognises the need for a systemic approach to unlock the potential of renewables and decouple energy demand from emissions.

THE ROLE OF UTILITIES:

Electrification remains a dominant theme for utilities, necessitating a shift towards sustainable practices. Trans-Africa Projects is at the forefront, advocating for and implementing these sustainable solutions.

GLOBAL ENERGY TRENDS:

Global energy demand is projected to rise by 1.8% in 2024. African governments' efforts to improve access and industrialisation will drive consumption. Coal-dependent nations like South Africa, Botswana, and Morocco will continue to see increased demand.

SUSTAINABLE ENGINEERING DESIGN:

Trans-Africa Projects specialises in sustainable engineering design, ensuring reliable electricity delivery while promoting economic, social, and environmental benefits. From power generation balance of plant to substations and transmission lines to rural electrification, TAP's solutions prioritise sustainability and efficiency.

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However, by the end of 2023 no winners had been announced nor private contracts signed for any of the tenders. In the absence of a late-stage development project pipeline, the forecast is conservative regarding the amount of utility-scale projects that will be commissioned by 2026 and therefore we expect gas will continue to account for the majority of generation (99%). This would result in power sector emissions growth of around 4.5% CAGR during 2024-2026 amid increasing power demand.

Algeria's interest in renewable energy is also linked to the country's water desalination programme. In March 2023, the government signed off on the creation of an independent national agency for water desalination with a view to ensuring water security and reaching 50% of drinking water from desalination by 2030. Six months later, the Algerian Energy Company (AEC) announced that the new 80 000 m^3 plant at Corso had hit full capacity. All seawater desalination plants combined are expected to have a capacity of 3.6 million m^3/d by 2024. The additional electricity use could be in the range of 1-4% of Algeria's current electricity demand, depending on the technologies employed.

To develop grid infrastructure, the government has announced an interconnection project linking the southern grid to the national grid. The construction of this 700 km double 400 kV high voltage transmission line would help boost the electricity supply to the country's southern provinces.

MOROCCO

DIVERSIFYING ELECTRICITY GENERATION MAKING SIGNIFICANT PROGRESS, WITH A FOCUS ON RENEWABLES AND FLEXIBLE TECHNOLOGIES

Electricity consumption in Morocco rose by around 2% in 2023 and is expected to grow at an average annual rate of 3.1% over the rest of the forecast period. Morocco has been striving to diversify its power supply and increase the share of renewable generation, with a target of reaching at least 52% by 2030. A series of successful tenders have resulted in a growing share of wind and solar (including PV and CSP) generation, as well as flexible technologies such as batteries and pumped storage hydro to support the integration of these new resources. Thermal generation accounted for almost 80% of generation in 2023, consisting of primarily coal-fired electricity (73%), which has steadily increased over the last five years at the expense of gas-fired generation. This comes after gas imports from Algeria ceased in November 2021 following the breakdown of diplomatic ties between the two countries.

As a result, increasing demand in Morocco over the 2024-2026 forecast period is expected to be met by growth in wind and solar PV production, also reducing the share of thermal generation in the energy mix. In July 2023, a 300 MW wind plant was commissioned, while the Moroccan Minister of Energy Transition and Sustainable Development (METSD), announced its Investment Plan for 2023–2027, which envisages the deployment of 7 GW of new renewable capacity.

Additionally, in August 2023, following the successful call for tender for the construction of a 400 MW solar PV plant with two hours of battery storage, a new call for tender was issued for an additional 400 MW solar PV plant with one hour of battery storage. This highlights not only the acceleration towards the power capacity target but also in flexibility to support the integration of these new resources. This is equally demonstrated by the recent MoU concluded between Morocco and China's telecommunications company Huawei, with the aim of harnessing innovative electricity storage technologies for the system integration of renewable generation. Morocco also adopted legislation in October 2023 that, when implemented into its regulatory framework, will both permit and encourage the broader deployment of decentralised generation.

While the focus of growth on the supply-side has been in renewables, Morocco also signed an LNG supply agreement with Shell for 0.5 bcm of LNG until 2035, which the METSD has stated would be in line with its decarbonisation goals. This would look to replace the loss of gas supply from Algeria.

NIGERIA

DETERIORATION OF POWER INFRASTRUCTURE INCREASED DEPENDENCY ON BACKUP GENERATORS FOR 40% OF ELECTRICITY CONSUMPTION

In 2022, 73% of Nigeria's population had access to electricity, an increase of more than 70 million people during the past decade. Although the country has a total installed capacity of about 13 GW, average available capacity remained around 4.5 GW in 2023 due to a combination of factors such as deteriorating units, poor maintenance and liquidity constraints. Unreliable power supply due to limited grid infrastructure, underinvestment and ineffective regulatory frameworks has resulted in an estimated 40% of all the electricity consumed in the country being produced from backup generators. To meet increasing demand, the performance of the Nigerian Electricity Supply Industry (NESI) is being reviewed and electricity supply remains a priority of the federal government. The

240 MW Afam Three Fast Power natural gas-fired plant as well as the gas-fired 50 MW Maiduguri Emergency Thermal Power Plant were commissioned in 2023. Similarly, the 700 MW Zungeru hydropower plant was commissioned in Q4 2023, boosting the renewable generation of the country.

The country's largest thermal power plant was announced, a 1 900 MW expansion of Egbin Power Plc (commercial operation by 2025). The 1 350 MW gas-fired Gwagwalada Independent Power Plant is currently under construction in three phases, the first of which is to be completed in 2024. Once operational, it is expected to provide around 11% of the country's electricity.

Gas-fired generation in the country is estimated to have increased by 6% in 2023 with new plants becoming operational. We estimate that electricity demand rose by 9% in 2023 as available generation increased. From 2024-2026, electricity demand is forecast to rise by an annual average of around 7%, as new gas-fired capacities enter operation according to plan, supporting an average 6% growth rate in gas-fired generation in 2024-2026. Nevertheless, delays in commissioning of the plants and continued problems with infrastructure are sources of uncertainty in our forecast - see Figure 5.

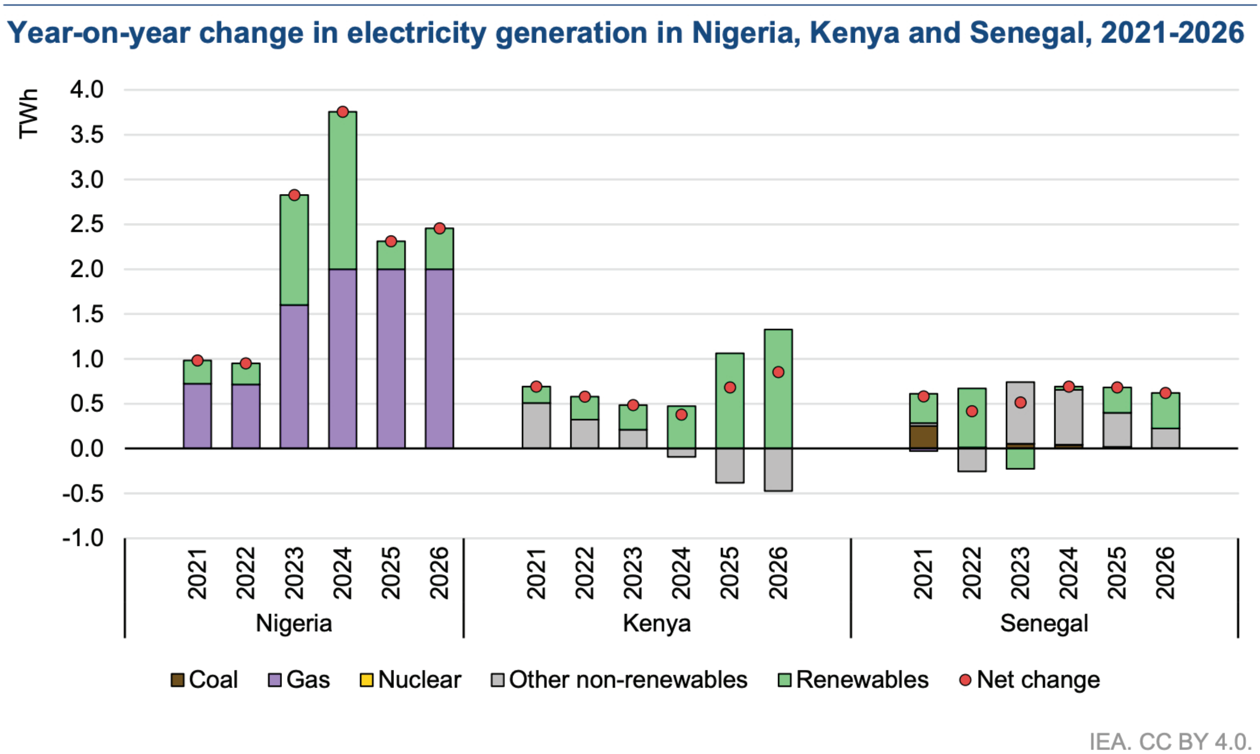
Natural gas accounted for around 75% of electricity generated on the main grid in 2023. Natural gas is expected to continue to play an important role in energy supply and grid stabilisation for Nigeria's power sector until 2030, and decline by 2050, according to the country's Energy Transition Plan (ETP).

Renewables are also forecast to increase over the 2024-2026 period at a CAGR of around 8% and a positive spillover in terms of GHG emission reduction (-1.8%). Hydropower accounts for most of the renewables generation during 2024-2026, largely due to the completion of the Zungeru project, with an estimated generation of 2.6 TWh per year. Hydropower is forecast to rise further, thanks to the completion of the 1 650 MW Makurdi Hydropower Plant.

Solar PV is expected to grow rapidly, with an average rate above 50% per year over the next three years, remaining at around 1% of generation in 2025. The off-grid space (including mini-grids, solar home systems and solar lights) represents a significant portion of the country's solar PV electricity supply, estimated to have reached 93 MW of installed capacity in 2021. It could drive much of the growth in the coming years. In May 2023, President Bola Tinubu announced the end of Nigeria's fossil fuel subsidies. This decision starts the use of solar-based solutions to replace expensive diesel generators.

The Nigerian Rural Electrification Agency (REA) promotes and co-ordinates rural electrification programmes. It has implemented the Energizing Economies Initiative, which aims to support the rapid deployment of off-grid electricity solutions in economic clusters through private sector developers. The strong growth of off-grid solutions in Nigeria is the driver of a broader growth trend in West Africa.

In June 2023, Nigeria adopted a new Electricity Act 2023, which aims to provide a comprehensive legal and institutional framework for a privatised contract and rule-based competitive electricity market, with a view to attracting private sector investments across the power sector. While the act strengthens the role of regulatory bodies, as it introduces consumer protection measures and provides for a transparent tariff-setting process, it also opens up the possibility of multiple licensing regimes by enabling regulation at state level. Although regulation at the federal level remains the rule where no state regulation is specified, careful co-ordination and streamlining of regulatory approaches across states would be required to minimise the uncertainty of different regimes.



Notes: Other non-renewables includes oil, waste and other non-renewable energy sources. The figures for 2024-2026 are forecast values.

Figure 5

OTHER AFRICA

In Kenya, over 700 000 new customers were connected to the national grid in 2022 and 75% of the population had access to electricity (both national grid and off-grid solutions), a substantial growth compared to 47% in 2015. Electricity demand is estimated to have increased by around 4.5% in 2023, and we expect annual demand growth of 5.7% on average from 2024 to 2026. Kenya has a total installed capacity of about 3.3 GW and generated about 13 TWh, of which more than 90% was from renewable sources. The Kenyan government has an ambition of reaching a 100% share of renewables in electricity generation by 2030.

The IEA estimate that in 2023 more than 44% of generation in Kenya came from geothermal, with the remainder of renewables coming mainly from hydropower and wind. Kenya's Lake Turkana Wind Farm is Africa's largest, with 365 turbines at 850 kWh capacity each. We anticipate the country's renewable generation to grow by around 7% per year in 2024-2026. The largest growth is anticipated in PV and wind, with 25% and 13% annual average growth, respectively. The government is considering the introduction of grid-scale battery energy storage systems to support increased uptake of renewable energy and displace thermal generation at peak. Kenya also aims to diversify its future generation sources to include nuclear power and have its first nuclear power plant up and running by 2038.

The Kenyan grid is interconnected with the Ethiopian grid through a 1 058 km line energised in 2023. The Kenya Power and Lighting Company (KPLC) started importing electricity at lower tariffs last year under a 27-year power-sharing agreement signed by the two governments. Further regional interconnections will be achieved through an interconnector with Tanzania, under construction, and a second line with Uganda, under implementation. These projects will eventually facilitate the creation of a regional power market. According to IEA analysis, Senegal is on track to achieve Sustainable Development Goal 7 (SDG7) of universal access to electricity by 2030. With some additional efforts and deploying off-grid solutions, it can reach its 2025 target. In 2022, 75% of the population had access to electricity, representing an increase of 17 percentage points over the past decade. Despite this rapid progress, disparities remain between urban and rural areas, where access rates are 97% and 55%, respectively. Adequacy and affordability of electricity supply to meet

growing demand is a key concern for the country.

Electricity demand rose by an estimated 8% in 2023 and is forecast to grow at a slightly stronger pace of 9.% in 2024-2026. Supply is mostly dominated by fossil fuels, particularly imported heavy fuel oil (HFO). In 2021, total installed power capacity amounted to 1.62 GW, with fossil fuels accounting for 72% (1.16 GW). In 2022, renewables accounted for around 25% of total electricity generation and 30% of installed capacity, in line with government targets.

Hoping to leverage domestic natural gas resources under development, Senegal is pursuing a gas-to-power strategy to switch from imported HFO to natural gas to reduce costs and emissions and increase supply security. A 300 MW gas-fired combined-cycle power plant at Cap de Biches will come online in 2024.

A new electricity code (Law no. 2021-31) approved in 2021 is paving the way for the unbundling of the power sector. Under this new framework, the government of Senegal is developing an Integrated Low-Cost Plan (PIMC) to enhance planning in the sector. In 2023, Senegal entered a Just Energy Transition Partnership (JETP) with France, Germany, the European Union, the United Kingdom and Canada. Under the JETP, the international partners are undertaking to mobilise up to EUR 2.5 billion to support the country in accelerating clean energy deployment for sustainable development. Senegal increased its renewable energy targets to 40% of installed capacity by 2030. **wn**

Accelerating an Equitable Transition

- A FRAMEWORK FOR ECONOMIC EQUITY

The green transition, driven by a rising urgency of accelerated climate action, is a transformative economic shift that impacts the production, distribution and consumption of goods and services with far-reaching and complex implications on equity, fairness and justice. Achieving net zero will encompass a wide range of changes: a clean energy system; the greening of agriculture, mobility and heavy industry; sustainable cities and infrastructure; and the scaleup of circularity models.

Carefully managing the economics of an equitable transition – putting at the centre the fair allocation of costs and benefits and the impact on people – will ultimately determine the success of this unprecedented transformation. The green transition is already impacting labour markets, shifting relative and absolute prices, changing the landscape of basic goods and services, and drawing new divides in the access to capital, knowledge and technology.

The risk of the green transition widening inequalities is not a peripheral concern. It is set against a backdrop of widening inequality within countries and stalling global economic convergence, as well as a cost-of-living crisis currently felt by many people around the world. In no region of the world do the bottom 50% of the population own more than 5% of wealth, nor contribute to more than a quarter of their region's emissions. Yet climate policies such as carbon taxes and efficient equipment mandates can have a disproportionate impact on low- and middle-income groups, including in advanced economies. The social and political support that the transition requires cannot be developed and sustained unless fairness is a foundational principle. Climate action that exacerbates inequalities can give rise to geopolitical and social fragmentation, which might impact the cost and speed of the green transition.

The perspectives offered in this paper take a step towards this ambition, offering a framework for economic equity that categorizes the costs and benefits of a shift to a low-carbon economy for workers, consumers and entrepreneurs.

By focusing on economic equity, we aim to surface the distributive impacts of climate mitigation on people and mobilize businesses and governments to maximize opportunities and minimize risks. Retooling economic and business strategies to place equity at the centre of the green transition can have far-reaching impacts in a world of integrated supply chains and increasing public-private investment and collaboration.

This framework will be used as a starting point for the World Economic Forum's Equitable Transition Initiative, which attempts to create a platform to connect stakeholders, develop insights and build consensus on the necessity, vision and organizing principles for an equitable green transition. The initiative's ambition is to ensure that the shift toward a low-carbon future places people – together with the planet – at the centre. While economic equity is only one aspect of fairness, it is deeply relevant to the daily experiences of large populations and an area of focus where a global coalition of government and business leaders is well-positioned to accelerate progress.

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1 Introduction: The climate-inequality nexus

The interplay between climate vulnerability, income and wealth manifests between and within countries, intensifying existing inequalities and risking the emergence of new divides. Over 780 million people globally are currently exposed to the combined risk of poverty and serious flooding.[2] Within low- and middle-income countries, the income losses from climate hazards of the bottom 40% are estimated to be 70% larger than the average.[3] The serious consequences of climate change and its uneven impacts heighten the imperative to limit global temperature to 1.5°C.

However, the costs and responsibilities of the socioeconomic transformation that a carbon-neutral future requires fall unevenly too – and the ramifications are increasingly evident in the political and social polarization surrounding climate discourse and action. This creates a strong risk that existing inequalities may be amplified, if not addressed actively.

1.1 Emissions and inequality: Parallel trends

Over the past four decades, the richest 1% of individuals captured more than twice the world's income growth compared to the poorest 50%.[4] This divergence parallels inequity in carbon emissions: Since 1990, the top 1% of emitters have been responsible for 23% of global growth in carbon emissions, while the bottom 50% have been responsible for only 16%.[5] Those between the 75th and the 95th percentile of the emissions distribution have seen their per-capita emission levels drop over the past 30 years by rates of up to 15%. This group overlaps largely with the low-income and middle classes in rich countries, who have seen their income shares stagnate or even decrease in the past 30 years (Figure 1).

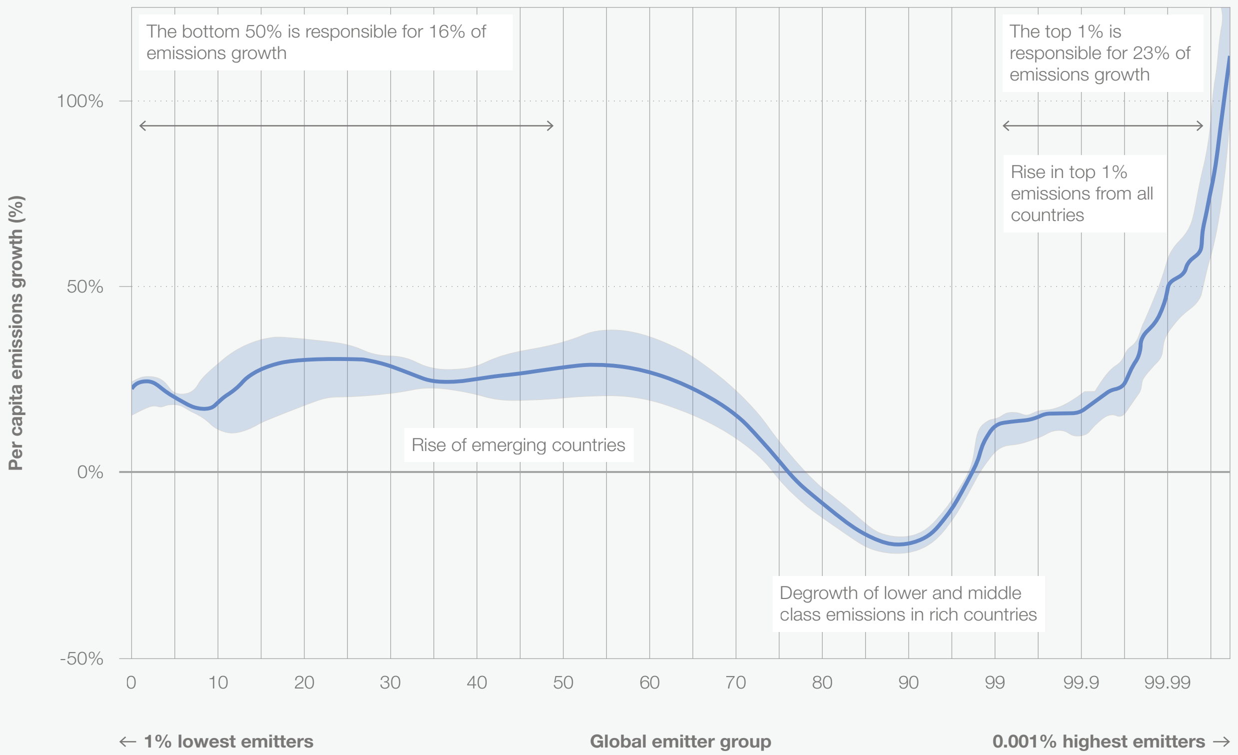
Today, within-country income inequalities explain a significantly larger part of global income inequalities than 40 years ago,[6] and a similar trend is reflected in inequality of per-capita emissions, showing the urgency to realize an equitable transition as much within countries, as it is between countries. Figure 2 shows that 64% of global inequality in per-capita emission today is due to within-country gaps. The inverse was true in 1990, when between-country divides accounted for 62% of global carbon inequality.[7]

To build the social and political capital required to progress on the green transition, a focus on fairness in the distribution of costs and benefits arising from the transition is a necessity. As countries embark on the green transition at the speed and scale required, it is only viable if inequality is curtailed, and more ambitiously, reduced through it.

1.2 Understanding the socioeconomic impacts of the green transition

Throughout modern history, no country has achieved economic growth without increasing its energy consumption. Energy is the lifeblood of the modern economy, an enabler of modern life, and has powered technological progress over the past two centuries. As the environmental consequences of this energy-fuelled growth become apparent, the green transition entails harnessing cleaner forms of energy and decoupling economic growth from energy consumption and emissions. However, given the complex linkages between the energy system and the economy, the green transition is not confined solely to the boundaries of the energy system. Rather, it encompasses the means of

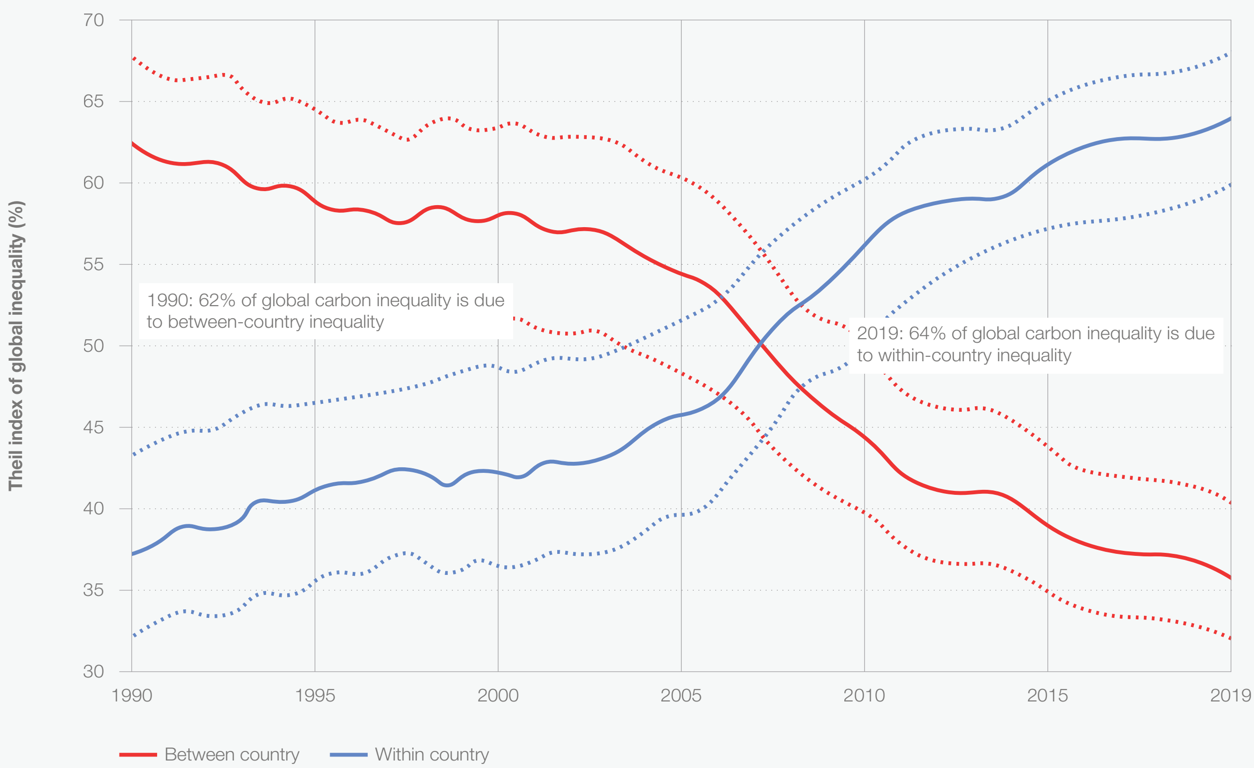
FIGURE 1 | **Emissions growth by percentiles, 1990-2019**



Source

Chancel, 2022.

FIGURE 2 | **Global Emissions Inequality: between vs. within country, 1990-2019**



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Chancel, 2022.

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industrial production, modes of transportation, urbanization, consumption habits and the rethinking of the future of low-carbon growth.

As the urgency of an accelerated green transition rises, it's imperative to understand and address the inherent economic costs and benefits that will asymmetrically impact different segments of society. Consider the impact on workers. Over 50% of senior executives globally believe that the climate and green transitions will be key drivers of job creation in the next five years.[8] Available estimates quantify the net-positive impact of the green economy on the labour market to be approximately 25 million additional jobs globally. While that breaks down to 103 million new jobs created, it means 78 million workers will lose their jobs by 2030.[9] The impact on green jobs unfolds against a backdrop of broader labour-market transformations, driven by changes in technology and a volatile economic outlook. The combined effects of these disruptions lead to an estimated one in four jobs being affected globally, both through growth and decline, and 44% of workers' core skills expected to change in the next five years.

In addition to labour-market dislocations, price volatilities or cost of living implications of the transition can limit the access to energy and affordability of basic goods and services in the near term, even as renewable energy holds the promise of cheaper localized energy in the long term. The impacts herein are felt by individuals, businesses and policy-makers alike. Despite strong progress on universal access to electricity, recent trends indicate that the critical milestone of universal access by 2030, as endorsed by the UN Sustainable Development Goals (SDGs), will be missed.[10] This is largely due to disruptions following the COVID-19 pandemic and subsequent macroeconomic volatility. Between 2019 and 2022, for example, many African utilities bore the cost of keeping energy affordable for users, contributing to high debt levels and constraining the financial resources available to expand access to energy.[11] The constrained fiscal space in many low- and middle-income countries elevates the emphasis on financing while, in parallel, evidences the benefits to be derived from strengthening local capacity through an effective diffusion of technology and know-how.

If principles of equity are embedded into global decarbonization plans and implementation, global leaders can create opportunities for workers, consumers and entrepreneurs, and ensure a fairer distribution of the costs linked to the green transition, ultimately building broader support for climate action around the world.

↓ **Image credit:** Markus Spiske, Unsplash

2 What is an equitable transition?

Equity, inclusivity and justice in the climate transition have a long political history, shaped since the 1970s by the efforts of labour unions to achieve justice for workers while responding to environmental concerns.[12] Since then, there has been a broader emphasis on dialogue and engagement with key stakeholder groups beyond workers and decent jobs. For example, there has been an increasing focus on communities (e.g. loss of land, cultural capital), on human rights (e.g. use of child labour in cobalt mining) and broader stakeholder engagement (e.g. representation and inclusivity in decision-making).

The following principles are common across ambitions for a just and equitable transition:

- **A low-carbon economy that thrives within planetary boundaries.** It is imperative to recognize the urgency of aligning to targets to reduce greenhouse gas (GHG) emissions to net zero by 2050 while ensuring that economies in all parts of the world can grow and prosper.

- **An inclusive path.** All stakeholder groups must have a voice and role throughout the transition process; the process is as important as the outcome.

- **Leave no one behind and drive shared prosperity.** There must be equitable outcomes across all stakeholder groups in both the access to and distribution of benefits and costs, taking into account that current socioeconomic systems benefit some groups over others.

Despite multiple efforts to define a "just" and "equitable" transition, there is not yet a unifying definition of what this means or a shared understanding of how to achieve it in practice.

This paper contributes to this discussion, developing a framework for "economic equity." Economic equity considers the fairness in distributing the costs and benefits of the mitigation actions arising from the shift to a low-carbon economy. It is one dimension among other aspects of fairness and can be broken down into five key areas, including: employment and job transitions, affordability of products and services, accessibility of products and services, access to financing and investments, and access to capacity. Within these dimensions, this paper will highlight the impacts of climate mitigation actions on people, in particular, the following key stakeholder groups: workers, entrepreneurs and consumers.

↓ **Image credit:** Spencer Scott Pugh, Unsplash

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3 A Framework for Evaluating Economic Equity of the Green Transition

To put people, together with planet, at the centre of the transition requires a comprehensive understanding of where the mitigation actions of the green transition might result in inequity on the lives of people, whether as workers, entrepreneurs or consumers. To reveal where and how inequalities can manifest across lenses, the green transition dimensions can be considered in relation to the economic dimensions of equity.

The following section outlines the proposed green transition and economic equity dimensions, highlighting those areas with the broadest applicability across geographies.

FIGURE 3 **Defining the Green Transition Dimensions**

Green Transition Dimensions	
Transitioning away from fossil fuels	Reductions in coal, oil, gas (including extraction, pipeline, refineries, power)
Scaling up low-carbon energy sources	Increase in solar, wind, hydropower, green hydrogen, nuclear power and associated impacts on supply chain (including green metals and batteries)
Greening transportation and mobility	Transforming of shipping, aviation, other vehicles including SAF, EVs and changes in the mix of transport and mobility services (e.g., increased use of public transport and soft mobility)
Greening agricuture and food production	Increase in sustainable and regenerative farming practices, development of food technologies and changes in consumers preferences
Greening heavy industry	Increase in sustainable production practices of hard to abate sectors (e.g., steel, cement, chemicals)
Greening infrastructure and built environment	Increase in sustainable buildings practices, including retrofitting, new building materials and changes in consumers' behaviours
Moving to a circular economy	Increase in adoption of sustainable production practices aiming to reduce, reuse and recycle necessary materials

3.1 Dimensions of the economic equity-green transition matrix

The green-transition dimensions are seven high-emitting and major segments of the economy that require transformation to achieve carbon neutrality.

- **Transitioning away from fossil fuels.** Reflects the reduction in fossil-fuel extraction activities, including the mining of coal and drilling for oil and gas. It also encompasses the scaling down of infrastructure such as pipelines, which transport oil and gas over long distances, and refineries, where crude oil is processed into usable fuels. The scope further extends to include the shifting impacts in the power sector, notably a reduction in the dependence on fossil fuels for electricity production.

- **Scaling up low-carbon energy sources.** Encompasses the increased use of renewable and low-carbon energy sources including solar, wind, hydropower, green hydrogen and nuclear power. It also includes the associated impacts on supply chains, particularly in the mining and production of raw materials such as cobalt, copper and rare earth elements used in the manufacture of low-carbon technologies and batteries for renewable energy storage.

- **Greening transportation and mobility.** Captures the transformative shift across various modes of transport. This includes the adoption of cleaner fuels such as in shipping and aviation (for example, Sustainable Aviation Fuel [SAF]), the widespread adoption of electric vehicles, the broad electrification of transportation systems, the greening of transport companies (such as logistics and delivery companies) and the shift to more sustainable mobility models, for example, supporting the expansion of public transport.

- **Greening of Agriculture and Food Production.** Considers the shift towards sustainable and regenerative farming practices that prioritize factors such as soil health, water conservation and crop rotation to ensure long-term sustainability of the land. The scope also includes the development and growing consumption of plant-based meat alternatives, organic offerings and more sustainably produced foods, but also the reduction in livestock farming.

- **Greening of Heavy Industry (Steel, Cement, Chemicals).** Reflects the shift toward sustainable production practices within traditionally hard-to-abate industries through the adoption of innovative technologies and processes.

- **Greening of infrastructure and built environment.** Encompasses the movement toward sustainable practices for both new building construction and the retrofitting of existing structures. The former includes the use of energy-efficient materials, green architecture and technologies like solar panels, heat-pumps and green roofs to reduce energy consumption and lessen environmental impact. The latter, meanwhile, involves upgrades such as improved insulation and energy-efficient windows. This dimension also encompasses changing consumption patterns, for example reduced reliance on heating and cooling systems.

- **Moving to a circular economy.** Comprises the increased adoption of sustainable production practices aiming to reduce, reuse and recycle necessary materials. In textile manufacturing, for example, this can include the use of eco-friendly materials, the reduction of waste and a shift away from single-use and non-recyclable items (especially plastics).

Economic equity considers the fairness in distributing the costs and benefits of the mitigation actions arising from the shift to a low-carbon economy. This framework includes five economic equity dimensions and considers the impacts on key stakeholder groups including workers, entrepreneurs and consumers.

- **Employment and job transition.** Places emphasis on workers in declining industries and value chains that need to move to new sectors. This dimension is both concerned with support for job transitions via social protection and reskilling, as well as job quality in growing occupations.

  Even in countries with advanced social protection and active labour-market systems, transition from brown to green industries remains difficult. Using data from the EU Labour Force Surveys, it has been estimated that, across the most advanced countries in Europe, only one worker out of four who had lost a job in a brown sector found a new occupation in a green industry one year later. In addition, while 35% of them were still unemployed one year later, approximately 20% moved into in non-green industries, 15% went into retirement and only 5% were in training.[13] This highlights the need for social protection and accelerated investments in skills development for effective job transitions. Moreover, relative to jobs in the fossil-fuel industry, jobs in the renewable energy sector can offer shorter contract durations,[14] in part reflecting the sector's need for more workers at the infrastructure-heavy onset and fewer for maintenance. The wage differential between sectors can further inhibit transfers,

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FIGURE 4 | **Defining the Economic Equity Dimensions**

Economic Equity Dimensions

Employment and job transition	Ability to navigate job loss with adequate social protection, support for reskilling, and to have access to good work in new and existing value chains.
Affordability of goods and services	Ability to purchase relevant products and services (e.g., impact of short-term price hikes) and green alternatives.
Accessibility of goods and services	Availability and ability to use relevant products and services as well as green alternatives.
Access to financing and investments	Ability to access finance and investments to transition into and out of industries/sectors.
Access to capacity	Ability to access knowledge, technology and other resources to create and use relevant products and services.

again evidencing the emphasis on job quality as a key enabler for job transitions. In developing economies, jobs in renewable energy are in some cases primarily in the informal economy.[15] This, therefore, reiterates the necessity for new green jobs to unlock a leap forward in equity, expanding the global share of workers with access to good work where security and fair wages are a given.

– **Affordability of goods and services.** Recognizes that the economic transformation required for the green transition can impose long-term shifts in costs, near-term price hikes and market volatility. Affordability is, firstly, a priority with respect to basic goods and services impacted by the wider macroeconomic context and then extends to include products more directly linked with greening (e.g. retrofits in residential homes). This dimension therefore also considers the policy instruments that can impact affordability (e.g. carbon taxes, direct cash transfers).

Increases in the cost of goods (e.g. as a result of carbon taxes), including sustainable alternatives, can significantly impact poorer countries and households. For example, food expenditure can take, on average, up to 44% of the consumption basket in low-income countries compared to 28% in emerging market economies and 16% in advanced economies.[16] The disparity holds within countries: in the United States, 27% of household spending in the poorest income quintile goes to food, compared with 7% among the richest income quintile. This can impact consumer choices – in a recent study on consumer behaviour, 52-65% cited pricing as a key barrier to sustainable purchases, particularly across groceries, electricity and cars.[17]

– **Accessibility of goods and services.** Linked to and reinforced by affordability, relates to the availability of relevant goods and services across various geographies and communities, and the reach of complementary services and infrastructure necessary to operate them.

While worldwide access to electricity has steadily increased over the past decades, from 75% of the global population in 1999 to 91% in 2021, approximately half of the population in Sub-Saharan Africa remained unconnected to the electricity grid in the same year.[18] In the European Union, only 40% of the population is connected to the gas grid.[19] Current energy consumption trends mirror the existing economic inequalities, with the top 10% of global energy consumers using 30 times more energy than the bottom 10%.[20] Lack of infrastructure is not the only constraint to access to goods and services. Only half of the urban population around the world has access to some form of public transport services, and about 11% has convenient access to high-capacity transport systems.[21] These divides often compound each other and lead to increased costs and exclusion as countries move their energy and transport systems towards low-carbon models.

- **Access to financing and investments.** Recognizes the sizeable increase in financial capital required to facilitate the green transition and focuses on its distribution, within and between countries. This dimension is also concerned with the policy instruments that affect financing, including the use of taxes and subsidies.

  The Climate Policy Initiative (CPI) estimates that the average annual need for climate finance in 2030 will be $9 trillion, while current flows are at $1.3 trillion. In addition, there is a significant disparity in how existing flows are distributed. For example, for clean energy the International Energy Agency (IEA) projects that the annual capital spending on clean energy in emerging markets and developing economies (EMDEs) must increase from under $150 billion in 2020 to over $1 trillion by 2030. Despite accounting for two-thirds of the global population, EMDEs hold only 10% of global financial wealth and have accounted for only 10% of global sustainable debt issuance. This disparity is also reflected within countries. For example, many entrepreneurs that own micro or small-to-medium enterprises cite a lack of funding as a key barrier to climate action.[22] This can be a similar concern for consumers from lower-income households in accessing green finance (e.g. green mortgages). These two groups tend to be disproportionately exposed to the physical risks of climate change and thus financial institutions may offer these groups services at higher rates, or not at all. This can lead to the financial exclusion of vulnerable segments of the economy.[23]

- **Access to capacity:** Includes access to knowledge, technology and natural resources, and considers each of these components in combination (e.g. the nexus of knowledge and technology as expressed through capacity for innovation and intellectual property development).

  Five countries – Japan, United States, Republic of Korea, Germany and China – accounted for 85% of all green patents held by industrial firms in 2022.[24] Innovation in this regard opens markets and opportunities but, in the absence of opposing policy measures, favours the proprietors. The effects of inequity in capacity are evident in prior transitions – notably, the differential impact of the Industrial Revolution on agricultural labour productivity in Africa versus the rest of the world. Another example is that of female farmers, who account for roughly 43% of global agricultural workers[25] and lag male counterparts in terms of productivity, owing to less access to knowledge and resources.[26] In addition to technology and know-how, access to shared intellectual property and access to raw materials influence overall capacity. An electric car, for example, requires nearly double the amount of copper than a car powered through combustion engines. Against this backdrop, the share of global exports of critical raw materials subject to restrictions surged from 5% in 2019 to around 30% in 2022. This sharp uptick imposes vulnerability into supply chains with not only the risk of cost passthrough to entrepreneurs and consumers, but also in reinforcing inequity in who has the capacity to innovate for the green transition.[27] Inequity in transparency of information for consumers can also hinder adoption of sustainable alternatives, for example in solar photovoltaic (PV) adoptions.[28]

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4 Green transition-economic equity intersections

↓ Image credit: American Public Power Association, Unsplash

At the intersection of each green transition and economic equity consideration, there are both costs and benefits whose allocation will ultimately determine the equity of the transition to net zero (Figure 5). Tables 1-7 outline examples of the distributional impacts of each green transition dimension across the five economic equity dimensions identified in the framework.

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FIGURE 5 | **Exploring the green transition-economic equity intersections**

Green Transition Dimensions	Economic Equity Dimensions: Employment and job transition	Affordability of goods and services	Accessibility of goods and services	Access to financing and investments	Access to capacity
Transitioning away from fossil fuels Scaling up low-carbon energy sources Greening transportation and mobility Greening agricuture and food production Greening heavy industry Greening infrastructure and built environment Moving to a circular economy	What are the economic equity implications for workers of each green transition dimension, in terms of job losses, new employment opportunities, changes in livelihoods and working conditions and capacity to transition into new roles?	What are the economic equity implications for consumers and entrepreneurs of each green transition dimension, in terms of price changes for goods and services currently in use or green alternatives?	What are the economic equity implications for consumers and entrepreneurs of each green transition dimension, in terms of changes in the availability and ability to use goods and services in current use or green alternatives?	What are the economic equity implications for consumers and entrepreneurs of each green transition dimension, in terms of their capacity to invest in new, low-carbon business opportunities and divest from legacy business models?	What are the economic equity implications for consumers and entrepreneurs of each green transition dimension, in terms of their access to knowledge, technology and critical resources necessary to produce and use new, low-carbon goods and services?

Note
Circularity principles embedded across all green transition dimension categories e.g. transportation, steel, chemicals.

TABLE 1 | **Transitioning away from fossil fuels**

Employment and job transition	Approximately 13 million energy-related jobs[29] are likely to be lost globally as a result of the phase-out of fossil fuels within the energy system. Most of these job losses will be concentrated in communities built around the fossil-fuel value chain, where alternative employment opportunities are less likely to be available. As a result, further investment in schemes that support reskilling and reemployment in alternative workplaces is required, pointing to the continued need for development of active labour-market policies. When job transition is not possible, early retirement, rehabilitation or additional redundancy payments are often used to compensate those adversely affected. However, on their own, such policies are insufficient to meet the needs of those displaced. Environmental Transition Contracts (as developed in France in 2018) point to a possible way forward.[30]
Affordability of goods and services	As governments progressively remove fuel subsidies and increase carbon taxes and other forms of carbon pricing, this is expected to have cost-of-living implications for low-income households. For example, a study by the Congressional Budget Office (CBO) of the United States found that a carbon tax of $28 per metric tonne on CO_2 emissions disproportionately affected lower-income households by 2.5 times the effect on households in the highest income quintile.[31] Such households should be compensated through targeted measures and supported to move away from the use of fossil fuels. Recent protests across many countries in the wake of a period of energy price volatility underscore the political sensitivity that surround fuel prices.[32] Moreover, as the relative share of fossil fuels in the energy mix declines, a disorderly transition may trigger further energy market volatility and create energy insecurity.[33] Fuel price shocks – which indirectly lead to price changes in food, transportation and other essential goods and services – tend to impact developing countries and vulnerable populations more severely than developed and wealthy groups. This was evident in the recent period of macroeconomic volatility.[34] In addition, the implications will be particularly severe for countries and communities reliant on fossil-fuel extraction and processing as a major driver of economic growth.[35]
Accessibility of goods and services	Many products derived from oil and gas serve as feedstock to a wide range of goods which lack scalable and affordable substitutes (e.g. plastic). This can restrict the accessibility of these goods until supply chains of sustainable alternatives mature.
Access to financing and investments	As competitive low-carbon energy sources account for an increasing share of the energy mix, major assets, primarily in fossil-fuel extraction and coal-power generation, may become stranded. Stranded asset write-offs are estimated to hit $1-4 trillion,[36] concentrated largely in developing economies. The impact that these stranded assets and impaired investments have will disproportionately affect small-to-medium enterprises that have heavily invested in equipment and manufacturing processes and across the supply chain.
Access to capacity	The geographic mismatch between fossil-fuel and renewable energy sites combined with the implications to public finance (e.g. lost tax revenue) illustrates that transitioning away from fossil fuels can exacerbate capacity gaps if the equity dimensions pertaining to skills and access to technology associated with scaling-up renewables are not adequately addressed, as detailed in the subsequent sections.

TABLE 2 **Scaling up low-carbon energy sources**

Employment and job transition	As new manufacturing operations, supply chains and power-generation facilities take shape, they can be avenues to rehabilitate and reskill workers displaced by the phase out of fossil fuels, or to diversify economies of countries and communities reliant on fossil fuels as source of growth. The rapidly growing renewable energy sector faces a skills gap; some estimates suggest that 36% of the workforce requires specialist know-how in this field (versus 27% in the broader economy).[37] Addressing this shortage with the gradually displaced fossil-fuel workforce can support the twin objectives of meeting the labour demand to accelerate renewable energy and mitigating socioeconomic fallout from transitioning away from fossil fuels.
Affordability of goods and services	Renewable energy is the cheapest power source globally.[38] However, given the intermittent and geographical attributes of renewable energy, additional system costs related to maintaining system resilience, adequacy and building transmission infrastructure are incurred. As the share of renewable energy in the power system expands further, steps should be taken to ensure these broader system costs do not fall unfairly on already energy burdened low-income households. Beyond system-level planning, scaling up low-carbon energy also requires households and consumers to install decentralized power for self-generation, and to replace end-consumption appliances with energy efficient alternatives. Despite a positive payback in the long term, high up-front capital costs for these low-carbon solutions act as affordability barriers.[39] Mechanisms to incentivize adoption of clean energy, such as tax credits for residential solar applications, have largely accrued to high-income households.[40]
Accessibility of goods and services	Innovations in clean energy can increase access to electricity in remote and rural areas. For example, distributed energy systems, such as rooftop solar panels and energy storage systems, can enhance access to energy and reduce reliance on a centralized power grid. Maximizing the potential of clean-energy sources will require designing policies and technologies to make them equitably accessible and affordable, especially for low-income consumers, rural households and small businesses.
Access to financing and investments	The annual financial flows to low-carbon energy technologies have grown consistently, reaching more than $500 billion in 2022. Yet, current financing levels fulfil only 17% of the $3 trillion[41] in annual financing needed for a timely transition to net zero. Certainly, a significant share of that gap is reflected in disparities – in terms of meaningful climate finance shortfalls – between advanced countries and emerging and developing countries. At the same time, however, there is also inequitable access within countries; for example, with low-income households facing limited access to finance to meet high upfront capital requirements for localized clean energy generation.
Access to capacity	Knowledge and technology are key enablers to support the scaling up of low-carbon energy sources and energy-efficient solutions. Countries lacking the necessary knowledge and resources have been slow to adopt clean energy. Advanced knowledge and information infrastructure have enabled developed countries to take advantage of global trade in clean energy technologies. Between 2018-2021, while the total exports of green technologies from developed countries increased from $60 billion to $156 billion, exports from developing nations only increased from $57 billion to $75 billion.[42] Mechanisms that enable developing countries to build localized skills and resources can help them pursue green growth with greater participation in higher value-added sectors. Digitally enabled smart energy management is a critical component of net-zero transformation, which allows consumers to optimize their energy demand through greater transparency. Adoption of smart technologies is limited by existing inequalities in access to digital services.[43] The expansion of renewable energy operation is expected to drive increased global demand for metals and minerals such as lithium, graphite, nickel, copper and cobalt. Security in access to critical minerals has a direct impact on supply chains and the consequent price and risk passthrough to businesses and consumers.

TABLE 3 | **Greening transportation and mobility**

Employment and job transition	The Automotive and Transport industries are significant employers, both directly through manufacturing jobs and indirectly through their supply chains and services.[44] In the EU, the Automotive sector generates 13 million direct and indirect jobs, accounting for 7% of total EU employment.[45] Ensuring timely and effective rehabilitation and reskilling of affected workers is at the centre of the electric vehicle (EV) transition. This was evident in the recent negotiations between car manufacturers and autoworkers unions in the United States.[46]
Affordability of goods and services	Fuel taxation and environmental levies are primarily market-based instruments to incentivize efficient consumption and investment in low-carbon transport options, from public transport to cleaner private vehicles. However, these policies, together with mandates to phase out internal combustion engines (ICEs), adversely affect those unable to afford cleaner modes of transport. In the absence of supportive policy incentives, low-carbon alternatives – from EVs to SAFs – come at a price premium as compared to traditional options, raising affordability challenges for low-income consumers. Significant investment is required to green public transport, with a risk that this is passed onto consumers as an additional cost burden. Furthermore, consumption taxes on road transport are a significant source of fiscal revenue (e.g. 5.3% on average for OECD countries in 2016).[47] The shift to EVs could cut into those revenues for some economies. Progressive taxation of consumption and reforming the tax system for a low-carbon future could support an equitable transition.
Accessibility of goods and services	Considering the essential nature of transport services for normal economic activities, and the direct impact increased fuel taxes have on household budgets, the availability of public transport systems is a key component of an equitable transition to a greener transport and mobility model. Similarly, complementary infrastructure (e.g. bike lanes, EV charging stations) plays a significant role in ensuring equitable access in new mobility models. Finally, technology design parameters need to consider the needs and means of wider sections of the populations. The electrification of transport in Asia and Africa is a good example, where more affordable two- and three-wheeler vehicles enjoy the fastest rate of electrification and consumer adoption.[48]
Access to financing and investments	Decarbonization of mobility, from light-passenger transport to hard-to-abate transport sectors such as Aviation, Marine and Road Freight Transport, will require major capital investments and large-scale infrastructure development. While these investments and developments are likely to yield significant socioeconomic dividends, they also come with uncertain financial returns and poor economics in the early years of operation. These challenges continue to hold back investments at the scale required.[49] Blending grants with flexible debt could offer one avenue to scale, including for the charging infrastructure required to power low-carbon vehicles. Within the Transport sector, SMEs and start-ups in the growth phase find it particularly difficult to access finance. In Europe, the financing gap for this group is estimated at between €5.5bn to €13bn annually.[50]
Access to capacity	Low-emission transport technology solutions are in early stages of development, concentrated in advanced economies, and less accessible to emerging countries due to intellectual property and competitiveness concerns. Given the globally interconnected nature of these sectors, ensuring access to low-emission transport options within emerging economies will help drive the decarbonization at scale and speed.

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TABLE 4 | **Greening agriculture and food production**

Employment and job transition	The sector employs a quarter of the world's working population, more than 850 million people.[51] The ILO estimates that 5% of jobs in the industry will be lost by 2030,[52] driven by less labour-intensive practices. This could impact many workers, including rural workers, and tenant and smallholder farmers.[53] Greening of Agriculture and Food Production might disrupt employment and production in some segments of the industry, for example livestock farming. Meanwhile regenerative agriculture and other green practices, which will require the upskilling of farmers and agri-workers, are generally expected to have positive net effects on employment and livelihoods. For example, regenerative agriculture – which includes practices such as topsoil regeneration, focus on biodiversity, and water cycle improvement – has been estimated to create up to 5 million new jobs by 2040 in Africa.[54] Regenerative farming practices can improve farmers' incomes, with estimates suggesting 15-25% return on investment.[55] For smallholder farmers, who account for roughly 85% of farms worldwide[56] and rely on agriculture and food production for their livelihoods, this will represent a significant transformation.
Affordability of goods and services	Organic farming practices are environmentally positive but may reduce yields compared to conventional agriculture.[57] The effects of organic and regenerative farming can contribute to food-price inflation.[58] Higher prices may make it difficult for vulnerable population and developing countries to achieve food security.
Accessibility of goods and services	In addition to food supply-side measures, demand-side measures are necessary to nudge consumer behaviour. Alternative proteins, which include plant-based alternatives, lab-grown meat and insect-based alternatives, can support mitigation of methane emissions from livestock farming. The accessibility of these alternatives tends to be restricted to high-income consumer groups, given the price premium to conventional protein.[59] Over time, as consumer acceptance improves, and alternative proteins become mainstream, it can have effect on livelihoods in the livestock value chain.
Access to financing and investments	Accelerated greening of agriculture relies on access to finance and innovative technologies. The current distribution of finance and technologies is concentrated in developed countries or in large, industrialized farms.[60] Ensuring access to financing opportunities and technologies to other stakeholder groups – including smallholders, family farms and women – is necessary for the equitable transition of agriculture.
Access to capacity	With increased investments in agricultural and food technologies, there has been a surge in patenting, with over 330,000 green food and agri-tech related patents filed over the last five years.[61] Ensuring equitable access to the technology landscape can help to accelerate agricultural and food innovation across businesses and countries.

→ **Image credit:** Aboodi Vesakaran, Unsplash

TABLE 5 **Greening heavy industry**

Employment and job transition	The transformation of heavy industries is expected to cause job losses, particularly for unskilled workers involved in the low-carbon processes who will need support in transitioning to new employment opportunities. For the remaining workforce, significant upskilling will be required to manage new materials and processes. The scaling up of new technological models might also lead to a geographical relocation of production around new clusters that provide better access to key production inputs. Such geographic shifts could potentially create challenges and opportunities, just as the shift of industrial manufacturing to emerging economies did over the past few decades.
Affordability of goods and services	Heavy industries will continue to be impacted by the progressive increase of carbon costs and the expansion of carbon-pricing schemes. Prices are likely to increase across the sector and in the downstream value chains that source intermediate goods from heavy industries. Moreover, as carbon prices rise, international trade is likely to be reshaped. For example, applying carbon prices specified for 2030 in the IEA's scenario for reaching net-zero global emissions by 2050, some estimates put the cost of carbon in the Republic of Korea at 12.85% of the current selling price of steel.[62]
Accessibility of goods and services	Accessibility of relevant goods and services is not expected to be a significant economic equity dimension in the context of the decarbonization of heavy industries.
Access to financing and investments	Currently, financial allocation to industrial decarbonization is just 1% of what is required,[63] owing to the risk profile of low-emission technologies and low profit margins of these industries. Pilot green industrial projects are typically driven by large enterprises with strong balance sheets and the capability to raise external capital. Small and medium enterprises account for a significant proportion of industrial manufacturing. For example, SMEs constitute 33-35% of India's crude steel capacity.[64] However, these smaller players may lack the capital required to undertake green projects. Targeted measures to improve access to finance to SMEs are necessary to ensure their participation in the green transformation.
Access to capacity	Innovations in low-emission production technologies are largely concentrated in select high-income countries. Today much of the knowledge related to decarbonizing heavy industries is concentrated among a limited number of companies. For example, most patents and R&D investments related to the production of low-carbon steel are held by American, Japanese and German companies.[65,66] Lack of access to advanced solutions can affect the manufacturing operations currently based in developing countries, with implications for economic growth and employment.

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TABLE 6 | **Greening infrastructure and built environment**

Employment and job transition	The construction industry provides employment for an estimated 220 million people (or 7% of total global employment in 2022).[67] Building retrofits are labour-intensive and can boost local labour markets by creating large numbers of construction jobs. In addition, the greening of infrastructure and the built environment is likely to transform and shift employment within industries producing relevant products, from heating systems to windows and insulating systems. Labour conditions and job security in the construction sector vary widely around the world, and the application of international labour standards are therefore key to ensure a equitable transition for construction workers.[68]
Affordability of goods and services	Electrification and retrofitting of existing buildings can optimize energy demand, leading to reduced operational and maintenance costs for households. Despite the long-term cost savings, the high upfront investments required for building renovations restrict access for households with limited savings or inability to obtain credit.[69] Policy measures to incentivize investments in building renovations and retrofits do not evenly accrue to areas with lower economic resources or a higher share of rented dwellings.[70] Renovated buildings often result in higher rental values, which are not completely offset by the reduction in energy costs.[71] In the current macroeconomic climate, with housing affordability at an all-time low, this can further deepen the cost-of-living crisis and have a disproportionate impact on low-income households.
Accessibility of goods and services	Measures such as the creation of public parks or bike lanes, planting of trees, or better storm water drainage can dramatically improve the urban quality of life. However, these measures have also led to increased gentrification as green urban re-development often leads to higher property values, which restricts access to green spaces among low-income urban residents.[72] As more and more urban spaces open up for greening, households and businesses in low-income urban neighbourhoods face the prospect of displacement.
Access to financing and investments	The decarbonization and increasing climate resilience of urban infrastructure require high volumes of capital, estimated to be $4.5-$5.4 trillion per year.[73] The ability for countries to mobilize capital varies dependent on the sources of municipal income and ability to access capital markets.
Access to capacity	The quality, delivery and accessibility to urban services can be significantly enhanced with the application of digitalization and smart technologies. Building capacity in cities with low levels of readiness for technology adoption is crucial for inclusive, equitable and sustainable urban development.

→ **Image credit:** Chuttersnap, Unsplash

TABLE 7 | Moving to a circular economy

Employment and job transition	According to the International Labour Organisation (ILO), the shift to a circular economy is expected to create (net) 6 million jobs,[74] though this will also affect employment in the current waste-management value chain primarily in Asia-Pacific and Africa. Older, mature industries with linear processes may not be able to shift completely to circular economy models. New circular employment will need to offset the job losses in linear industries, but must also carry the opportunity of better quality of work, decent wages and improved records on child labour and human rights.
Affordability of goods and services	Recycled materials continue to have a sizeable green premium over traditional ones, due largely to undersupply, low elasticity of demand and costs differentials. In the case of plastic materials, the green premium is estimated to be as much as 60%, with downstream consequences in terms of affordability of related consumer products.[75] However, in the long term, closing product-to-waste loops and increasing recycling and reuse of materials can reduce demand for raw materials and help mitigate demand-driven price volatility in commodity markets, lower production costs, and improved affordability.
Accessibility of goods and services	Building a circular economy requires access to an efficient network of services to collect, recycle and redistribute materials. Supply of recycled materials is currently limited in most geographies; recycled material accounted for only 11.7% of material used globally in 2021, an increase of less than one percentage point since 2010.[76] As a result, many businesses are not able to increase the recycled content of their products and end consumers' demand remains unmet.
Access to financing and investments	Moving to a circular business requires significant investments in terms of product design, recycling facilities and process management and design. As some of these activities might have low and uncertain returns, businesses with solid financial fundamentals are likely to be first movers and reap most of the economic benefits stemming from the transition to a circular economy.
Access to capacity	Advances in new materials lie at the heart of the transition to a circular economy, enabling breakthroughs in terms of product design and recycling technologies. Organizations and countries with existing advantages, greater know-how and a more established recycling ecosystem are advancing faster to circular manufacturing.

→ **Image credit:** Unsplash

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5 Conclusion: Creating a path to an equitable transition

The proposed framework to consider economic equity across various green-transition dimensions aims to uncover where inequity can be created or exacerbated in the lives of people – whether as workers, entrepreneurs or consumers – as well as to identify opportunities for human development and improving living standards. Recognizing that inequity heightens the prospect of social fractures and resistance to the transition itself, the challenges and opportunities identified at the intersections of green and equity present a scope of focus – an initial articulation – of what a vision for an equitable transition must encompass. The scale and nature of these intersections reflects the complex stakeholder landscape of the globalized modern economy, necessitating the need for collective action to forge a consensus on a vision and pathways for an equitable transition.

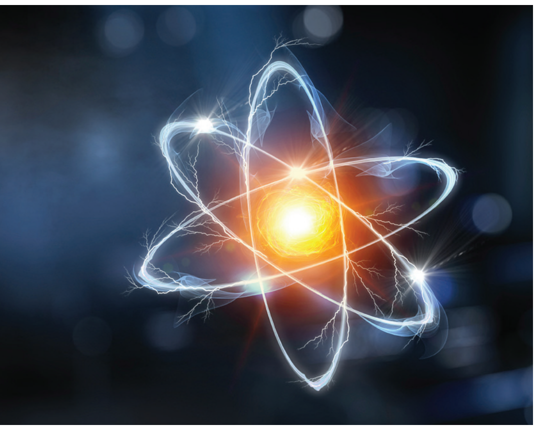
The Framework for Economic Equity in the Green Transition is the foundation of the World Economic Forum's Equitable Transition Initiative. The initiative aims to develop and build consensus on a vision and organizing principles for an equitable green transition, distilling thought leadership into actionable frameworks and tools at sectoral, national and local levels. The initiative additionally offers a platform to connect stakeholder groups across sectors and geographies for knowledge-exchange and partnerships, recognizing the centrality of public-private collaboration in responding to equity gaps both globally and locally.

The framework will be further used as a basis to analyse risks and opportunities of each green-transition dimension and provide an actionable toolkit for businesses and governments, based on industry and country heatmaps grounded in a set of common metrics. The framework will also guide the identification of sectoral and national best practices to inspire change among key stakeholders, as well as the development of a playbook of guidelines and examples.

While efforts to accelerate an equitable transition must be concerned with addressing the negative impacts caused by the transition, the opportunities of the green transition to accelerate social progress and drive economic development compel a bolder vision. A shared language on what equity entails is critical for accelerating action on an equitable transition.

As we push toward a more sustainable future, we must strike a delicate balance – harmonizing the critical drive to decarbonize the global economy with the equally vital imperative to address human needs. Absent that equilibrium, we risk leaving many behind and dampening the momentum required to keep net zero within reach. But if we put fairness and equity at the heart of climate efforts, we can accelerate progress for people and for the planet. wn

Flexible Nuclear Energy Using Molten Salt Heat Storage



In the drive for a "Net Zero" solution for the future of electricity generation, one of the clear choices is nuclear power. Nuclear power is used almost exclusively for the "baseload" purpose. While many see this as a function of current nuclear power's inability to follow the load changes in the grid, this is not fundamentally true.

By David Nicholls

Of all the standard power generation technologies, nuclear has the highest investment cost (as in construction cost) and the highest fixed portion of its operating costs. Its fully marginal cost, the cost of the fuel it uses, is the lowest of its competitors.

This combination means that the most economical method of operation is to run at as close to 100% power as possible. This is shown by the normal operation of all such stations, which run at 100% power whenever available. The most successful nuclear operators (such as the USA) achieve a national average of 93% production. This means they are run at full power between refuelling shutdowns, which generally occur every 18 months and last about four weeks.

This operating mode is not a function of the capability of the nuclear power plant design but the economics of lowest cost grid dispatch rules. This can easily be seen by considering the origins of the current Pressurised Water Reactors (PWRs) such as Koeberg.

These comprise the majority of nuclear power plants in the world and were developed from nuclear submarine power plants, which are the original PWRs. Nuclear submarine plants were designed (and operated) to allow unrestrained power changes between about below 10% power to 100%, and given the nature of submarine options, this flexibility was used frequently!

Figure 1 compares the capability of nuclear, coal and combined cycle gas turbines to change power when asked to do so. The standard PWR nuclear core design allows a 10%/minute load change between 20% and 100% power. The technical rules for Koeberg allow for this, which is more than that for any Eskom coal station, but is never exercised due to the economic issues discussed above.

The only country that has used this flexibility regularly is France because their nuclear power stations dominate their grid, and they, therefore, had to use some of these plants to change load frequently to match the system demand. The Eskom 2015 load profiles in Figure 2 show this profile. As can be seen, this calls for flexible operation, which does not appear to match the best economic profile of current nuclear power plant designs.

Therefore, the issue becomes how to create a nuclear power solution that can be economical in this dynamic load situation. While it is technically feasible to build versions of current generation

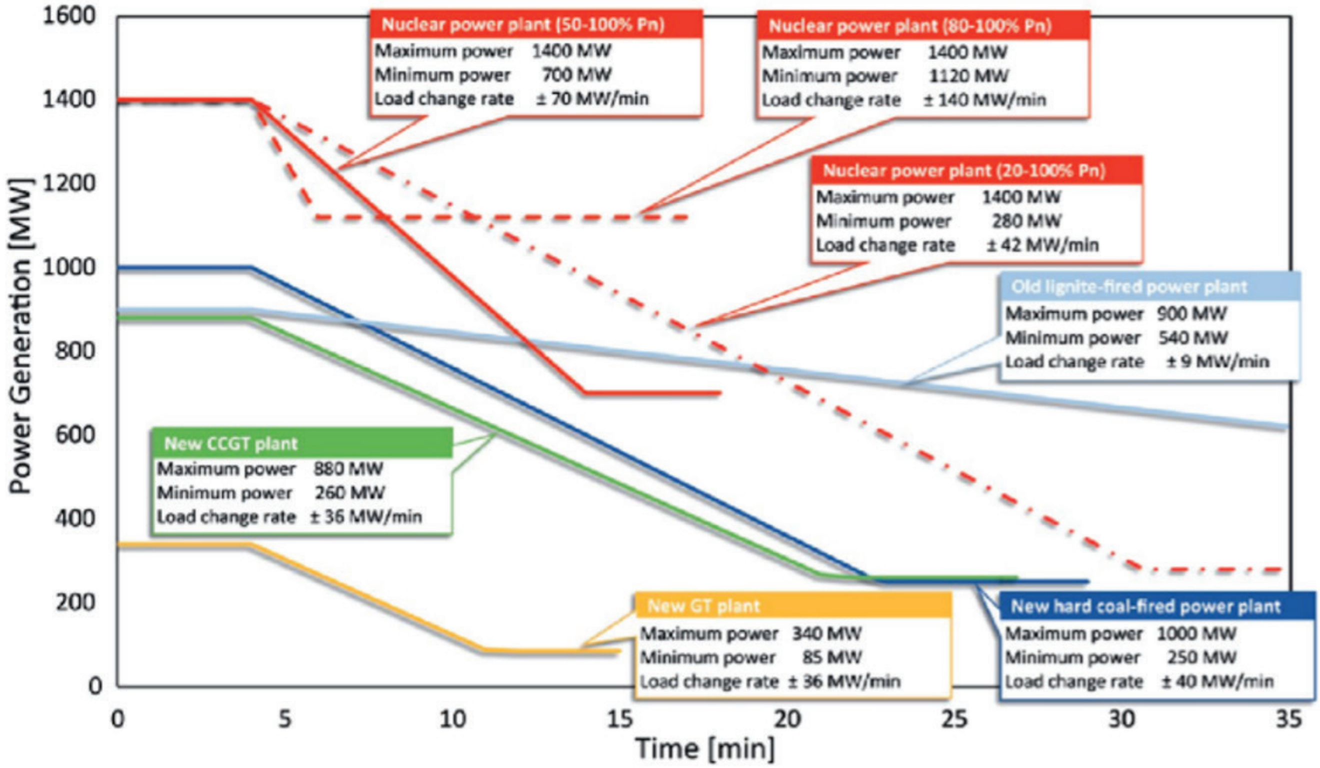


Figure 1

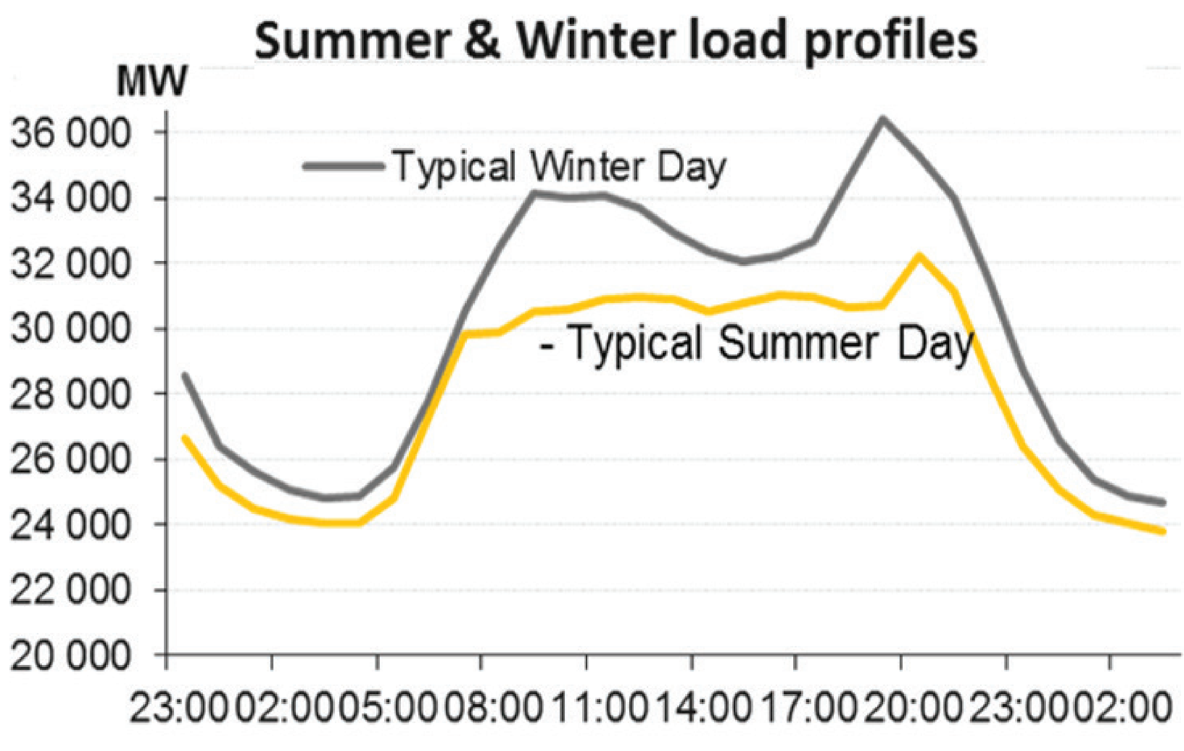


Figure 2

NUCLEAR continues from page 61

plants which can provide the flexibility required in the "modern grid", it is not economical. If a current technology plant is operated at an average load factor of 45% compared to the possible 90%, it would effectively double its cost per kWh.

In considering the economics of a nuclear plant it must be recognised that the dominant fixed cost element is the nuclear part of the plant, both in terms of the capital cost, the operating cost and the overheads. Therefore, operating the nuclear component with the highest possible capacity factor becomes essential. The non-nuclear part (the "conventional island") is a far lower-cost element. Therefore, The issue is how one creates the energy buffer between the nuclear reactor and the conventional stream turbine?

In recent years, the Concentrating Solar-thermal Power (CSP) plants have solved this challenge. CSP technologies use mirrors to reflect and concentrate sunlight onto a receiver. The energy from the concentrated sunlight heats a high-temperature fluid in the receiver. The fluid is normally a molten salt or a mineral oil. This fluid has two tanks, a "hot" tank and a "cold" tank.

The fluid is pumped from the cold tank to the receiver and returned to the hot tank at a high temperature. When power is required, the fluid from the hot tank is pumped to a steam generator that creates steam to drive a conventional turbine, making power for the grid. The fluid is then returned to the cold tank. The relative size of the tanks determines how much excess power can be made by the sunlight before being used by the turbine for power generation.

This technique clearly is beneficial for the CSP plants because they can generate electricity when the grid needs it and not just when the sun is shining. So it turns an intermittent source into a dispatchable supply. Unfortunately, while technically working, the costs of these plants worldwide have not been seen to be competitive.

The same technology can, however, be used to convert a stable heat source into a variable one. If a nuclear reactor were to heat molten salt with a two-tank system, being a hot and a cold tank, then the steam turbine system linked to the molten salt-driven steam generator could respond to the load changes at whatever rate the grid requires. A simple model of the results is shown in Figure 3. In this case, the nuclear plant is a nominal 100MW equivalent with a 170MW steam turbine and a storage capacity of 410MWh. This has been matched to a simile of a grid load profile. The reactor is assumed to be at 100% of its power throughout the cycle.

As can be seen in Figure 3, the proposed system could, therefore, meet the needs of the grid using current established systems.

For such a system to work, it would need an appropriate input temperature from the reactor system. At present, the CSP systems in the world operate with a hot tank temperature of 565˚C, with a cold tank temperature of around 290˚C. This allows the steam generator to generate superheated steam to drive a standard steam turbine. The current South African Redstone CSP power plant uses this technology with a 100MW steam turbine and has 1200MWh of storage.[1]

The issue with this temperature range is that the current water-cooled reactors (PWRs, etc) have a maximum working temperature of about 320˚C. This is inadequate. Several high-temperature reactor technologies operate in the appropriate temperature range and have been technically proven. These include liquid metal-cooled designs (sodium-cooled or lead-bismuth-cooled), molten salt-cooled designs and gas-cooled designs. Of these, this article will discuss the High-Temperature Gas-Cooled Reactor (HTGR) as it is the one which has a currently operating full-scale design (HTR-PM in Shandong, China) at the required coolant temperature (750oC) and with which South Africa has excellent technical understanding due the previous PBMR project.

The only technical item not demonstrated at the appropriate level is the helium-to-molten salt heat exchanger. While this specific application has not been operated, the temperature and pressures involved are well within the experience of the exchanger industry and should not present any serious technical challenges.

The proposed solution will cost more than a simple baseload reactor of the same type. The current 210MWe HTR-PM in China, which has two 250MWth reactors linked to a single turbine, has a previously quoted capital cost of $1bn for the lead unit. This leads to a cost of $5000 per kWe. The analysis of a 655MW combination of 6 HTR-PM units (named HTR-PM600) leads to an expected cost of $2500 per kWe [2]. Clearly, the extra cost over a nuclear plant with no thermal storage is that storage.

US Department of Energy Office of Energy Efficiency & Renewable Energy has quoted [3] an expectation of a thermal energy storage cost of less than $15/kWh(th) with an exergetic efficiency greater than 95%.

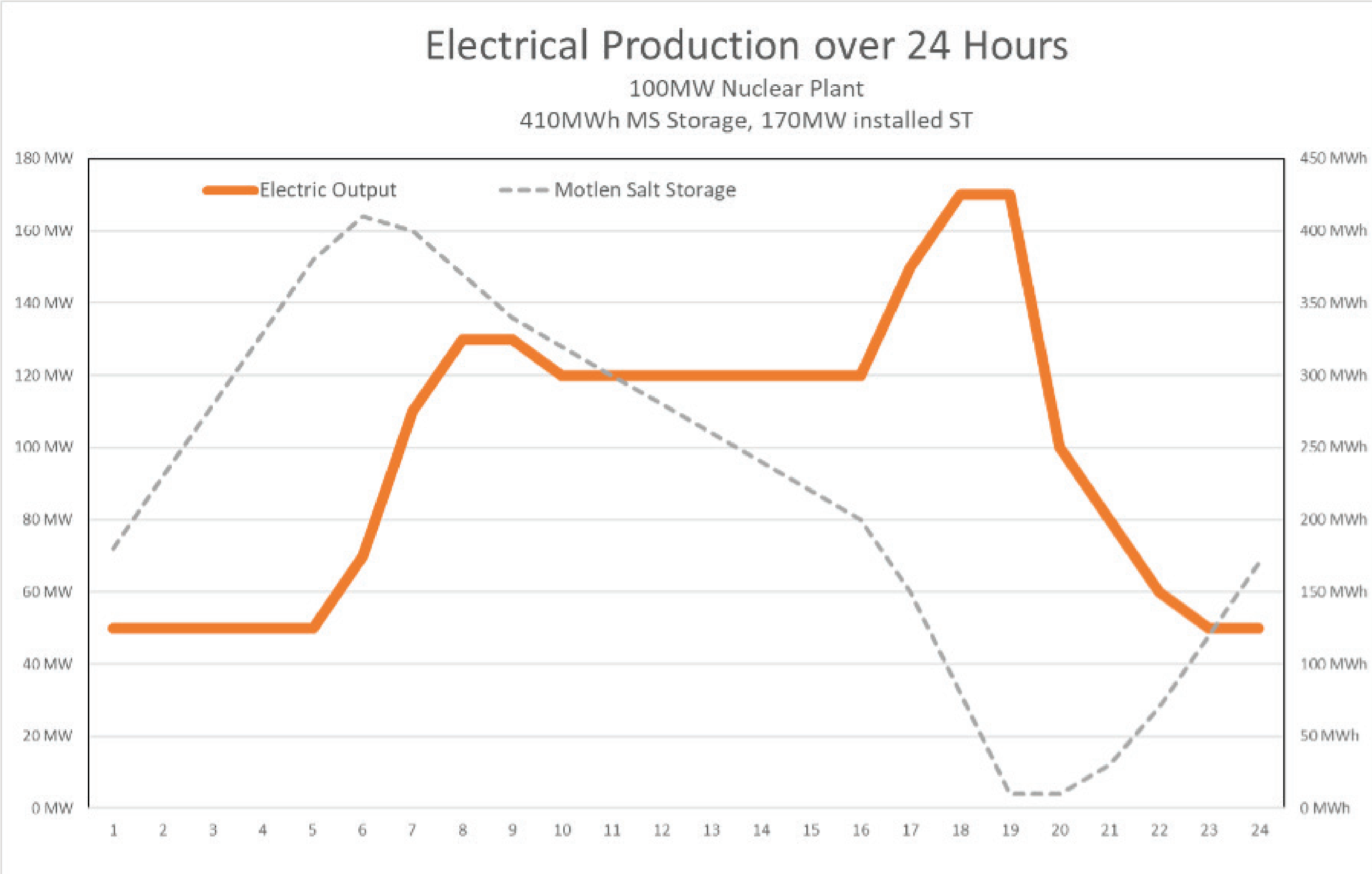


Figure 3

If a plant such as that listed in the earlier section is developed, the target molten salt storage cost, based on 5 hours of storage with a 40% thermal efficiency of the turbine system, would lead to a storage cost per kWe installed of $15 x 5 x (1/0.40) = $187.50. This is a small increase in the costs of the nuclear plant. The impact of the exergetic efficiency can be seen to reduce the output of the overall system by less than 5%. While these numbers are estimates, it would indicate that an economically efficient full load following HTGR based on the HTR-PM600 would lead to a lower estimate of ($2500 + $187.5)/0.95 = $2830/kWh for the average output of the station, and $2830/1.7 = $1500/KWe for its peak output.

These estimates are clearly optimistic, but nuclear plants are currently a very competitive option in South Africa for the baseload operation if the capital costs are in the order of $4000/kWe.

It would, therefore, be logical to assume there is enough margin in the above calculation to show the real potential for this option wn

[1] Redstone Solar Thermal Power
[2] Next Big Future Nov 2021
[3] US Department of Energy Office of Energy Efficiency & Renewable Energy

AI could dramatically speed up the rollout of renewable energy solutions

Artificial Intelligence (AI) is taking over in every industry and sector and has the potential to drive an efficiency and productivity revolution. In the renewable energy sector, AI modelling could assist with optimising power plant design, ensuring that various renewables sources are effectively integrated and load balanced, provide optimised and continuous monitoring and much more.

By Viren Sookhun
Managing Director, Oxyon

However, statistics show that while 95% of companies have an AI strategy, only 14% are ready to integrate it, and this is often driven by fear that AI will take over human jobs. Understanding that AI, particularly within the renewables space, will not take away jobs but rather create them, is key to leveraging the immense power of this technology to drive South Africa (and the world) forward on the sustainability journey.

SUPPORTING THE TRANSITION

AI has numerous applications in the renewable energy space which will help to improve efficiency and speed up the time taken to deliver on these vital projects. For example, AI can assist with resource optimisation by analysing vast amounts of data, including weather patterns, energy consumption and grid performance, to optimise the allocation of renewable resources, maximising energy production and reducing waste.

In addition, AI can predict equipment failures and perform preventative maintenance to minimise downtime and ensure the reliable operation of renewable energy infrastructure.

AI can help balance supply and demand and optimise both storage and distribution of renewable energy, a critical factor given that sources like solar and wind provide intermittent supply to the grid. AI can also predict energy demand patterns, balance loads, and improve grid stability, which will help with facilitating the integration of renewable energy sources into existing infrastructure. Other areas include energy production forecasting on the supply side, optimising energy consumption on the demand side, and enhancing the efficiency of the manufacturing process to speed up supply of renewables components.

From an environmental perspective, AI can be applied to monitor and assess the environmental impact of renewable energy projects, including evaluating the effects on wildlife, ecosystems, and overall sustainability as well as the predicted power output of areas. This can help Independent Power Producers (IPPs) to select the best sites for deployment of renewables plants and the best location and positioning for the components, while also easing land acquisition by ensuring criteria for environmental impact assessments are met.

AI DOES NOT REPLACE PEOPLE

The benefits of harnessing AI in the renewable energy rollout are numerous. If leveraged correctly the technology could not only improve the efficiency and maintenance of these solutions, but it could also ensure that they can

be rolled out faster and can begin to address South Africa's ongoing power crisis. The reality is that, globally we are not on target to meet the Paris Agreement goals, so anything that we can do to fast-track the process will be essential.

Using AI means we will be able to get more projects to shovel-ready status and commissioning phase quicker, helping to bridge this gap, but it will not replace the role of people in the process.

We still need the engineers and the specialists and the construction teams, and so on, but using AI will make all these jobs easier and increase efficiency. Bringing AI into the renewable energy space will help create new jobs and opportunities while augmenting the roles of existing players in the space.

By accelerating the development of renewables projects, this will in turn boost the economy, alleviate the energy crisis, and enable greater productivity for the country. It is imperative to take a bigger picture view of the situation – AI cannot take jobs that do not even exist at present, and if South Africa does not address immediate problems (which AI can assist with), the job landscape will become even more dire.

Sustainable strategies shaping ESG compliance in South Africa

Environmental, Social, and Governance (ESG) principles are becoming more important for businesses, and for good reason. Embracing ESG practices is not just a trend; it is a strategic move towards long-term success. Given the potential environmental impact in the sanitation and waste management industry, the adoption of ESG principles is more of a responsibility than a choice.

By Robert Erasmus
Managing Director, Sanitech

However, it's not a choice without benefit. By understanding the significance of aligning with these principles, businesses can simultaneously create lasting value for stakeholders while contributing meaningfully to local and global sustainability goals.

THE GROWING IMPORTANCE OF ESG IN BUSINESS

ESG principles provide a comprehensive framework for evaluating a company's operational performance in relation to its social and environmental impact. Traditionally, investors focused on financial metrics, but evolving business practices and growing investor consciences demand a broader perspective. Investors and stakeholders are now scrutinising a company's commitment to environmental sustainability, social responsibility, and willingness to evidence strong governance. This makes the shift towards ESG compliance a necessity for attracting investment in today's eco-conscious, interconnected world.

THE SURPRISING PRACTICALITY OF ESG IMPLEMENTATION

Understanding ESG can seem daunting at first, but at its core, it is a set of practices that evaluate a company's performance through the lens of its social and environmental impact. While the implementation of these principles might seem overwhelming, it's much easier to gain momentum taking an incremental approach.

One of the most productive methods for organisations to elevate their ESG status is by means of ISO 14001 environmental accreditation, which provides a structured path to address issues such as energy consumption, waste management, and more. ISO 14001 is an internationally agreed standard that sets out the requirements for an environmental management system, which helps organisations to gradually improve their performance through more efficient use of resources and reduction of waste, which ultimately intends to gain both a competitive advantage and the trust of stakeholders.

PRACTICAL STEPS TOWARD SUSTAINABILITY

Within the sanitation and waste management sector, for example, ESG compliance centres on environmental stewardship, extending beyond straightforward waste reduction to include responsible choices aligned with environmental preservation. Companies in the sector should commit to aligning processes with global standards through ISO 14001 environmental accreditation.

Such a sustainability journey starts with minimising the construction impact

associated with operations, which will be achieved through responsible planning and execution to prevent environmental encroachment and reduce the ecological footprint of any infrastructure development.

Additionally, companies within the sector should actively support renewable energy initiatives, along with displaying a dedication to promoting environmentally friendlier alternatives, such as the use of bio-waste for energy generation.

Companies must place a strong emphasis on water conservation and responsible wastewater management to contribute to the reduction of water consumption with adherence to stringent environmental standards.

Furthermore, the reduction of greenhouse gas emissions pose a notable challenge for most industries, particularly those with intricate logistical operations. It is possible to address this challenge within the sanitation and waste management sector in a number of practical ways, such as championing the adoption of decentralised wastewater treatment plants. Such a strategic approach will not only minimise the environmental impact associated with waste transportation but will also present opportunities for water reuse which creates a dual benefit for businesses.

As an additional measure to mitigate gas emissions and reduce its transportation-related carbon footprint, companies have already begun evaluating the impact of introducing electric vehicles into their fleets. Such initiatives can contribute significantly to the reduction of exhaust fumes, particularly in urban areas.

SOCIAL RESPONSIBILITY THROUGH WATER AND SANITATION

The social component of ESG is where companies in the sanitation and waste management sectors have the opportunity to shine as investing in water and sanitation projects is one of the most powerful ways for businesses to fulfil their social responsibility goals within the ESG framework.

Water and sanitation projects have the most profound impact on communities and by leveraging their expertise, businesses can partner with sanitation and environmental management companies to create positive social change, particularly in areas that desperately need improved water and sanitation infrastructure.

Shared values and business collaboration
Governance forms a critical aspect of compliance, and organisations that want to take ESG seriously should join forces with like-minded companies that have a shared commitment to ethical practices. This is important because strong governance values provide a foundation for transparent reporting and effective management of ESG initiatives, which is critical to businesses aiming for sustainable growth and attracting investments.

This will not only facilitate smoother collaboration but also ensure a unified approach to tracking, measuring, and reporting on ESG initiatives, which will make the journey less complex and more attainable. Practical steps, such as focusing on specific areas like waste reduction, or water and sanitation, can significantly contribute to a company's overall ESG compliance without incurring exorbitant costs.

Unwavering commitment to ESG principles for a business in the sanitation and environmental management industry aligns with global sustainability objectives while establishing that company as a preferred partner for businesses looking to elevate their own ESG compliance standards.

By demonstrating their own dedication to increasingly sustainable business practices, companies in the sanitation and waste management sector can play a significant role in fostering environmental responsibility while delivering value to stakeholders. wn

Universities in South Africa

It is only through education that people are able to improve themselves. One of the most important factors for escaping from poverty is education. The only way a society can continue to grow and prosper is through proper education at all levels.

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MEMBERSHIP FEES EFFECTIVE 1 DECEMBER 2023

The Council meeting held on 1 September 2023 approved subscription & entrance fees as from 01 December 2023 as per schedule indicated below.

PLEASE NOTE: In terms of Bylaw 3.2 annual subscriptions are due on 1st December 2023

MEMBERSHIP FEES CAN BE PAID IN MONTHLY RECURRING PAYMENTS

Council agreed to a discount for fees paid before 31 March 2024. Members are therefore encouraged to pay promptly to minimize increase impact.

Grade of Membership	Annual Subscriptions paid before 31 March 2024		Annual Subscriptions paid after 31 March 2024		New Members FEES * see Notes 1 & 4 below.	
	RSA incl VAT (R)	Outside RSA excl VAT (R)	RSA incl VAT (R)	Outside RSA excl VAT (R)	RSA incl VAT (R)	Outside RSA excl VAT (R)
Student	173	150	208	180	208	180
After 6 yrs study	1 800	1 565	2 160	1 878	2 160	1 878
Associate	1 800	1 565	2 160	1 878	2 160	1 878
Member	1 989	1 730	2 387	2 076	2 387	2 076
after 6 years	2 325	2 021	2 789	2 426	2 789	2 426
after 10 years	2 433	2 116	2 919	2 539	2 919	2 539
Senior Member	2 433	2 116	2 919	2 539	2 919	2 539
after 6yrs/age 40	2 637	2 293	3 164	2 751	3 164	2 751
Fellow	2 637	2 293	3 164	2 751	3 164	2 751
Retired Member (By-law B3.7.1)	1 118	972	1 342	1 167	n/a	n/a
Retired Member (By-law B3.7.3)	nil	nil	nil	nil	n/a	n/a

1. The fee for all new applications is R3337.00 which includes an entrance fee of R950.00. On election to the applicable grade of membership the new member's account will be adjusted accordingly and refunds/additional payment made on request. Entrance fee for Students is free and new Student applicants require payment of R208.00.

2. Transfer fee to a higher grade is free for all grades of membership.

3. Members are encouraged to transfer to a higher grade when they qualify. It will be noted that the fees of Member and Senior Member grades after 10 and 6 years respectively are equal to the fees of the next higher grade.

4. Members elected after May 2024 pay a reduced subscription fee.

5. By-law B3.7.1 reads "Where a member in the age group of 55 to 70 years has retired from substantive employment in the engineering profession, such member may make written application to Council for recognition as a retired person and a reduced membership fee".

6. By-law B3.7.3 reads "any member complying with the conditions of B3.7.1 but who has been a member of the Institute for not less than 25 consecutive years, shall be exempt from the payment of further subscriptions." Members who comply with the requirements of By-Law B3.7.3 may make written application to Council for exemption from paying subscriptions".

7. By-law B3.9 reads "any member in good standing who has been a member for fifty (50) consecutive years shall be exempt from the payment of further subscriptions."

8. Members not in good standing by failing to pay their subscriptions by end of June of each year will, subject to Council decree, be struck-off the SAIEE membership role.

9. Members in good standing and no longer in substantive employment and do not receive payment or salary for work done may apply to Council for a reduction in their annual subscriptions.

10. The members monthly magazine ("wattnow") is available on line and members who require a hard copy may acquire same on request and for a nominal fee subject to minimum uptake numbers.

11. Members who wish to pay their membership fees in recurring payments should activate the payments on their banking portal. Members will receive the early bird discount only if their fees are fully paid by 31 March 2024.

SAIEE

2024 SAIEE MEMBER BENEFITS

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- Jobs portal for WIL
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres

ASSOCIATE MEMBER

- Jobs portal access
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres

MEMBER

- Jobs portal access
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Long standing member gifts
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres

SENIOR MEMBER

- Jobs portal access
- Services Directory
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Long standing member gifts
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres
- Eligibility for nomination as Center Chair

FELLOW

- Jobs portal access
- Services Directory
- Mentorship
- Exclusive Networking Events
- CPD training discounts
- Charge Reward Programme earnings
- Long standing member gifts
- Bursary programme
- Publication access (wattnow & ARJ)
- Site visits
- SAIEE Centres
- Eligibility for nomination as Center Chair
- Eligibility for nomination as an Office Bearer

MEMBERSHIP UPGRADE DISCOUNT STRUCTURE

LENGTH OF MEMBERSHIP	DISCOUNT UPON UPGRADE
10 - 19 years	5%
20 -39 years	10%
40+ years	15%

Become a member today and start earning the rewards!

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MARCH 2024

06/03/2024	Fundamentals Of Practical Lighting Design for Commercial and Industrial Application
12/03/2024	Enhancing the Municipal Electrical Revenue Value Chain
12/03/2024	Finance Essentials for Engineers
15/03/2024	SAIEE Centre Chair's workshop
15/03/2024	SAIEE Annual Awards
18/03/2024	Anatomy of Wind Turbine
18/03/2024	The Eradication of Copper theft - hybrid event
19/03/2024	Design Thinking and Innovation for Engineering Professional
19/03/2023	SAIEE Annual General Meeting
26/03/2024	Photovoltaic Solar Systems

APRIL 2024

03/04/2024	Transformer Construction, Operation, Maintenance, Testing and Protection
09/04/2024	An Introduction to Artificial Intelligence for Professionals
10/04/2024	Incident Investigation and Management (Root Cause Analysis)
16/04/2024	Substation Design & Equipment Selection
16/04/2024	ORHVS - Operating Regulations for HV/MV Systems
23/04/2024	Power Systems Protection
24/04/2024	Smart Metering Courses: Smart Electricity Meter (Free State)
25/04/2024	Smart Metering Courses: Water Demand Management (Free State)

SAIEE Sections, Chapter & Centre Events

SAIEE Academy Online Training

SAIEE Academy Classroom Training

SAIEE TELEVISION

View past events & webinars on SAIEE TV here.


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