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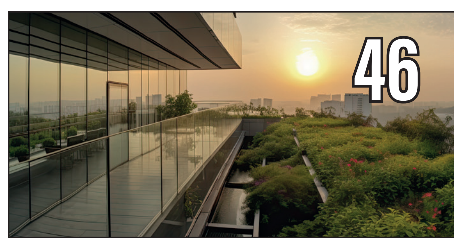
RENEWABLE ENERGY

CONTENTS

FEATURES

GENERAL



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Dear **watt**now reader,

With load-shedding on everyone's lips these days and the fact that it costs South Africa 1 billion rands per day - I thought it apt to bring you this issue on Renewable Energy. Even though people might think it is easy to go and install solar panels on your rooftop, there are a few other factors to be considered.

Our first feature article talks about "Electricity + - electricity as the backbone of an integrated energy system", which discusses a new framework highlighting the opportunities to optimise integrations between the electricity sector and other infrastructure to enable a transition to a net-zero economy. The framework has been developed during a series of dialogues with executives from the electricity industry and other sectors. It will serve as thought leadership to start further planning and collaboration across sectors. Read it on page 34.

The world is in the midst of an infrastructure and buildings boom. In every part of the globe, especially in the developing world, urban commercial centres and residential housing are expanding as economies grow. At the same time, new roads and bridges are being paved and designed to provide logistics channels for moving parts, supplies, manufactured goods, and commuters while old infrastructure is being modernised. This is all potentially good news for the global economy, except for one glaring downside: buildings and infrastructure are responsible for approximately 40% of global carbon emissions each year, around 15 gigatonnes (Gt). Read this feature, "Scaling Low-Carbon Design and Construction with Concrete", on page 46.

Sumi Moodaliyar wrote an article on Renewable Energy and the case for Battery Testing (pg 60) and states that global electricity generation mainly consists of centralised generation. Renewable energy generation has been on the rise recently. However, intermittent energy production cannot provide a regular supply that can be easily adjustable to network load demands.

The June issue features Power, and the deadline is 19 May 2023. Please send your paper/article to: minx@saiee.org.za.

Herewith the May issue; enjoy the read!

Minx

PROF JAN DE KOCK
2023 SAIEE PRESIDENT

Prof de Kock is registered as a professional engineer with ECSA and fellow of the SAIEE. He has served on the SAIEE council for nine years in various roles. In 2013 he received the SAIEE Presidential Award, and in 2018 the SAIEE Engineering Excellence award for his contribution to electrical engineering in South Africa.

Load-shedding is crippling South Africa. The estimated cost to the economy was as high as R899 million per day in 2022. Load-shedding was implemented for 207 days in 2022, more than double the amount in 2021. Three thousand seven hundred seventy-three hours of load shedding was recorded in 2022, more than triple the hours of 2021, and the shared energy more than quadrupled in the same period. Various options have been presented to solve the problem, with small-scale embedded generators (SSEGs), PV plants, wind farms, and battery energy storage being the most common suggestions. Can these technologies solve our problems, or are there hidden pitfalls people are just not seeing? Are we just so desperate for electrical energy that we are willing to throw caution to the wind and endanger the lives of ordinary South Africans?

INTRODUCTION

This load-shedding is probably on everybody's mind nearly every day as we continue to watch apps to see when we will be shed again. People are so focused on solving the problem; they forget that there are also pitfalls. I want to talk about the different generation technologies we can consider and some of the pitfalls that have not been discussed openly. Let us look at possible solutions for the next few years.

Frequency stability is the holy grail of system performance. For those who do not understand how load-shedding works, it is best described as a balance between generation and load for every second of every day. If there is a change in this balance, the frequency will change. Without a stable frequency, the system will fall apart. So, to give you an idea of how sensitive the system is; currently, about 250 MW of change in either load or generation will cause a 0.1 Hz change in frequency. The grid is normally governed within the limits of 49.80 Hz to 50.20 Hz, which is a very narrow band. For a blackout to occur, the frequency must drop below 47.50 Hz. That is how narrow the band is.

The number of hours of load-shedding we had last year equals everything we have had before that, plus some extra. To maintain frequency, we need to load shed if there is a generation shortage, which is why we have had load-shedding. This has affected us in many ways; for example, water cannot be pumped, and sewage plants cannot operate without electricity.

Load-shedding affects our lives in a vast number of different ways. The raw sewage is then dumped in our rivers, our telecommunication systems' bandwidth is limited, and food production is affected. You may recall that there was a chicken shortage earlier this year because of load-shedding.

THE SITUATION IN OTHER COUNTRIES

Let us also look at what is happening with our neighbours. In Zimbabwe, in

Load-shedding - can South Africa be saved?

SAIEE PRESIDENTIAL ADDRESS

January 2023, there were 20 hours of load-shedding per day, i.e. four hours of electricity per day. Currently, load-shedding is down to about eight hours per day. The reason is found in the level of Kariba Dam. At the beginning of the year, the dam was empty, which meant that Zimbabwe and Zambia had to shut down their generation.

Fortunately, the dam level is rising again. It is about two meters above the minimum level, and the rainy season is starting. If we look at Zambia, they also experienced significant load-shedding at the end of the year. They were far more fortunate, though, in that they rely on Kariba Dam and the water coming down the Kafue River, which has been far more consistent than the Zambezi in the last year. That meant that from February onwards, they had not had any load-shedding.

We then turn to Mozambique, where we import more than a thousand megawatts daily; we see that Cahora Basa, the bottom end of the Zambezi River, the hydro plant, has had an excellent year with an energy availability factor (EAF) over 86%. This is mainly because of the water that comes from the Kafue River.

This shows what can happen in three countries, mainly dependent on renewable energy.

South Africa has been talking about importing electrical energy from our neighbours for the last seven years, but we have major constraints in our interconnected system. The transmission lines between Zimbabwe and South Africa are limited. Although we have a 400 kV link, power transfer is limited to 300 MW. Similarly, at some stages in the year, we can import some power from Namibia, but that is only when the Kunene River is in flood, which is for a short period in the fall of each year.

We think that the sun will always shine. That is not necessarily the case.

In the USA, there was a solar eclipse whose shadow moved across North America from California to New York. The national system operator had to bring in additional generation to cover the shadow of the moon as it moved across the USA.

THE SITUATION IN SOUTH AFRICA

Transmission and substation capacity
Let us turn to our situation and look at our system's capacity to accept new power plants. A map of the Eskom transmission system (Figure 1) shows each dot represents a main transmission substation in the grid. Looking at the Northern Cape, you will see a host of black dots. Those all indicate that the power system in that area cannot accept any more generation. These substations are constrained either by the number of transformers that are fully loaded or by the transmission lines that are fully loaded, or both. The yellow dots in the Western and Eastern Cape show substations that will be constrained soon. The wind farms that can typically lie in this area will soon also reach the limit of what we can install there. Although we probably have the best sunshine in the world for PV plants, we cannot use the nice sunshine there. To alleviate this problem, building new transmission lines will take us about 12 years if we decide to build them now. Well, the biggest delay is getting the servitudes from farmers, which will take a long time. Transmission transformers are also becoming a scarce item in the world, and the delivery period has now doubled from 12 months to 24 months.

If we go back to this map, we will see that the next available areas are in North-West Province, and this wave of black dots is on its way to Gauteng. The Vryburg area in North-West Province has already been constrained with capacity. Around Klerksdorp, Potchefstroom and Lichtenberg, there is still a lot of capacity available, and we are already seeing PV plants being built in those areas.

This phenomenon of having delays in building transmission lines is not unique to South Africa. It is a global problem. In the UK, for example, there is about a 10-year delay from deciding to build a power line to when it is commissioned. If we look at Australia, there is so much competition for connecting to key substations, e.g., as many as eight large battery projects (BESS) compete for

continues from page 7

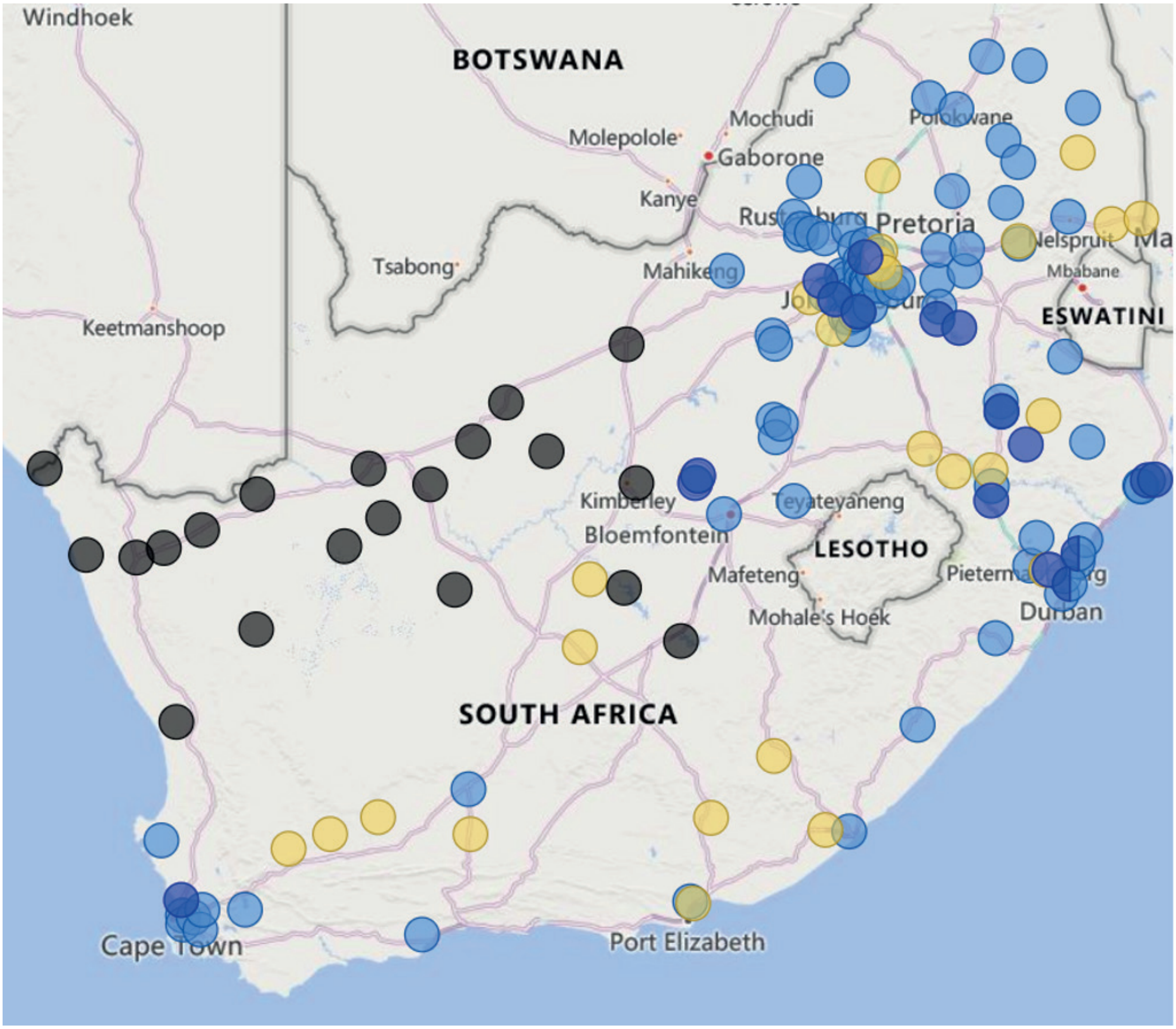

Figure 1: Eskom Transmission System

connection to the same grid point. They even propose that companies pay an extra fee to connect their plant to the substation.

RENEWABLE ENERGY

The hydro generation for South Africa is primarily from the Orange River and Cahora Basa. In the last few years, we have seen a steady increase in wind and PV entering South Africa.

Wind farms typically range from 50 MW to 150 MW. The turbine sizes are typically 2 MW each. Most are in the Western and Eastern Cape, mostly on the mountain ranges that form the border between the Small- and Large Karoo.

The wind blows when it wants; see the example from last year in April - Figure 2. Each of these light blue lines represents a day in April, given the production. We have an installed capacity of 3.1 GW, but we have never even reached it on any day. Wind production (EAF) is around 30 to 40% of the installed capacity.

A cumulative graph just for August 2022 shows SA typically produces about 1500 MW. Above that, it becomes very unpredictable, which means that the energy availability factor does not even reach 40%.

PV plants typically range from 5 MW to 100 MW; now, it is open season. For example, in the North-West province, in the last round of the government's renewable energy program, only three farms were approved for round six, although there were far more bids. If you look at the number of bids, you will see a total of more than 1.2 GW offered to the government, of which they only took

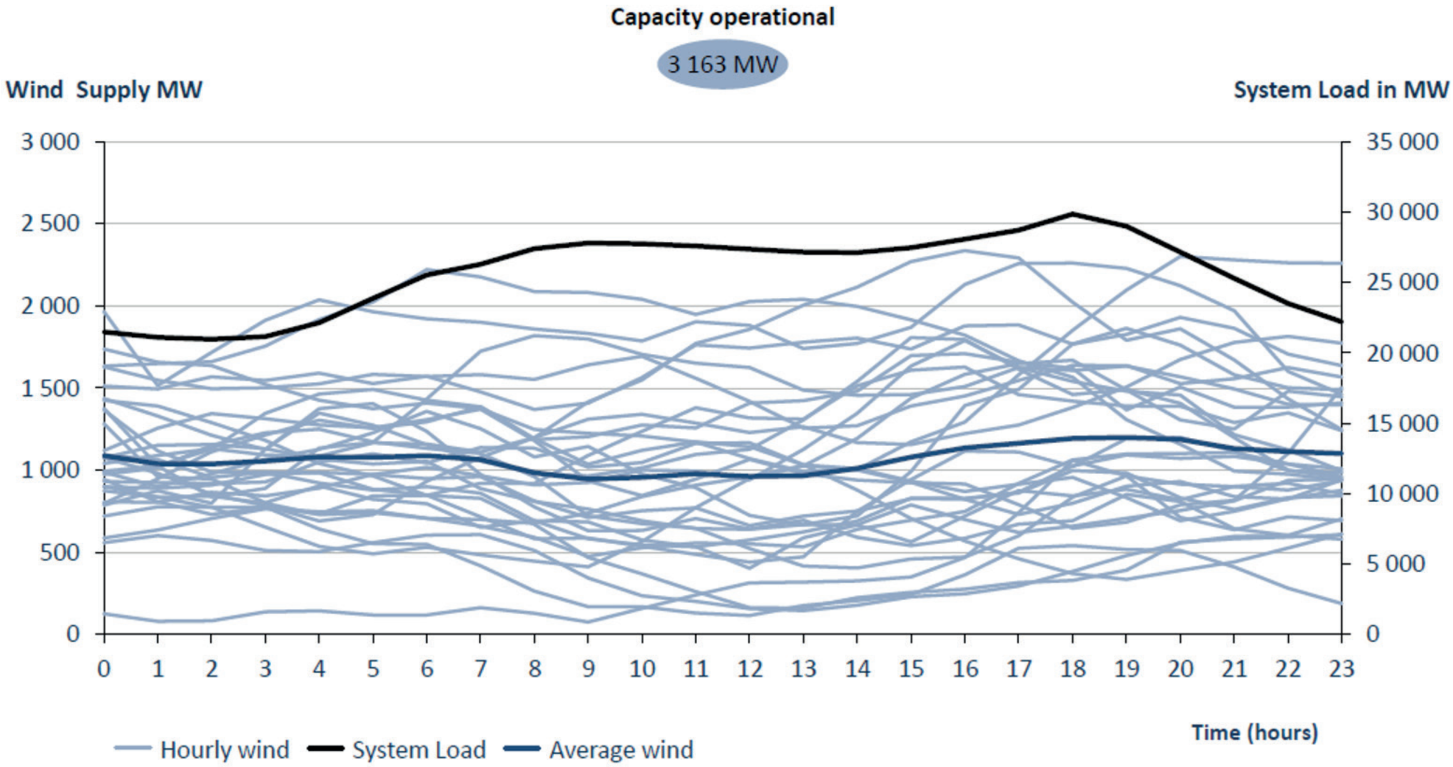

Figure 2: Wind capacity April 2022

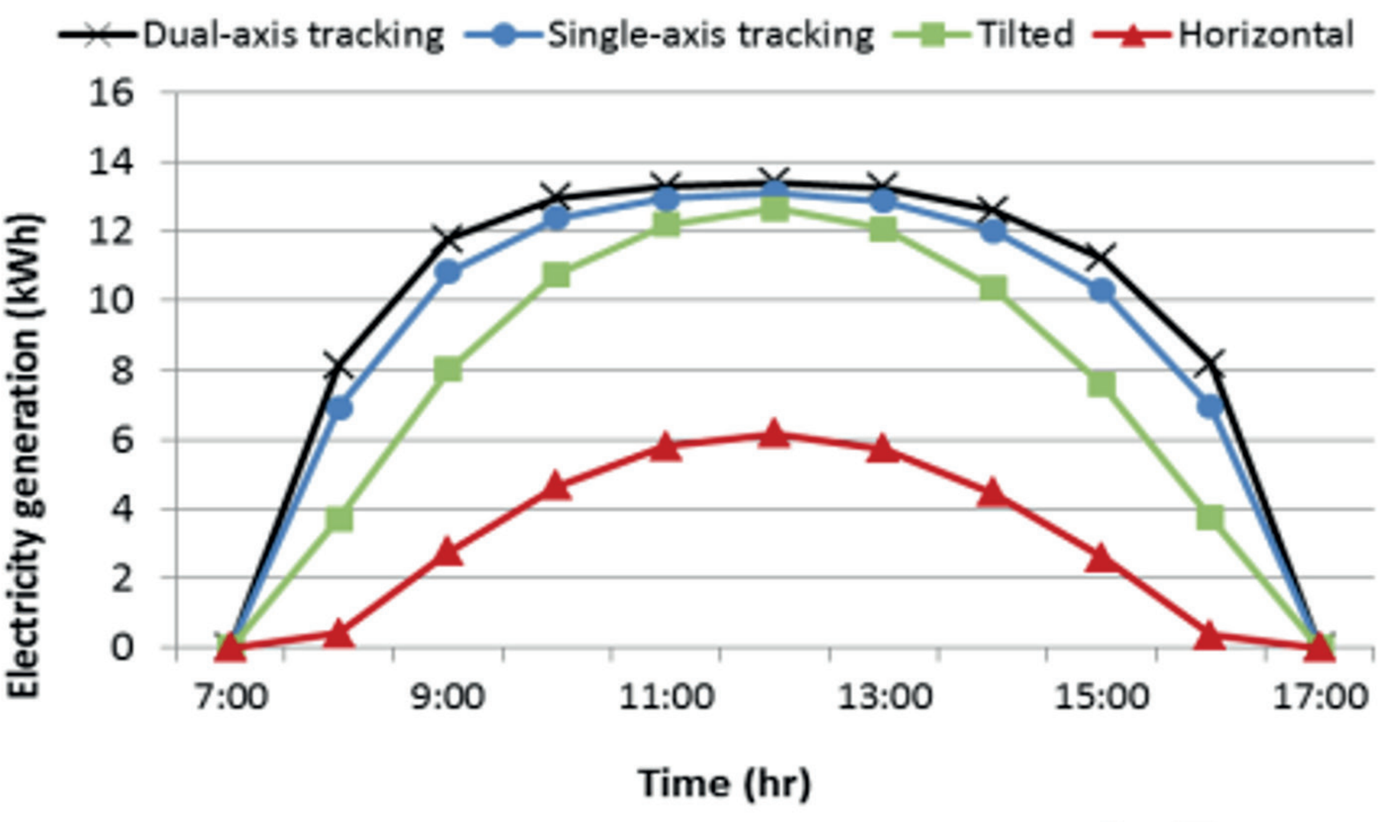

Figure 3: PV Solar installation generation

up 420 MW. There is a lot of initiative in South Africa now in building large PV plants, and essentially three options are being utilised. One is panels with a fixed angle, the second is single-axis tracking panels, and the third is dual-axis tracking panels. If we look at how all of these perform, we will see (Figure 3) that the green line represents fixed-angle panels.

The red line represents horizontal panels, rarely used in South Africa. The blue line is for single-axis tracking panels, and the black line represents dual-axis tracking panels. There is no big difference between the performance of single- and dual-axis tracking systems. Very few dual-axis tracking plants are being installed simply because of their cost and the required physical area. If we look at PV plant performance near the equinox last year, there is a large variation in a month in terms of the output for an installed base of about 2.2 GW.

South Africa has also installed some concentrated solar power (CSP) plants. CSP have two basic topologies, one has a field full of mirrors that can tilt in two axes, and they all focus the sun's beams on the heliostat in the middle, where molten table salt is heated as a thermal storage medium. The second technology is a trough design where the sun's rays are focused on a focal point in each trough. This makes for a far cheaper construction. Most of the plants in South Africa are designed for about five hours of thermal storage so that we can cover the evening peak. Using the thermal storage from about 5 p.m. to about ten at night shows the additional output we get from the thermal storage. However, a plant has already run for 21 days non-stop and can achieve an EAF as high as 65%.

Let us turn our attention to hydropower. One of our past presidents has been very actively involved in the Inga project, but I think it is still a pipe dream. Too many things are involved in getting power from Inga in the DRC through Angola to South Africa. Locally, there is 600 MW of generation on the Orange River. It is primarily operated in peak hours, except when there are floods, as we have had in the last few months. The Department of Water Affairs will control the amount of water let out if the dam levels are below 98%. There are still several possibilities for small hydro, typically run-of-the-river, an example being the Neusberg hydro plant produces 10 MW and last year had an EAF of 82%.

GAS AND DIESEL PLANTS

Everybody knows about burning diesel in gas turbines in South Africa, but let us consider combined cycle power plants using liquefied natural gas (LNG). In a combined cycle power plant, you have an aircraft derivative engine producing energy to drive a gas turbine and generator. The waste energy is then put through a boiler. For every three to four gas turbines, you add a steam turbine.

If you utilise the waste energy, you can get high thermal efficiencies of over 60%. This is typically what is done in the Middle East, where they then desalinate seawater for drinking water and solve the water crisis in coastal cities. To quote Dries Wolmarans, "If you can have two gains out of a project, it is far better than only one". Cape Town is a prime example where you can permanently alleviate the water shortage.

Furthermore, gas turbines, from a system perspective, have ramp rates in the order of 10% per minute, which is far better than coal-fired plants. Another big advantage of gas turbines is how quickly we can put them up. Internationally a plant is typically constructed in 24 to 30 months, which is impressive. They are not green, but we are still busy burning coal, and gas turbines pollute the atmosphere far less than when we would by burning coal.

OTHER THERMAL TECHNOLOGIES

There are two more technologies that we have not exploited in South Africa. The first is biomass, and the other is utilising the energy from municipal solid waste. We can use the manure in cattle feedlots; typically, for about 20,000 head of cattle, you can produce 3 MW.

The second is using municipal solid waste. Each South African throws away 3 kg of waste daily in the dustbin. In the Durban area, for example, they are now harvesting methane from landfill sites. We should also consider municipal solid waste (MSW) incineration, which solves two problems. One, it contributes to our energy generation 24/7; secondly, we eliminate our big waste dumps, a big environmental hazard. Again, they have very high energy availability and can run as baseloads. There are more than 1600 of these plants already installed worldwide. Plants typically vary in size from about 0.5 MW to 25 MW. The question is, why are we not building and using MSW plants?

ENERGY STORAGE

The use of batteries is on many people's minds at the moment. I want to classify them into two categories. One is on an industrial scale, typical Battery Energy Storage System (BESS) plants that produce about 100 MW for 4 hours. Then we have batteries in households to help us through load-shedding.

Battery banks in household applications can, from a system perspective, be counterproductive because as soon as power returns, the batteries are charged as quickly as possible, and that is beyond the control of the system operator. This nullifies the load-shedding from a system perspective. You can control the recharge rate on a large scale, which is a big advantage.

If we turn our attention to pump storage, Ingula, for example, has an installed capacity of 1300 MW, and the dam can hold more than 80 hours of water. Comparing the BESS of 100 MW for four hours with pumped storage, pumped storage is larger by a factor of 266. Therefore pump storage is still the way to go.

If we look at molten salt thermal storage, for example, in CSP, then we can have a 100 MW plant with storage for 12 hours. Importantly salt does not age like batteries. When compared to BESS, CSP has three times more energy storage available. Unfortunately, South Africa has not invested much in storage in the last decade after the commissioning of Ingula, as only six CSP plants (500 MW) have been put up. Eskom has envisaged a pumped storage plant in the Steelport-area for the last 20 years, but nothing has been developed there yet. BESS and pumped storage have efficiencies of between 75% and 80%. Batteries respond much faster than pumped storage and thermal plants, which is probably their biggest advantage.

Furthermore, BESS can be constructed in under two years, whereas pump storage will take us ten years plus. However, hydro has a very slow ageing rate, whereas batteries must be replaced every seven to 10 years. Another key advantage of CSP and pump storage is that it uses rotating machines.

Batteries are modular, and we can even move them if need be. At the moment, I think batteries are a local solution where there is a constraint in the system. You can install BESS to utilise the transmission network fully and get the advantage of some storage that will be available nationally. So, although batteries do not add inertia to the system, they have a very fast response to counter a generation loss to reduce under and over-frequency incidents.

The more PV and wind farms we put up, the more we lose system inertia. You need to install, for example, a battery or pump storage with PV or wind so that it is available when you want the energy to cover the evening and the morning peak. People forget this when we look at the price of PV, which costs 60 c/kWh for large-scale PV plants. You still need to have the storage and factor this into your cost calculations, and as soon as you do that, you will find that CSP now becomes very attractive. Furthermore, batteries do not contribute to the system fault level, and they pollute the system with harmonics.

DIESEL POWER PLANTS

I want to suggest that we convert all the big gas turbines that currently run on diesel to LNG because the operating costs are far less, and converting them in combined cycle power plants ups their efficiency from around 40% to 60% plus. This is an easy, quick fix. Diesel plants typically have low efficiency in the order of 30% to 40%, and they are very expensive to run simply because of the cost of diesel. However, all diesel generators have very fast ramp rates, meaning they can respond quickly to a generation loss. What we have not done yet with all the diesel engines is follow the lead of Australia. In Australia, the utilities have contracts with the owners of medium-sized diesel generator sets and lease their diesel plants from them for about ten years. When needed, the utility can then call on them to avert load-shedding. So instead of everybody using their diesel generators to supply 40% to 70% of their load, the utility can run them at full load and benefit the whole country. This is something that we can very quickly roll out as the capital has already been spent. We simply need just to put a model like this into place.

COAL-FIRED PLANTS

Suppose you have listened to Andre de Ruyter in the last few months. In that case, you may have picked up that he said that banks are no longer willing to provide loans for new coal-fired power plants. Similarly, large insurance companies do not want to do the same, mainly because of the environmental pressures from lobby groups. Therefore, Eskom is not going to build new thermal coal plants anytime soon, but we can fix what we have. That typically takes 30 months per unit because you have to order spares, plan, and execute the project in the last six months. If you think there are 80 units, there is a long road ahead. There is also increasing environmental pressure to decrease the emissions from coal-fired power stations. We must also not forget about the impact of coal mining on the environment.

NUCLEAR POWER

Nuclear power plants can be as big as 2000 MW per unit. The problem is they take forever to build, typically between 15 to 20 years from start to commissioning.

South Africa developed the pebble bed modular reactor technology, which has now been closed but is being pursued in other parts of the world. It is still a relatively new technology, but I do not think utilities will look at pebble bed modular reactors on a commercial basis very soon. Nuclear power is a green technology we probably need to pursue in the long run. Still, there is also a lot of opposition to nuclear power worldwide; in that respect, South Africa is no exception.

THE DOWNSIDE TO RENEWABLE ENERGY

PV will help us in the day with load-shedding, but as soon as the sun goes down, we will be in trouble again.

Then secondly, residential PV is not controllable at a national level, but everybody can put one up and will use them as much as they can. The ramp rate of the early morning and evening peaks is soon going to be very high, and I am not sure that our thermal plants will be able to meet that. We have been very slow in taking up storage.

Furthermore, it would be best if you remembered that PV, wind, and batteries all pollute our grids with current harmonics, which is becoming a far bigger problem in the foreseeable future. The harmonics and switching rates of power electronics have affected many of the transformers installed in wind- and PV plants in South Africa and worldwide. PV and wind farms do not contribute to fault levels or system inertia, things that we need in places like the Northern Cape. We also have not utilised the reactive power control that we can get from PV and wind farms either.

We will also have problems with everybody putting up PV on their roofs because residential grids are not designed for reverse power flow and dynamic voltage control. This will provide a lot of challenges to municipalities in the coming months.

A further word of warning, in Australia, the system operator, as far back as 2017, has already declared that there is a shortage of system strength, and a year later, also a shortage of inertia. Five years on, they have not solved the problem yet. Synchronous condensers went out of fashion in the 1980s and 1990s, but in the last 15 years, there has been an increasing surge in the production of synchronous condensers. One way that Australia, for example, is countering the weakening system strength is by using synchronous condensers.

THE NEAR FUTURE

So, what can we do in the next three years? This is where our immediate challenge is. Yes, we can put up PV and wind farms, and we can do that in less than two years, but as I have shown, the wind blows when it likes, and it is not predictable. On the other hand, PV is far more predictable, and we can build it simultaneously. However, they only operate when the sun shines, and our crisis is going to move from load-shedding through the day to mainly load-shedding early in the morning and in the evening peak as soon as new PV plants come online. CSP is the technology that we need to pursue. It would be best to compare it to either wind or solar plus batteries and synchronous condensers because CSP has built-in thermal storage and inertia and contributes to the system fault level. Therefore, we need to build far more CSP plants.

We also need to pursue generation from biomass and municipal solid waste. It is on a far smaller scale but simultaneously solves several other problems.

Just think briefly about what has happened in Europe with the war in Ukraine. Germany, for example, replaced the gas storage facilities within 198 days after Russia cut them off. In the Netherlands, they did the same in 160 days. This shows you where there is a big need and a national will; things can come together very quickly.

We also need to fully utilise the resources we have with diesel power. If we turn our attention to thermal storage (CSP) and batteries, this can be done very quickly, typically in a two-year window. Those are available immediately.

Let me give you another example. Most of the PV plants have 5% to 15% reserve capacity, which has not been sold to Eskom for contractual reasons, but the capacity is there. We need to use it, and it is available immediately.

So, what should be done now? Well, first, use all the spare capacity that we have, for example, PV plants, wind farms and in all the diesel plants that we have around the country. Then let us repair broken units at our coal-fired power stations. That is going to take some time. Then I beg you that we invest in rotating machine technology like CSP, combined cycle gas turbines with desalination, biogas, and synchronous condensers and not only in power electronics.

IN CLOSING

I want to show you how the pendulum swings. Let us go back a hundred years in South Africa. Then we had a lot of small power plants. Each municipality had its own small power station, and we had the largest private IPP in the world at the time, the Victoria Falls Power (VFP) Company. Eskom bought the VFP for the staggering amount of 13.5 million pounds in 1948. The VFP was the largest utility in the British Empire and a true utility in that it provided electric energy to South Africa and compressed air to all the mines on the Witwatersrand. They were far ahead of their time. From 1924 we had a national power company, Eskom.

Now look at what happened 100 years later. We are again putting up small power plants, and we have large IPPs, a national utility and a grid. So, the pendulum has completely returned to where we were 100 years ago. wn


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SAIEE Eastern Cape Centre: Dedisa Peaking Power Station Visit

The SAIEE EC Centre visit to Dedisa Peaking Power Station attracted nine visitors, including engineers, technicians and students from Nelson Mandela University. The weather was typical of a mild late Eastern Cape afternoon.

Dedisa has two diesel-powered OCGT (Open-cycle Gas Turbine) generators with a combined output of 340 MW. The project was awarded in 2013 to a consortium of South African and international sponsors comprising ENGIE (France) 38%, Legend Power Solutions (RSA) 27%, Mitsui & Co, Ltd (Japan) 25% and The Peaker Trust 10%. The DoE (Department of Energy) endorsed the plant under a 15-year power purchase agreement.

Construction of the R 3,5 b plant started in 2013, with commercial operation starting in October 2015. The project contributed significantly to Gqeberha and the Eastern Cape Province through employment, materials procurement and skills development.

The facility supplies electricity to the national grid during peak demand hours and emergency and load-shedding situations. Functionality includes grid voltage fluctuation stabilisation. The plant is located adjacent to Eskom's 400 kV Dedisa Sub-station. Two 200 MVA 15,75/400 kV generator transformers feed power into Eskom's substation via 630 mm² 400 kV XLPE-insulated single-core cables.

Visitors were screened for identity, authorisation and inebriety before entering the complex and then shown to a well-equipped meeting room. After a comprehensive safety briefing, Chris Eloff (Operations Manager) gave a detailed and fascinating overview of the 2x170 MW diesel-power OCGT plants. The site tour coincided with the start-up of the second 170 MW OCGT unit.

As the 2-hour visit slot had almost run out, visitors were invited back to the meeting room for a question and answer session.

The overall impression was of a well-maintained and tidy strategic facility. Dedisa management is particularly concerned about water-usage optimisation in the drought-stricken Eastern Cape and the timeous delivery of diesel fuel by road tankers.

Longer-term plans included conversion to LNG (Liquified Natural Gas) and combined cycle technology with significant improvement in thermal efficiency.

The visitors thanked Chris Eloff and Lizl Blom: Administrative Professional: Nelson Mandela University, for hosting and arranging the interesting excursion. wn

Written by JW Yuill Pr. Eng.

Turning South Africa's Special Economic Zones into energy ecosystems

The Special Economic Zones (SEZs) in Saldanha Bay, Richards Bay, and East London have massive potential to be turned into energy ecosystems. Not only will this help solve South Africa's energy problems, but it will also move us forward in reducing carbon emissions and even possibly allow the country to sell excess power generation to neighbouring countries once more. While there are numerous considerations around turning the SEZs into such hubs, including government and investor involvement, a key component will be labour and skills development. Turnkey employment services from a reputable and experienced Temporary Employment Services (TES) provider will prove invaluable on this journey.

BRINGING IT BACK HOME

With the push toward renewable and sustainable energy, South Africa has once again turned to import components at scale because the supply chain is not in place to meet requirements locally. However, we have the facilities, the capabilities and the infrastructure needed to produce many of these components as well as renewables systems and solutions in-country. This includes solar panels and blades for wind turbines, cabling and accessories for various solutions and even electrolysers for green hydrogen.

Not only will local manufacture make these components more cost-effective to source, but it will also reduce the carbon footprint involved in deploying them, further assisting with emissions reduction. However, to achieve this and turn the SEZs into energy ecosystems, they must be designed and planned to support energy production, distribution, and consumption.

This will require significant investments in energy infrastructure, including renewable energy systems, smart grid technologies, and energy storage solutions. It also needs support from the government in terms of policies, incentives, and regulations to encourage private-sector investment and ensure the sustainability and effectiveness of the energy ecosystems.

IDEALLY LOCATED

South Africa's SEZs offer huge potential for setting up entire supply chains around renewables, bringing this together for easier distribution and deployment. They are ideally located at the ports essential for transport and have access to road and rail. Furthermore, land is available for setting up large-scale manufacturing facilities essential for solar and wind component manufacturing.

Tax incentives are also available for setting up a business in a SEZ in South Africa. These incentives include a reduced corporate tax rate of 15% for qualifying businesses, accelerated depreciation allowances for capital assets, and customs duty and VAT exemptions on imported materials and goods used in production. Additionally, SEZ businesses may be eligible for employment tax incentives, such as a Youth Employment Tax Incentive and a Learnership Tax Incentive.

The SEZs are also well located for sourcing and drawing labour as there may already be skilled workers with the technical expertise required to cross-skill and re-skill in component manufacturing. There is also a large pool of available workforce to draw on, and collectivising this by upskilling communities can be hugely beneficial in the long term.

TURNKEY EMPLOYMENT SOLUTIONS

A turnkey TES solutions provider can offer a host of services that will facilitate the development of energy ecosystems and add value for businesses. The TES takes on aspects such as recruiting, vetting, training, and placing staff, typically administrative-intensive and costly, to ensure that workers are always available and with the appropriate skill sets. In addition, a TES will engage in training and development programs, safety and compliance management, and workforce management solutions.

MAKING ENERGY ECOSYSTEMS A REALITY

Achieving the goal of turning our SEZs into energy ecosystems will require a collective effort by the government, private sector, and investors. The government needs to actively market and promote South Africa as a destination of choice for businesses in the energy sector to attract the required investment. It should offer feasibility studies to assist investors with market analytics, return on investment and more. A supportive environment regarding policy, infrastructure, access to finance and skills development is key.

Investors should look to partner with local businesses, communities, and government entities to create a mutually beneficial environment for all stakeholders with a focus on sustainable business practices for the long term. A turnkey employment solutions provider is invaluable in this, from the setup of manufacturing facilities to operations. This will help investors and businesses navigate the complexity of the local labour environment to build successful energy ecosystems in South Africa. wn

Written by Viren Sookhun, MD,
Oxyon People Solutions

BCX Digital Innovation Awards 2023 is Open for Entries

Calling on technology innovators who are digitally transforming South Africa

Centurion: The 2023 BCX Digital Innovation Awards has officially opened for entries, with three major categories, namely, Public Sector Entities, Corporate Enterprise, and Small & Medium Enterprise. Entrants are looking to enhance their contributions to our society while moving us closer to a digitally transformed country.

"I am excited to see what innovations our entrants bring to this year's awards. Each year, my fellow judges and I have been astounded by the ingenuity and creativity of the entries. It is also encouraging that the BCX Digital Innovation Awards have grown in stature and recognition. Reputable businesses, such as Old Mutual, Discovery Bank and Shoprite Checkers, have been some of the previous entrants and winners. It is also encouraging that the SME entrants have produced inspiring innovations that are impacting industries in South Africa and, in some instances, across the world," says Mandisa Ntloko-Petersen, Chief Marketing Officer and the Awards Programme Sponsor at BCX.

Now in its fifth year, the BCX Digital Innovation Awards has become a showcase for innovative technology professionals and organisations in South Africa. Through creativity and out-of-the-box thinking, entrants are shifting how we do things. Their social innovations in the Public Sector have improved the welfare and well-being of South Africans, while the introduction of new products, processes or services are ultimately driving business growth and digitally transforming businesses to serve their customers better.

"We are looking for innovations that have achieved remarkable results, built by South Africans for South Africans. We are calling on all Public Sector Entities, Corporate Enterprises and SMEs to move the dial on digital innovation to step forward. It is an opportunity for you to showcase your ingenuity to help us shape and digitally transform our country," adds Ntloko-Petersen.

The 2023 BCX Digital Innovation Awards are open for entries from the 3rd of April until the 31st of July 2023, with shortlisting and judging taking place from September to October 2023. The winners will be announced in November 2023 at an awards ceremony in Johannesburg.

To enter, click here or follow #BCXDIA on social media.

Watch The Making of the BCX Digital Innovation Awards for inspiration. wn

ISO-Reliability Partners champions the benefits of predictive maintenance

Clients looking for improved reliability and availability of industrial equipment have a new partner in ISO-Reliability Partners. "Our expertise combines the sciences of lubrication, filtration and tribology. We offer unique and dramatic cost-reduction solutions for our customers," says Craig FitzGerald.

"We analyse in-operation oil samples and implement proactive measures to counter machine wear, the essence of predictive maintenance," says Craig. The company's reputation and success span 25 years, with it owning and managing the iconic Filter Focus brand, and Craig having incorporated all his intellectual property into the new company.

ISO-Reliability Partners is an own emblem manufacturer (OEM) of class-leading micro fine oil filtration solutions, vacuum dehydration systems, automated water removal for compressed air and high efficiency industrial air scrubbing.
"The majority of our clients are manufacturing facilities, general industry and mining. Our products are suited to any large-scale user of industrial equipment, gearboxes or mobile machinery," explains Craig. "Our solutions excel in high speed, extreme load, high temperature and high contamination applications." ISO-Reliability Partners eliminates equipment failures and dramatically improves operating efficiencies.

ENERGY EFFICIENCY THROUGH PREMIUM LUBRICATION

A trend in industry is to chase after price when considering lubricant purchases. The resulting inability of the lubricant to eliminate metal-to-metal contact has adverse effects on equipment performance, operating cost and ultimately the equipment's productivity. "Significant performance improvements can be achieved when lubricants are treated as assets," asserts Craig.

To bolster the company's solutions, it holds distribution rights for premium US lubrication brands Bel-Ray and Royal Purple. "Both are phenomenal lubricant grades that significantly improve energy efficiency on large equipment," says Craig.

Another USA manufactured product it distributes is Seal Saver, a breakthrough in preventative maintenance tools for hydraulic cylinders. ISO-Reliability Partners is the sole exclusive distributor for Seal Saver hydraulic cylinder protection solutions. Numerous companies trust the company with lubrication of open gear systems. For example, at Sibanye Stillwater it holds the open gear lubrication contract, a critical application in the mining industry in terms of productivity and efficiency. "To be charged with lubricating the most important components at Sibanye's operations is quite a feather in our cap," comments Craig, as it reflects the client's trust in the products it distributes and the associated thermal analysis services on offer.

Another major reference is Rand Refinery, which had a history of equipment breakdowns and unplanned stoppages prior to using the company's products. The largest integrated single-site precious metals refining and smelting complex in the world, Rand Refinery went from 80% red indicators on problem machines to 98% green and available, with zero breakdowns to date.
"The engineering team now also has the opportunity of evergreen time to address any potential issues well in advance, whereas previously the maintenance regime was largely reactive," says Craig.
As for the future, he concludes that ISO-Reliability Partners will continue to champion the advantages of reducing energy consumptions through lubricants and make inroads into its existing industrial and mining markets as well as new ones. wn

SCHLETTER GROUP EXPANDS PRODUCTION AND LOGISTICS

The Schletter Group, one of the world's leading manufacturers of solar mounting systems, will commission a new manufacturing site in Türkiye this month. At the plant in Dilovasi near Istanbul, Schletter will primarily produce for the markets in Europe, the Middle East, Africa, and America. In parallel, the company is expanding its logistics network with a new 12,000-square-meter logistics centre in Northern Europe.

"With our new plant in Türkiye, we are not only significantly increasing our production capacity but also placing our production on a broader basis," explained Florian Roos, CEO of the Schletter Group. In addition to the plant in Türkiye, Schletter maintains production in Asia and a flexible network of certified suppliers. "With this diversified and efficient supply chain, we can react very agilely to the requirements of our customers in the project business," Roos said.

The plant has a maximum capacity of around 1 GW per year and is equipped with state-of-the-art machinery. "Thanks to good process planning and new machines with extremely short setup times, we have achieved an extraordinarily high level of plant efficiency," emphasized Schletter COO Ralf Maus. The plant will open in April and will initially produce ground-mount systems. In the year, the production of roof products is also expected to start.

"After 12 years with Schletter Türkiye, I am pleased to be able to supply the increasing number of ground-mounted projects in Türkiye with locally produced systems," said Taner Öztürk, Managing Director of Schletter Türkiye. Schletter has also commissioned its new warehouse in Northern Germany. The location has a storage area of about 12,000 square meters. As a central logistics centre for Northern Europe, the hub will be able to supply Schletter customers in Scandinavia, Great Britain, and the Benelux countries much faster. "With the new northern warehouse, we want to shorten our delivery times in these countries significantly," Maus said. wn

IoT - The Internet of Things starts with a sensor

The Internet of Things (IoT) offers "smart" solutions that help make life easier and more convenient, improve and streamline processes, and receive information in good time that was previously unavailable or difficult to acquire. Smart solutions are highly personalised but always begin with an object and a sensor.

A level measurement with a remote transmitter is highly practical for detecting hazards and other level and fill-level applications. Take pubs, for instance, where an emptying beer tank could be equally dangerous. In this application, two pressure sensors work at the heart of the solution to measure the liquid level in the tank and send a warning message to the brewery by e-mail via the GSM-2* remote transmitter, the mobile phone network, and the Internet. The brewery sends an automatic order proposal to the landlord, who simply has to confirm the order.

This automated, "smart" M2M (machine-to-machine) solution reduces stress for landlords and saves brewery drivers from profitless emergency weekend deliveries. Inaccurate order entries are now a thing of the past, shipping can be optimised, and landlords have a continuous supply of fresh beer. Crisis averted. wn

Contact INSTROTECH on 010 595 1831 or sales@instrotech.co.za

SOLAR POWER MARKET IS SET FOR 2023 UPSWING - Fluke's top 5 installation and testing tools for engineers

With the solar power sector expected to rise sharply throughout 2023, installation and testing engineers will need access to the best tools to work at optimum efficiency and safety.

As the world makes its unstoppable transition to renewable energy sources, the global solar energy market is predicted to have grown by around 20.5% to reach R406.5bn between 2019 and 2026 (Allied Market Research). Engineers need to be ready.

Fluke, locally represented by COMTEST, a global technology leader in the manufacture of compact, professional electronic test and measurement tools and software, says that the top five tools engineers will need – whether working on residential systems, solar farms or photovoltaic (PV) farms – are:

- a Multifunction PV Tester
- solar irradiance meter
- insulation tester
- infrared camera (thermal imager)
- solar clamp meter (DC & AC true RMS)

These will all help to improve accuracy and efficiency during installation or periodic maintenance, including checking the integrity of system wiring and connections while keeping accurate measurement records.

INSTANTANEOUS MEASUREMENTS

A Multifunction PV tester enables solar professionals to test PV systems safely and accurately while streamlining workflows faster than ever. Flukes recently released SMFT-1000 Multifunction PV Tester is an all-in-one tool that's ideal for safety and performance testing of installations that operate up to 1000 V DC.

Solar irradiance meters measure solar irradiance, PV module temperature, array orientation and tilt angles. Fluke's award-winning IRR1-SOL Solar Irradiance Meter operates in accordance with the IEC 62446-1 standard. It enables engineers to take instantaneous measurements to determine Watts per square meter of solar irradiation.

An insulation tester makes it possible to quickly detect earth leakage problems by comparing measurements over time and allowing real-time decisions in the field. The 1587 FC Insulation Multimeter from Fluke enables engineers to monitor measurements remotely, accessing and sharing insulation resistance test results wirelessly with their smartphone via the Fluke Connect Measurements app.

SPACE AT A PREMIUM

Solar clamp meters measure DC and AC currents. Fluke's 393 FC Solar clamp meter – the world's first 1500V CAT III, IP54 rated, thin jaw clamp meter – is designed to deliver exceptional safety when working in DC environments up to 1500 V, such as solar arrays. The clamp meter's thin jaw makes it ideal for PV applications where space is often premium.

Hans-Dieter Schuessele, Application & Technology Expert at Fluke, said, "Countries worldwide are dealing with the dual pressures of climate change and reliable power sources. Renewable energy is an obvious solution that we believe will gain even greater traction throughout 2023 and years to come.

Fluke has always supported the solar sector and dedicated itself to developing ground-breaking tools for PV installation and maintenance engineers. We want them to be fully prepared for growth in this market. Only by having the best tools possible at their disposal can engineers in this demanding sector work at optimum efficiency and maximum safety."

For more information, contact COMTEST. wn

Yanfeng transforms its plants in South Africa with solar energy

Yanfeng uses solar energy in its two plants in South Africa. The official handover of the solar panels took place at the East London plant together with the SolarAfrica management. from left to right: Riwanca Julius, Customer Experience Lead from SolarAfrica, Gareth Matthew, Maintenance Manager and Luphumlo Ngxalambisi, Procurement, both from Yanfeng in East London, Simon Pella, Senior Manager Procurement at Yanfeng, received the award from David McDonald, CEO of SolarAfrica

Yanfeng has reached another milestone in its sustainability journey by bringing the power of solar energy to its plants in South Africa. The global automotive supplier already uses renewable energy at all its locations in Europe – some of which are already operating with 100% green energy – and now will supplement its operations in South Africa with sustainable and emission-free solar energy generation. This has put Yanfeng at the forefront of alternative energy in its industry, as it's the only supplier in the AIDC's Automotive Supplier Park in Pretoria, and the East London Industrial Development Zone Supplier Park that makes use of renewable energy. With this, the company is taking a further step towards resource-saving production and contributing to the reduction of CO2 emissions.

The new photovoltaic (PV) systems are operating at both sites and will produce an impressive combined 2,843,019 kWh of electricity in the first year. Each plant took approximately three months to complete with a total of 3,510 solar panels installed on the roofs of the production halls to convert sunlight into sustainable and cost-saving electricity.

Many sectors are facing major challenges with the transition to a low-carbon economy. The automotive sector in particular faces many operational and economic challenges when transforming production plants into net-zero emission operations. Thanks to its commitment to sustainability, 100% of the solar energy generated by the PV systems is used to power Yanfeng's production plants in South Africa, helping them save around 2,559 tons of CO2 annually while reducing their monthly costs and increasing efficiencies.

"Thanks to the change to renewable energy we can make our production processes more environmentally friendly and save resources," explained Simon Pella, Senior Manager Procurement at Yanfeng. "Energy and emission savings at our locations are an important measure to achieve our sustainability targets and our goal to reach net-zero emission production at our plants by 2030."

The solar energy systems were funded by SolarAfrica, which will also operate, maintain and monitor the systems going forward. "From the outset of these projects, Yanfeng's focus was on reducing their CO2 emissions and SolarAfrica is proud to partner with them to make their journey towards sustainability a success," said David McDonald, CEO of SolarAfrica. "It's inspiring to see a global company like Yanfeng invest in world-class facilities in South Africa, contributing to our country's green economy and supporting job creation in the automotive industry."

All Yanfeng European plants were converted to renewable energy by the beginning of 2022. With this new PV system, Yanfeng has implemented a milestone in the conversion to net-zero emission production at its two plants in South Africa. wn

Commvault a Leader in Cloud Backup for Ransomware Protection, According to KuppingerCole

Commvault, an enterprise data protection leader for the complex and mission critical hybrid environments of today's global businesses, announced that KuppingerCole Analysts AG has positioned the company as an Overall Leader in its Leadership Compass on Cloud Backup for Ransomware Protection. Within this rating, Commvault has also been named a Product Leader, Innovation Leader, and Market Leader.

"Today's hybrid IT environment creates additional challenges for backup and disaster recovery because of its complexity and heterogeneity, making it critical for customers to select solutions that align with their business requirements for service continuity, like resiliency, immutability, and scalability," said Mike Small, Senior Analyst at KuppingerCole. "Commvault has the broadest environment data protection with comprehensive functionality covering multiple use cases, a range of solution delivery options, and strong security features such as multi-layered zero trust. Its Metallic Data Protection as a Service (DPaaS) should be considered by organizations looking for DPaaS as part of a comprehensive solution with ransomware protection for their hybrid IT environment."

The KuppingerCole Leadership Compass provides an overview of the Cloud Backup for Ransomware Protection market, analysing vendors based on innovativeness, market position, financial strength, and ecosystem, as well as their respective products and services across a range of capabilities, including security, functionality, deployment, interoperability, and usability.

Commvault's enterprise-grade DPaaS excels in all of these categories and is championed in the report for delivering a wide range of cloud-native data protection solutions that cover a broad spectrum of workloads, including databases, endpoints, file & object, VM & Kubernetes, Microsoft 365, Microsoft Dynamics 365, Microsoft Active Directory, and Salesforce.

The report also spotlights the enhanced security and compliance protection from Metallic DPaaS via its Security IQ security tools and insights, ThreatWise cyber deception technology, and Government Cloud protection.

"We are thrilled to receive recognition for our excellence in cloud backup and ransomware protection! As one of the only vendors to be highlighted for both Overall Leadership and individual components of Product, Innovation, and Market Leadership in KuppingerCole's report, we are proud to stand out from the competition," said David Ngo, Metallic CTO, Commvault. "At Commvault, we take pride in providing unparalleled simplicity and trust to our customers, regardless of where they are in their cloud journey. We offer the ability to back up data in any environment, from on-premises to public and private cloud, and everything in between. Our advanced security features exceed the strictest compliance standards, ensuring that our customers' data is always safe and secure. With our extensive coverage for SaaS apps and structured and unstructured data, we remain at the forefront of cloud data protection. At Commvault, we don't just do it, we do it better than anyone else."

To learn more, download the full KuppingerCole Leadership Compass on Cloud Backup for Ransomware Protection on Commvault's website. wn

Power Trip

SA'S IMPERATIVE AND THE CONTINENT'S OTHER ENERGY CRISIS

Enlit Africa 2023 proposes to tackle the toughest questions around power, and as a result, has attracted energy experts from almost 90 countries

From 16 to 18 May 2023, Africa's most influential power, energy and water conference and exhibition, Enlit Africa, will take place at the CTICC in Cape Town. With South Africa's energy crisis entering its darkest period, the thought that consultants, analysts, developers, and experts from every sphere of influence will come together offers some hope.

"Considering that we're expecting more than 4000 delegates and over 180 speakers drawn from 87+ countries, from academia and start-ups, independent power producers, government and municipalities, utilities, service and solution providers, the regulatory and EPC sectors, and more… It is extremely exciting," says Chanelle Hingston, Group Director: Power & Energy of VUKA Group, the organiser.

"Enlit Africa 2023 is certainly more relevant than ever before as South Africa goes through a serious reckoning as to the future of electricity supply in the country," says David Ashdown, CEO of VUKA Group, the organiser. "There is a definite sense that we're facing an imperative, and the world's top energy professionals are coming to Cape Town to apply their minds to the multi-dimensional, multi-sectoral energy transition, which is our theme for 2023."
The energy transition is more than just an energy issue - it impacts multiple sectors, including transport, the production of alternative fuels and the intersection between energy and water, among other things. Increased energy production via renewable energy offers a chance to electrify many sectors currently reliant on fossil fuels.

"Our current electricity crisis offers us a chance to explore the opportunities that a truly competitive energy sector, driven by renewable energies, could mean for South Africa's economy and future and the legacy we leave as custodians of the planet," notes David Ashdown, CEO of VUKA Group. "This is also a chance to step up and lead the energy transition in Africa."

There will be two keynote sessions, two strategic conference tracks (the Main stage and the Strategic stage), and two practical conference tracks (a Renewable energy and storage hub, a Generation, T&D, and a water hub). Content to be covered across the various rooms includes generation, renewable energy, finance/investment, distribution, transmission, hydrogen, metering and revenue management, mini-grids, IT/ICT and, importantly, energy storage.
"Energy storage is a technology that promises to bring the full benefits of renewable energy to fruition," says Ashdown. "It is more than just an opportunity to store energy for later use – it is a technology that allows additional benefits across transmission and distribution networks as a means of improving power quality, addressing load demand challenges and network stability."

WHEELING AND DEALING

Large power users across South Africa are taking the security of supply into their own hands, taking advantage of updated policies and regulations to generate their own power. Multiple business cases for the implementation of generation and supporting storage will be explored at the conference, fostering an understanding of how adding each

business case changes the return on investment for each business.

There will also be a Municipal Forum, where multiple municipalities will come together to explore how changes in the power landscape in South Africa can support their efforts to drive local economic development.

"The ability to wheel power across municipal electrical networks will make municipalities more attractive to businesses for whom wheeling is a consideration, encouraging local employment and bringing in additional revenue to the municipality through wheeling arrangements," Ashdown explains. "By purchasing excess power from some of these large power users for local distribution, municipalities can also ensure energy security for their district, prioritising service delivery to consumers."

Key discussion points around the wheeling of electricity across municipal boundaries will include:

- What progress has been made in supporting the policy and legal frameworks needed to facilitate this?
- How will the accounting for electrons moved and delivered be handled?
- Where are pilot projects delivering learnings?

The programme also includes multiple opportunities to network or attend a variety of site visits and product launches; and an expo with 368 exhibitors, including international pavilions for Belgium, Brazil, Canada, China, Germany, India, Taiwan, and the USA.

Ashdown says, "Enlit Africa offers everything you need to see and everyone you need to meet in one place."

AFRICA'S OTHER ENERGY CRISIS

"When we hear the words 'energy crisis,' we South Africans immediately think 'load-shedding.' But there is another issue, which should be the focus for Africa for the next seven years – we need to ensure that we clear up as much of the energy access deficit as possible. We need to prioritise the 700 million people on the continent who have no access to modern energy resources.

"That is another reason I'm so heartened to see the large number of delegates we're expecting. We need to stand together as a continent, learn from one another, and know Enlit Africa provides a vehicle for real inter-African collaboration," concludes Ashdown.

SAIEE MEMBERS SPECIAL RATE

Don't miss out on this opportunity to connect, network, and learn from the key decision-makers in Africa's energy sector at the most influential power, energy and water conference and exhibition – Enlit Africa. Use the code SAIEE2023 to qualify for a 10% discount on any Delegate Pass type for Enlit Africa 2023. Register here. wn

Make certain that your solar panels stay put!

The realisation by business owners and residents that the loadshedding challenge is not going to be solved anytime soon has resulted in a huge demand in the supply and installation of mainly rooftop solar, with many 'so called' installers, with little or no experience, jumping on the band waggon in the anticipation of a quick buck.

Svilen Voychev, CEO at Valsa Trading, explains that never has there been a better time to emphasise the old adages, 'buyer beware', and as Benjamin Franklin said: "The bitterness of poor quality remains long after the sweetness of low price is forgotten."

"For the vast majority of potential buyers, their ignorance of both the mechanical and electrical aspects of a solar installation make them vulnerable to any potential installer and due diligence is the watchword as it's difficult to tell a 'Johnny come Lately' from an experienced installer.

"Having a qualified and certified electrician to handle the electrical component of the solar installation is one thing but ensuring that the panels are correctly and securely mounted is vital for dependable, safe and long-lasting solar performance," he adds.

FOURTEEN YEARS' EXPERIENCE

Valsa Trading has been a manufacturer and supplier of PV solar mounting solutions since its establishment 14 years ago in 2009, offering the widest range of tried and tested products designed to meet the needs of both businesses and homeowners looking to install solar power. It's solutions are designed for easy installation, durable, and highly effective, ensuring customers achieve their energy goals while reducing their environmental impact.

GROUND MOUNTED OR ROOFTOP

A solar array doesn't just mean rooftop mounted but can also be for ground, pole or even a floating installation and Valsa offers a solution to meet any application, whether its static solar panels in a field, on a hillside, in a backyard, or even a single or dual axis tracker, its ground-mounted systems can be customized to suit a specific need, Voychev explains.

"Corrosion resistant ground mounted panel systems are robustly constructed to withstand the harshest weather conditions, mitigating damage to panels during storms, high winds, or heavy snowfall."

He says that Valsa's roof-mounted solar panel system is designed for easy installation, with a range of customizable components that make it suitable for almost any roof type of construction - tile, thatch or IBR - or configuration - a flat roof, a sloping roof, or a complex roof design, its roof-mounted systems are infinitely adaptable.

ENERGY EFFICIENT AND RESPONSIBLE

"Not only a perfect fit, our roof-mounting system is also highly efficient, with a streamlined design that allows the panels to capture the greatest amount of sunlight, ensuring the maximum amount of energy generated per panel," adds Voychev.

"With a commitment to sustainability and reducing our environmental impact, Valsa Trading's products and services are eco-friendly and include a solar panel recycling programme where end of lifespan panels are safely and responsibly recycled, ensuring that they don't end up in landfills or harm the environment."

In addition to its PV solar mounting solutions, a range of complementary products and services are offered ,which includes a solar panel cleaning service, which helps to keep panels operating at peak efficiency, and solar monitoring systems, which allow customers to track their energy generation and usage in real-time. wn

Going "Off-grid" with Satellite Broadband

- BUILDING BUSINESS RESILIENCE IN A DYNAMIC ENVIRONMENT

Eskom's ongoing programme of loadshedding, which sees electricity supply to users suspended in the form of rolling blackouts, is intended to protect the integrity of the national grid. It is creating one of the most difficult business environments in South African history. As a result, enterprises have had to invest in generator back-up or alternative solar supply options to ensure business continuity. While the response of South African business owners is testament to the tenacity and commitment at the heart of South African culture, loadshedding represents an existential threat to many SMMEs, in particular. Ongoing power outages are also causing additional communication network "off-grid" situations.

"OFF-GRID" TELCO NETWORKS?

The continued power disruptions have caused widespread mobile network signal degradation and, in some cases, a complete collapse of network services.

The repeated power disruptions result in infrastructure failure on the towers, leading to service disruptions. This is particularly problematic for merchants and businesses that rely on 3G connectivity to transact and complete credit card payments.

In these situations, merchants, businesses and e-commerce platforms can find themselves "off-grid" from a telecommunication network perspective. While these business owners may manage to resolve localised electricity supply problems, they are still left without connectivity which means no e-commerce or point-of-sale trading.

SATELLITE IS ROBUST

Satellite networks offer a unique and attractive solution to this problem. By their very nature, satellite networks are extremely dependable and immune from terrestrial power disruptions or physical damage to infrastructure. This is because satellite communication networks require only a terminal to be installed on the end-user's premises. This then communicates with a central gateway (or teleport) via the satellite in the sky. The satellite network gateway is then connected to the Internet to provide the user with broadband and business data connectivity services.

This means that as long as the user terminal is operational and powered, typically using a small generator or a solar-powered supply, the business will be fully connected and can trade as usual. In this way satellite communications offer a robust solution to the disruption of business communication networks caused by loadshedding.

SMART SATELLITE SERVICES

Satellite network technology continues to evolve with the development of Smart Satellite Services such as the Twoobii service, developed and operated by the Q-KON Africa engineering team.

Smart Satellite Services incorporate advanced quality-of-service features and additional security measures to enable integration with merchant credit card readers and point-of-sale trading systems.

Twoobii is also the only certified solution for a leading e-commerce bank with direct integration from merchant point-of-sale devices to the core financial network.

Combining the fundamental reliability of satellite networks with the rapid transaction functionality of the Twoobii Smart Satellite Service therefore provides merchants with a robust communication alternative that can complete trading transactions in <1 second while maintaining near-perfect network availability (at least 99.95%).

SMART DELIVERY

The fundamental reliability of satellite networks and the security and quality-of-service features of Smart Satellite Services combine to create an attractive solution, but one further element is lacking from the perspective of business owners looking for a frictionless delivery option. That missing element is Smart Delivery.

The Twoobii service directly addresses this issue – it is underwritten by Smart Delivery in the shape of an end-to-end business model, pricing and delivery concept. Twoobii can therefore provide merchants with a simple one-stop option for going off-grid and ensuring reliable trading.

The Smart Delivery model greatly simplifies the contract and costing structures and includes equipment rental, life-time equipment warranty, on-site support callouts, equipment spares (if needed), core network integration and satellite connection service fees - all for less than R1,100 per month.

By leveraging the benefits of the Smart Delivery model, retailers and shop owners can now simply contract Twoobii for an end-to-end service as a primary or back-up service to terrestrial 3G mobile networks. This will ensure reliable trading at all times and at all locations, and eliminate the loss of trading opportunities caused by mobile network service disruption during loadshedding (or as a result of vandalism). Twoobii offers the additional advantage that the communication is highly secured and can't be disrupted by criminal activities.

Using this Smart Satellite and Delivery service bundle, merchants and shop owners can now go fully "off-grid" whilst still enjoying reliable and trusted communications for their ongoing business operations.

To learn more about Twoobii's satellite connectivity services and their flexible packages for merchants and retailers, visit www.twoobii.com wn

"WEEE Are Ilembe" Partnership Begins

The iLembe region is playing an increasingly important role within the waste electrical and electronic equipment (WEEE) recycling industry in KwaZulu-Natal and South Africa.

Not only is the region one of the fastest growing in KZN, but several WEEE (also known as e-waste) recycling companies based in the area have a national footprint and recover and treat e-waste. Despite WEEE being the fastest-growing waste stream in most countries, South Africa's current recycling rate is between 2% and 2.5% for waste lighting and 10% and 12% for other electrical and electronic equipment. This became more important when on 23 August 2021, a landfill ban for e-waste became effective in addition to the landfill ban for lamps already put in place five years earlier.

Although this ban has been enacted by the National Department of Forestry, Fisheries and Environment (DFFE), there is limited awareness and a lack of understanding about the implications of the recent e-waste landfill ban, particularly by local government, small businesses and households.

Falling under the Vuthela iLembe LED Support Programme, the Sustainable Recycling Initiative (SRI) local component's research has highlighted that little has been done in iLembe to comply with the WEEE ban; local policies and by-laws have not been scrutinised to ensure alignment with this ban, and limited WEEE collection and disposal options are available to avoid sending WEEE to landfill, especially for households and small businesses.

On 29 March 2023, stakeholders from provincial and local government, iLembe business and resident's associations, WEEE recyclers, NGOs, representatives of waste pickers, Producer Responsibility Organisations (PROs) and the SRI team gathered in Ballito to discuss a partnership to improve WEEE recycling in the district. This partnership, titled "WEEE are iLembe", is envisaged to create collaboration between stakeholders in the industry and work towards a shared vision.

The partnership aims to increase the amount of e-waste released for recycling, grow the industry and ultimately create new business and employment opportunities. Our objectives are to increase awareness and education, create new knowledge, encourage enhanced WEEE collection, harmonise local policies and by-laws, and create a platform for engagement.

Commenting on the partnership, Nisaar Mahomed from Trade and Investment KZN noted that a major part of the problem is a perception issue, where people see waste as something to be disposed of. He noted that people are now seeing how you can monetise waste. He stressed that "WEEE are iLembe" needs to consider broader things like sustainable job creation through waste.

Keith Anderson from eWASA agreed, noting that the challenge is not only the waste but also one of job creation, stressing the need to include the disadvantaged community. Keith further noted that the alignment of partners is also important, as various organisations were carrying out WEEE recycling campaigns.

Langalakhe Msomi from iLembe District Municipality stressed the importance of involving all the local municipalities in the initiative and focusing on WEEE within government offices, where he reported they had significant stockpiles.

A previous study noted that "stockpiling e-waste is typical, and the government sector may account for up to half of all e-waste". The SRI project has also conducted a pilot study on how to address the challenges in freeing up government WEEE assets. It is developing a toolkit to assist municipalities in this regard.

CEO of Enterprise iLembe Linda Mncube said that the district's development agency fully supported the partnership and was particularly interested in the business expansion and development opportunities by creating an enabling environment for the recycling of WEEE. wn

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AES keeps the wheels of industry turning by driving energy optimisation and best practices

As the local manufacturing and industrial sector continues to be challenged by the ongoing power crisis and struggling economy, the optimisation of energy production processes is crucial in keeping the wheels of industry turning. Experienced steam and boiler operations and maintenance (O & M) service provider, Associated Energy Services (AES), has been proudly assisting industrial plants to achieve energy usage optimisation and best practices for over 25 years.

Managing Director Chris Paterson notes: "I believe our services have never been more important in the country than at this current time - particularly in the wake of the country's declining gross domestic product (GDP). The current energy and productivity crisis requires agile, flexible and diverse solutions. As an innovative, reliable and

Chris Paterson
Managing Director | AES

well-established steam and boiler O & M service provider with a 25 year-plus track record, we can assist with energy efficiency optimisation through a wide-ranging portfolio of solutions."

These offerings include the following:

- Mitigation of risk and reduction of energy plant downtime;
- Assistance with the care of assets over the energy plant's life-time;
- Procurement of efficient fuel combustion;
- Diversification of the plant's energy resources;
- Improvement in site operations; and
- A reduction in carbon footprint.

REDUCING PLANT DOWNTIME THROUGH EFFECTIVE O & M

Commercial Director Dennis Williams explains: "AES is passionate about mitigating risk and reducing plant downtime through effective operations and maintenance and the optimisation of thermal energy streams from coal, liquid fuels, biomass and gas, allowing our clients to optimise energy efficiencies, future-proof their plants and secure ongoing sustainability and profitability.

"O&M provision is critical in driving an energy plant to achieve successful and sustainable operations, allowing our client-partners to benefit from the ongoing availability of steam and reliability of assets at an equitable price."

Williams explains that AES is fuel-solutions- and technology-agnostic, saying: " We believe coal will be the mainstay in South Africa regarding power generation for the next 10 years at least, and the same goes for process energy, which also has a substantial fuel requirement. However, AES provides solutions to diversify the fuel mix and are agnostic around fuel - we can assist clients in diversifying by providing access to numerous fuel and technology-based energy solutions: from coal and LPG (liquid petroleum gas) to biogas, biomass and more.

"We are also able to mitigate fuel risk through an established fuel procurement offering. Being extremely stringent in terms of the quality of fuel which we provide, we assist in plant efficiency improvements, using less fuel and improving the plant's carbon footprint."

A VARIETY OF OPERATING MODELS

Williams continues: "The production of thermal energy is integrated into a client's overall production. We always say that the boiler house is the metaphorical 'heart' of the operation, and if this is inefficient, it has a knock-on effect on the quantity and quality of product produced – ultimately negatively impacting the bottom-line.

With resources and skills shortages playing a large role in today's economic challenges, AES is able to offer the client fully-outsourced energy plant operation: including the provision of our own team members on site for operations, maintenance and training. We can also present a 'cradle to grave approach', paired with the 'build, own, operate, transfer' model. We are flexible and work according to the client's requirements."

POWERFUL PIONEERING

Paterson explains: "AES operates across a broad range of industrial sectors, with a well-established national footprint. We

Dennis Williams
Commercial Director | AES

promote optimised energy processes in the following industries: power generation, mining, chemical, timber, pulp and paper, textiles, dairy, poultry, food and beverage."

Williams observes that AES is widely regarded as the pioneering local O & M service provider in the steam and boiler plant management and maintenance industry locally, based on its nearly three decades in operation as well as the size of its client base.

"The company officially began as AES in 1996, but some of its earlier operations actually pre-date this period, and were then transferred to AES when it became a standalone operation," he clarifies.

"Our client base is also larger than any of our competitors. Additionally, AES was the first to offer an industry uptime and availability guarantee, which once again speaks to risk mitigation, as well as our status as a pioneer and forerunner."

PEOPLE AND SAFETY FIRST

AES subscribes to the highest ethics and operates according to strict safety standards, being ISO 9001, 14001 and 45001 certified.

Paterson comments: "AES is committed to quality, diverse and sustainable technology advancement and the development of human capital on an equal opportunity basis. Our certification ensures that we maintain a focus on achieving, benchmarking and optimising our internally and externally-focused processes and activities. There is no doubt that the current energy crisis requires robust, sustainable solutions. AES is determined to continue playing our role in supporting the South African economy through the optimisation and management of industrial energy efficiency, energy solutions diversification, carbon footprint reduction and risk mitigation," he concludes. wn

One of the padmount 2.7MVA 0.69/33kV inverter transformers produced for the wind turbines of the Kangnas wind farm in the Northern Cape in Round 4.5 of the national REIPPPP programme

ACTOM Power Transformers are at the forefront of energy generation

ACTOM Power Transformers (APT) is increasing the production capacity of its Wadeville, Germiston, plant, mainly to meet the substantial upsurge in demand expected from South Africa's rapidly growing renewable energy generation sector.

APT has identified IPP renewables as a growing market segment, with Rounds 5 and 6 of the REIPPPP gathering momentum and recent legislative changes around power generation by the private sector, driving further demand for power transformers.

Round 6, targeted to generate a total of 4200MW of power, received a total of 33 PV Solar and 23 Wind generation bids, totalling 9600MW. The projects in this round are also substantially larger than previous rounds due to the relaxa¬tion of cap limitations.

"All these new public and private sector projects add up to greatly increased demand for electrical infra-structural equipment with ACTOM's Transmission & Distribution divisions being in a strong position to supply 'balance of plant' equipment," said Steve Jordaan, Power Transformers' Divisional CEO.

In conjunction with its Switzerland-based transformer design partner, APT successfully developed a full range of inverter transformers for both wind and solar inverter applications and recently expanded the size range up to 12MVA. "This is in line with the larger capacity projects introduced in Round 6 compared with the earlier rounds of the national renewables programme, along with the larger-sized individual wind and solar generator units being brought into play in the latest round," Steve remarked.

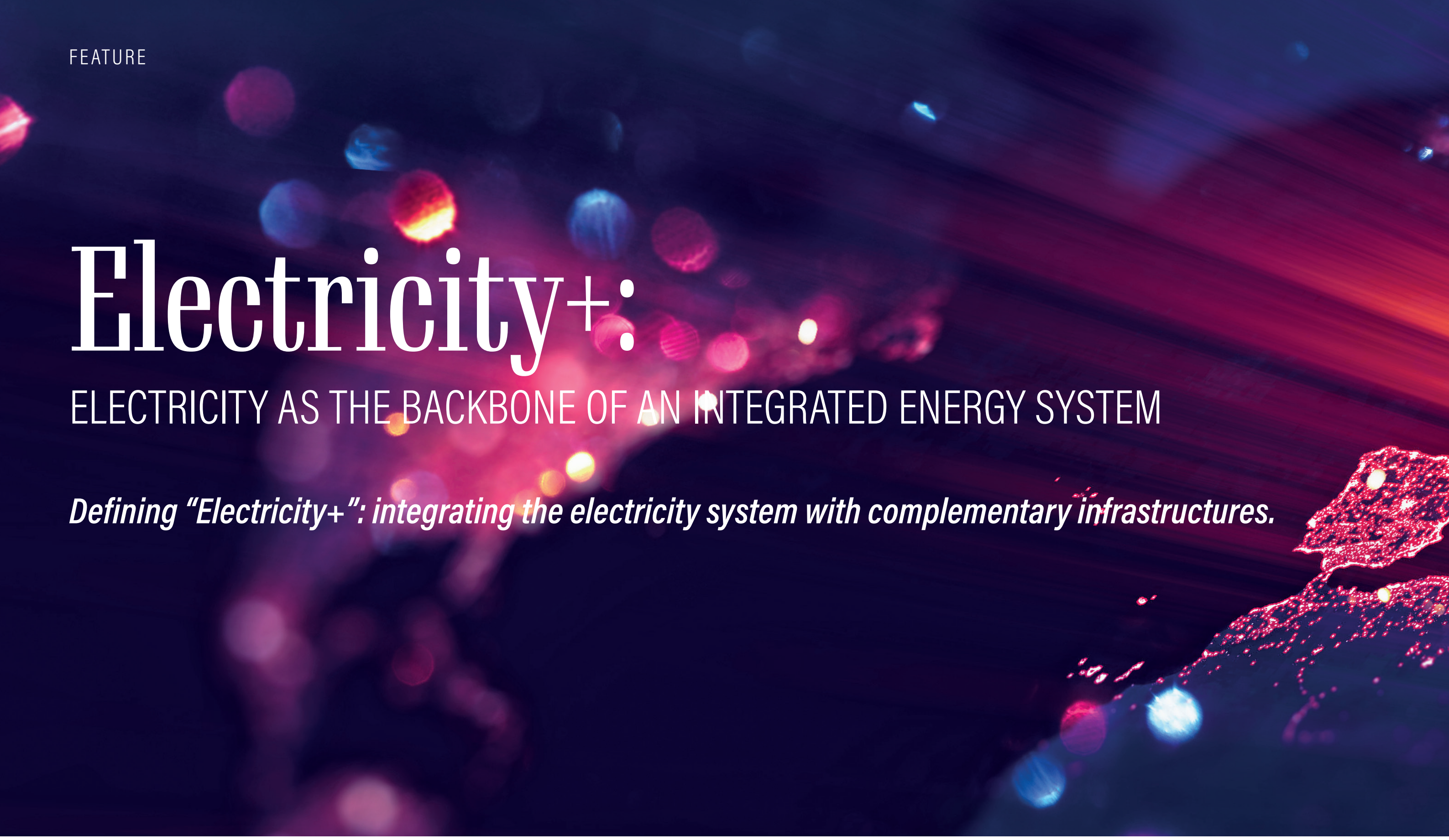
"This application requires specific design criteria for the step-up transformers to mitigate the effects of harmonics and dynamic response characteristics of the inverters," Steve explained.

Under REIPPPP round 4.5, 109 X 2.7MVA 0.69/33kV inverter transformers were supplied to the Perdekraal and Kangnas wind farm projects. "These have proven to be efficient and completely 'gas free,' which places APT at the forefront among local manufacturers of inverter transformers for renewable energy generation projects," Steve stated.

"Furthermore, APT offers the solution of combining the low voltage and medium voltage switchgear with the step-up inverter transformers in a skid-mount or containerised configuration, which Developers and EPCs generally prefer. This greatly simplifies the installation of the equipment and mitigates interconnecting cable faults on site," he commented.

The plant expansion caters for the skid-mount/containerised products and the larger inverter transformers up to 12MVA and increases the division's production capacity by more than 40% per annum.

The expansion, which includes the installation of a second vapour phase oven, additional vertical and horizontal winding machines, two additional assembly stations, and a state-of-the-art air cushion system, is due for completion by the end of March next year. wn



Electricity+:

ELECTRICITY AS THE BACKBONE OF AN INTEGRATED ENERGY SYSTEM

Defining "Electricity+": integrating the electricity system with complementary infrastructures.

Electricity+ is a new framework that highlights the opportunities to optimise integrations between the electricity sector and other infrastructure to enable a transition to a net-zero economy. The framework has been developed during a series of dialogues with executives from the electricity industry and other sectors. It will serve as thought leadership to kick-start further planning and collaboration across sectors.

The electricity system will evolve to be the backbone of the future energy system. To limit global temperature increases, a range of scenarios show that global final energy consumption must shift from 20% to 50-70% electricity by 2050. This massive economic transformation will require a fulsome reimagining of global energy systems.

A holistic vision for a future net-zero integrated energy system is needed, delivering broader system value across society, the economy, the environment and the energy system itself. The future integrated energy system will rely on a flexible, reliable, resilient digital electricity backbone. The multi-directional electricity system will include a) generation comprising significant renewable capacity from both large-scale and distributed energy resources, b) expanded and modernised transmission and distribution, increased interconnections, c) storage development, and d) electrification of end uses including heating, transport and industrial processes.

Since the future system will be highly electric, integration with other key infrastructures must be designed to create collaborations and maximise value. The key integrations are outlined as follows:

- Electricity + gas and storage
- Electricity + digital systems
- Electricity + transport and infrastructure – Electricity + liquid fuels and chemicals – Electricity + water and storage
- Electricity + waste and recycling

This paper, the Electricity+ framework has been applied to three markets: Spain, the UK and California. Yet this framework can be applied to any market and be used to assess the current state of integrations and identify collaborations and opportunities to create more efficiency.

INTRODUCTION

A holistic vision for a future net-zero integrated energy system is needed, delivering broader system value.

Electricity will be the backbone of the future net zero integrated energy system. To limit global temperature

increases to below 1.5 degrees Celsius, a range of scenarios show that global final energy consumption must shift from 20% to 50- 70% electricity by 2050. This will require fully reimagining global energy systems, including integrating historically separate systems.

There is no common, fundamental understanding of what is required for the net-zero integrated energy future nor of the value potential. Today's energy systems result from century-old technologies and policies built up in isolation and often based on point-to-point connections or linear flows. In most jurisdictions, the building blocks of the net-zero future – including waste, liquid fuels, gas and storage in addition to electricity, are subject to a patchwork of policies, market drivers and regulatory structures.

A holistic vision for a future net-zero integrated energy system is needed, delivering broader system value across society, the economy, the environment and the energy system itself. By integrating across sectors, collaborations will be created to help lift constraints linked to storage and use of excess capacity and flexibility in complementary infrastructures to promote the most efficient use of clean energy, supporting the uptake of clean electricity.

This paper sets out a framework for the future energy system, which has clean electricity at its core and outlines integrations with complementary infrastructure: gas and storage, digital systems, transport infrastructure, e-fuels and chemicals, water and storage, and waste and recycling.

The integration of electricity with complementary infrastructures occurs in the end-use sectors, Illustrating the value of integrating electricity with complementary infrastructures will inform the conversations on markets, including wholesale power markets, flexibility markets and carbon markets, that form the rules or frame for how the infrastructures and their stakeholders operate together in an integrated energy system. Key enablers (see Appendix) underpin the framework, including workforce skills development, technology innovation, and integrated system planning and operations. I.e. buildings, transport, industry and agriculture.

While further efforts will be essential, this high-level framework aims to serve as thought leadership to kick-start dialogue and collaboration across sectors, which will be needed at a market, regional and global level. It can be used to assess individual nations' energy systems and policies to gauge progress towards developing a future-proofed electricity backbone in an integrated energy system.

ELECTRICITY+ FRAMEWORK

Clean electricity will provide the foundation of the future integrated energy system.

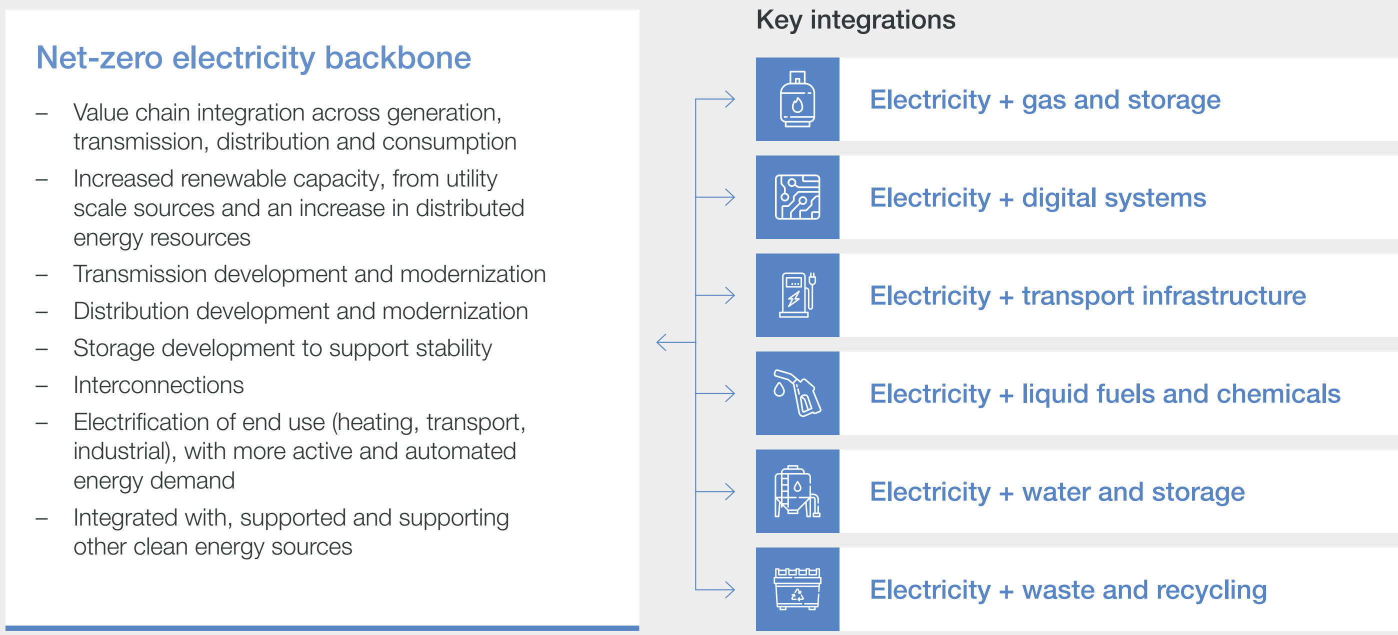


Figure 1: Electricity+ framework

The future integrated energy system will rely on a flexible, reliable, resilient and digital electricity backbone. Electricity generation, transmission, distribution and consumption must be optimised through multistakeholder collaboration to allocate and exploit resources efficiently. The electricity backbone will be multi-directional and must be fully integrated across all electricity infrastructure and other infrastructures.

Significant increases in renewable energy capacity will require timely onshore and offshore transmission and distribution development, modernisation and deployment of flexibility solutions. Increased cross-border interconnections will be needed to manage wind and solar's temporal and spatial complementarity while maintaining affordable supply. Additionally, developments in system operations, power and balancing markets, enhanced system services and storage will be needed to support the move from centralised power generation (synchronous) to a more distributed and variable renewables (asynchronous) grid system.

Distributed energy resources – consumer devices, electric vehicles, heat pumps, batteries and other storage devices, and rooftop solar – will be widespread.

Since many of these distributed resources both consume and provide electricity and can be aggregated, they contribute to increasing the system's flexibility but also the complexity of the system. This will require multi-directional and resilient grids and networks with local flexibility.

System integration across distributed energy resources and green hydrogen provides economical electricity storage, supporting an affordable and resilient electricity backbone.

The electricity backbone must support the rise in electricity demand and increased variability across domestic, commercial and industrial consumers. More active and automated demand-side management in these sectors will contribute to ensuring energy security, affordability and sustainability.

ELECTRICITY+ FRAMEWORK AND KEY INTEGRATIONS

The Electricity+ framework lays out the key areas of integration between the electricity backbone and other physical infrastructure.

The framework has been applied to Spain, the UK and California, serving as case studies.

GAS AND STORAGE

A forward-looking, integrated approach is needed when carrying out activities related to planning, operations and management of electricity and gas infrastructure. Gas infrastructure is primarily used today for transporting gas to industry for heating or as raw material, to domestic users for heating and cooking and to power stations for generating electricity.

Greater gas and electricity infrastructure integration will provide additional medium/long-term storage options to support the electricity backbone. Green hydrogen, green ammonia and methane (i.e. green gases), produced with renewable electricity during times of excess supply, can be fed back into the energy system.

DIGITAL SYSTEMS

The pervasive use of data, analytics, artificial intelligence (AI) and Internet of Things sensors, enabled by Wi-Fi and 5G technology, will be key to automating and controlling the future energy system. A much larger number of more diverse and distributed resources will rely on wireless connectivity. Digital systems will enable more efficient operations, allowing supply and demand forecasting and optimised grid management. Holistic planning and maintenance of electrical and digital infrastructure will reduce permitting requirements, outage times and societal inconvenience (e.g. laying fibre optic cables alongside/ integrated into electrical cables enables more efficient fault finding).

TRANSPORT INFRASTRUCTURE

Road transport electrification is accelerating as battery costs fall and more charging infrastructure is deployed. Electric vehicles can eventually also act as a source of flexibility to the grid, using the properly planned deployment of vehicle-to-grid and other smart charging technologies. In many regions, rail transport is already electrified. For port and airport operations, ships and planes will increasingly plug into the grid (shore power, cold ironing) with high voltage connection requirements. Biofuels, clean hydrogen and e-fuels will also help decarbonise these hard-to-abate sectors. Holistic planning of transport and electricity infrastructure, in close cooperation with system operators, will be crucial to maintain the speed and scale of the transport sector's decarbonisation.

LIQUID FUELS AND CHEMICALS

Liquid e-fuels (methanol and e-crude, also known as synthetic crude oil, which makes e-kerosene and e-diesel) and green hydrogen and green ammonia from renewable power will provide energy for hard-to-abate sectors, such as high-temperature industrial processes, marine, aviation and heavy goods transport. The planful build-out of large infrastructure to produce these fuels from electricity will be critical, for example, electrolysers connected physically or virtually to wind farms/solar parks. In addition, further electrification of industrial processes via heat pumps, e-crackers, and other technologies will require significant collaboration among the chemicals, fuels and electricity sectors.

WATER AND STORAGE

Electricity and water infrastructures are already highly integrated. Water also plays a cooling function for both thermal and nuclear power plants. Hydroelectricity operations generate clean electricity, while dam reservoirs and pumped hydro play a critical role in electricity storage and provide flexibility to the grid. Electricity is essential for desalination and water purification plants to supply fresh water to agricultural and industrial uses and clean drinking water to growing populations. Multi-function systems can provide power while using exhausted steam to run district heating systems. Examples of these systems include waste incineration or concentrated solar plants (providing heating, cooling and power) integrated with desalination plants to provide drinking water.

WASTE AND RECYCLING

A circular economy produces zero waste by reusing or recycling waste into new products. Waste can be used for power generation and heating. In addition, circular economy considerations are increasingly required from battery, solar panel and wind turbine manufacturers – component recycling requirements will probably increase in the short term, resulting in comprehensive, integrated waste management plans for businesses.

SYSTEMS ENABLED BY THE INTEGRATIONS

Electricity+ infrastructures will come together in four main systems.

BUILDINGS AND INFRASTRUCTURE

Efficient, connected buildings – whether residential, commercial or industrial – combine high-performance and low-carbon building materials with electric systems, distributed energy and intelligent management systems to maximise efficiency.

Buildings are no longer simply a consumer of energy, they are an active participant as a producer through distributed renewable resources such as solar rooftops, electric vehicle (EV) charging or even water heating. Self-generation will reduce pressure on transmission and distribution grids if integrated with the broader power system. Electrification of heat, adoption of heat pumps and implementation of district heating represent integrations of the energy system with buildings. Consumer waste, such as food waste, may be converted into bioenergy via feedstock provision for biofuel production.

Example systems:

Solar and wind farms provide renewable electricity for data centres. The heat from data centres is channelled through a heat pump to provide water and space heating to local apartment blocks.

Case study:

In the Tallaght district of Dublin, Ireland, waste heat from a data centre is used for low-cost water and space heating to buildings in the local areas.[1]

MOBILITY

EV charging points and rail electrification represent an integration between the electricity and transport sectors, providing an opportunity for electric transport to provide flexibility and storage for the electricity system.

Electrification mobility hubs and ports, alongside green hydrogen and e-fuels[2] for heavy-duty vehicles, maritime and aviation, will support the decarbonisation of goods mobility.

Example system:
Electric vehicle charging systems combined with batteries, solar panels and control systems connected to the power system to manage peaks and troughs at the community and individual levels.

Case study:
A vehicle-to-grid charging infrastructure project in the UK enabled over 3 million "free" miles for customers that made money from exporting electricity stored in their EV back to the grid at peak times.[3]

INDUSTRY

Industrial decarbonisation will include systemic efficiency and circularity, direct electrification, carbon neutral hydrogen (all colours of hydrogen) and carbon capture and storage (CCS). Waste heat from industrial processes (e.g. steel works) can be used in different industrial processes, and water can be used to store excess heat or electricity. Electrification of vehicles, industrial heat pumps and green hydrogen will enable the decarbonisation of industrial fleets and industrial processes.

There are efficiencies to be gained from pursuing decarbonisation in clusters.

Example systems:
Solar and wind farms provide renewable electricity for industry and green hydrogen production, which is used to produce green steel that can be used in car manufacturing.

Case study:
In the Basque Net-Zero Industrial SuperCluster, Iberdrola is helping the cement, steel, foundry and pulp and paper industries to reach net zero through direct electrification of processes and fuel switching.[4]

AGRICULTURE

Agricultural decarbonisation will include electrifying equipment, vehicles and processes where possible, the use of green ammonia for fertiliser and the use of biomethane and green hydrogen. Agricultural waste is an opportunity as input for biomethane.

Adoption of agrivoltaic practices, where agricultural land is simultaneously used for solar photovoltaic (PV) and agriculture, will enhance land use efficiency.

Example system:
Agricultural company powered by on-site solar energy, equipped with a control system to optimise energy consumption and relying on a fully electric vehicle fleet.

Case study:
Genagricola, Italy's largest agricultural company, partnered with Enel to install on-site solar PV capacity and a control system to optimise consumption, allowing it to decarbonise processes and electrify its vehicle fleet.

APPLICATION OF THE FRAMEWORK

The framework is an alignment tool for the public and the private sector to identify market improvement points.

To test the framework and its application for policy-makers, example test cases have been conducted for three markets: Spain (Figure 2), the United Kingdom (Figure 3) and California, US (Figure 4). This testing took place in August 2022 and has enabled the validation of the framework's robustness and identified potential improvement points within the markets.

CONCLUSION

The past decade, especially the past year, saw transformative changes across the energy system. There is significant momentum for the build-out of net-zero electricity and related infrastructure and further electrification of the economy. Electricity is expected to be the backbone of the future integrated energy system. The Electricity+ framework highlights key integration opportunities between the electricity sector and other infrastructures to enable a transition to a net-zero economy.

The energy transition aims to accelerate transformation whilst addressing the dimensions of the "energy trilemma" – energy security, sustainability and climate impact, and an affordable and just system. Yet there is an opportunity to take this a step further. It will be easier to manage reliability and resiliency, identify opportunities for flexibility and improve overall energy productivity and systemic efficiency by examining and planning for the physical integrations of infrastructures and making targeted investments and system upgrades accordingly. Government and business can pursue solutions and pathways that deliver broader system value across the economy, environment and society. The outcomes can include job creation, economic development and improved health through reduced air pollution. The Electricity+ framework encourages stakeholders to consider the system value framework while assessing opportunities to plan and deploy key integrations.

FIGURE 2 | Spain

Net-zero electricity backbone

Increased renewable energy capacity

2030: 74% renewable sources of electricity generation

2050: 100% renewable sources of electricity generation, net-zero carbon economy

2030 generation capacities: 50 gigawatt (GW) wind, 39 GW PV, 14.6 GW hydro, 9.5 GW pumping, 7 GW concentrated solar power (CSP), 3 GW nuclear plus 27 GW gas-fired combined cycle gas turbine (CCGT)

2050: about 250 GW renewable generation capacity

Transmission and distribution development

Increasing distributed energy sources with impact on low-medium voltage grids

Renewable energy sources self-consumption and demand side management promotion

Integrating bulk renewables, like floating offshore, and reinforcing existing grid

Storage

2030: 6 GW additional system capacity. In addition, distributed storage provided by electric vehicles, thermal storage in concentrating solar power systems, and hydrogen storage

Total storage capacity: 20 GW in 2030, 30 GW in 2050

Interconnections

2030: 3,000 MW with Portugal, 8,000 MW with France, to reach 15% interconnection capacity target

Enhancement of insular interconnectors

Value chain integrations

Promotion of independent aggregators

Renewable energy communities promotion

Streamlined administrative procedures for renewable sources of electricity integration

Financing of energy efficiency measures (inclusive of electrification) through a dedicated fund

Electrification of end use (domestic, commercial, industrial)

Energy provided by heat pumps grows from 627 thousand tons of oil equivalent (ktoe) (2020) to 3,523 ktoe (2030)

2030: buildings electrification: 53% 2040: 72%, 2050: 86%

It is hoped that this high-level framework can serve as a guide for dialogue, collaboration and planning across sectors to gauge progress and highlight opportunities to create a net-zero integrated energy system for the future.

INTEGRATED ENERGY SYSTEM FOUNDATIONS

The Electricity+ framework is underpinned by enabling elements critical to the transition to an integrated energy system and ensuring its enduring success.

LABOUR FORCE AND SKILL DEVELOPMENT

The energy sector must be attractive to younger generations and their career expectations. The labour force must be planned to ensure that employees have the skills to plan, design, operate, maintain and evolve the future integrated energy system. Adequate education, training and retraining need to be provided to ensure a sufficiently skilled workforce and an inclusive and just transition. Overlooking this aspect may cause decades of delay in deploying the transition due to the long lead time of the education cycle.

DATA AND DIGITALISATION

Data and digital processes will play a foundational role in providing visibility, automation and control, enhancing user interfaces and improving consumer engagement. For example, digital twins can be used to manage the energy ecosystem better and tell a story to improve consumer consent for new

Key integrations

Electricity and gas and storage

2030 electrolysers capacity 4 GW, 25% hydrogen consumption in industry is renewable, 150-200 fuel cell electric vehicle (FCEV) buses, 5,000-7,500 FCEV vehicles, two hydrogen railway lines.

Renewable energy gases (biogas and renewable hydrogen) promotion (support mechanisms, guarantee of origin (GdO), transportation regulations).

Operating merchant projects to store electricity and/or avoid renewable spillage through hydrogen production.

2050: large-scale renewable hydrogen production deployment to decarbonize hard-to-abate sectors.

Electricity and water and storage

Pumping station investments.

Desalination by using renewable energy, in turn, used as an input for green hydrogen production.

Improved hydro management to deal with droughts.

Regulations for electricity production and other uses.

Electricity and waste and recycling

Biogas production is expected to be dominated by anaerobic digestion of agricultural materials.

10.4 terawatt-hour (TWh) production by 2030, to be used in heating, transport and electricity generation.

Support measures and regulations for batteries recycling.

Electricity and digital systems

Regulation and systems to facilitate citizens' access to the data generated by advanced metering systems.

Smart grids support measures.

Projects and regulatory sandbox to structure and launch local flexibility markets.

More than 99% penetration of smart meters across the country.

Electricity and transport infrastructures

2030: 28% renewable energy sources transportation, mainly through electrification and advanced biofuels.

2030: 5 million electric vehicles with optimized pricing, e.g. smart charging by time of use.

2050: share of renewable energy at 79%.

Development of charging infrastructures.

Rules for access to urban areas that prioritize electric vehicles.

Support to ease the transition of the automotive sector from fossil to electric and connected vehicle manufacturing, including batteries and fuel cells.

5G deployment in roads.

Electricity and liquid fuels and chemicals

Measures to ease advanced biofuel penetration in transport, inclusive of specific goals in aviation and labelling regulation.

Key recommendations

- Further improvements in the permitting and consenting process for transmission, distribution, renewable energy, self-generation and EV charging infrastructure will enable faster deployment of the infrastructure required for the net-zero electricity backbone.
- Due to the increased prevalence of droughts, particularly in southern Spain, desalination using renewable energy is becoming more essential. However, the cost of desalination technology is high, so more research and development (R&D) is needed to make it economically viable.
- Further support to incentivize waste integration and circular economy, such as recycling of batteries as EV deployment increases and wind turbine blades as the fleet ages.
- Improvements and risk reduction in distribution regulation and review of the investment cap provision will enable an increase in investment to support the net-zero electricity backbone.
- Ensuring regulatory certainty will enable investor confidence required to build out the necessary infrastructure.

Figure 2: Spain (continued)

FIGURE 3 | **United Kingdom**

Net-zero electricity backbone

Increased renewable energy capacity

Ambitious renewables targets, including 50 GW offshore wind by 2030 and reforms to the planning system to cut approval times.

Acceleration of nuclear power, with one financial investment decision (FID) before the end of parliament and support for small nuclear reactors (SMRs).

Transmission development

2035 net zero electricity grid, 90% net zero grid by 2030, no limit on wind and solar by 2025.

Distribution development

Multiple distribution system operator (DSO) pathfinders and demand flex pathfinders.

Storage

Flexibility Innovation Programme

Longer Duration Energy Storage Demonstration Competition

Relaxation of planning legislation for easier battery construction at wind and solar sites

EV pathfinders

Interconnections

Offshore coordination project

Double interconnection capacity (seven interconnectors providing 7% of UK electricity in 2020)

Piloting a cap and floor scheme for multiple-purpose interconnectors and incentivizing the development of meshed offshore grids

Value chain integrations

Creation of future system operator

Electricity market reform

Open data initiative

Electrification of end use (domestic, commercial, industrial)

Heating:

- New heating appliances in homes and workplaces to be low carbon from 2035.
- No new gas boilers will be sold by 2035.
- 600,000 heat pump installations per year by 2028.
- £450 million boiler upgrade scheme to incentivize domestic consumers to install low-carbon heating.
- Heat Pump Investment Accelerator Competition

£3 billion fund to address building energy efficiency

By 2030, expect 10 million battery EVs on the road (27% of today's total vehicles) and 300,000 public EV charge points at a minimum

Key integrations

Electricity and digital systems

Modernising Energy Data programme working to embed data best practice, regulatory expectations for data and digitalization, and funding an energy data visibility service.

Energy Digitalisation Taskforce was established to focus on modernizing the energy system to unlock flexibility and drive clean growth towards net zero.

£2 million innovation competition called Modernising Energy Data Access.

£2.6 billion National Cyber Strategy 2022 to improve the cyber resilience of individuals and organizations across the UK.

Virtual Energy System initiative from National Grid ESO to create a digital twin of the UK energy ecosystem. This will be a shared industry asset and improve simulation and forecasting to support system planning.

Electricity and transport infrastructures

Rail: Target for net-zero rail network by 2050, with ambition to remove all diesel only trains by 2040.

Road: Target for all cars to be zero-emission capable by 2035. By 2030, expect 10 million battery EVs on the road (27% of today's total vehicles) and 300,000 public EV charge points at a minimum. £1.3 billion investment to accelerate charge point roll out and £500 million for development of electric vehicle batteries. Target for 4,000 new zero emissions buses and infrastructure by 2050. Hydrogen trials for buses and large goods vehicles (HGVs) are in progress, and trials for zero-emissions HGV technologies at scale on UK roads.

Aviation: Jet Zero Strategy to help UK aviation reach net zero emissions by 2050.

Waterborne transport: £20 million for Clean Maritime Demonstration Competition, Hydrogen trials for shipping in progress, ongoing public consultation on supporting the development of shore power.

Electricity and gas and storage

Future system operator to integrate long/medium-term electricity and gas planning efficiently.

Target for 10GW of low-carbon hydrogen production capacity by 2030, with at least half coming from green hydrogen and utilising excess offshore wind power to bring down costs.

Definition of hydrogen and CCUS business models.

Three hydrogen innovation programmes to support development of the hydrogen market, including green hydrogen: Industrial Hydrogen Accelerator Programme, Low Carbon Hydrogen Supply 2, Hydrogen Skills and Standards for Heat.

Electricity and liquid fuels and chemicals

Renewable Transport Fuel Obligation with biofuels blending mandates that increase the share of alternative fuels, including ethanol, bio/renewable diesel, biomethane.

Electricity and water and storage

Heat Networks Investment Project (HNIP): £19 million investment into five new heat networks in UK announced 2021. These heat networks use hot water in pipes to deliver heating and can be powered by any dedicated source, e.g. heat pumps, biowaste, recovered heat from industry, combined heat and power. The UK government estimates that heat networks could supply up to 20% of UK heat demand by 2050.

Electricity and waste and recycling

£75 million on net-zero related R&D for natural resources, waste and fluorinated gases, which may include electricity generation.

Biomass Feedstocks Innovation Programme, which can be used for electricity, biogas and biofuels.

Key recommendations

- The UK has ambitious hydrogen targets focused on supporting the decarbonization of industry in the UK. Further ambition is needed into the role that carbon neutral gas and hydrogen can play in storage for the electricity backbone and in clean electrification of industrial processes as green hydrogen will inevitably include hybrid systems.
- Further support is needed to enhance the distribution network capability (from a distribution network operator (DNO) to a distribution system operator (DSO)) to ensure it can manage increasing electrification requirements, distributed energy resources and demand-side interaction.
- Further support is needed for networks and grids to enable tighter integration with other infrastructures, e.g. gas.
- Increased emphasis on energy efficiency measures alongside insulation and building standards to upgrade the UK building stock and support the implementation of the net-zero electricity backbone infrastructure.
- Increased emphasis on valuing demand-side measures requiring further integration of digital systems, transport infrastructures and water and waste infrastructures.

Figure 3: United Kingdom (continued)

FIGURE 4 | California, US

Net-zero electricity backbone

Increased renewable energy capacity

California's Renewables Portfolio Standard (RPS) Program was established in 2002 by Senate Bill 1078 (Sher, 2002) with the initial requirement that 20% of electricity retail sales must be served by renewable resources by 2017.

The RPS Program was accelerated in 2015 with Senate Bill 350 (de León, 2015), which mandated a 50% RPS by 2030.

In 2018, Senate Bill 100 (de León, 2018) was signed into law, which again increases the RPS to 60% by 2030 and requires all the state's electricity to come from carbon-free resources by 2045.

Transmission development

Streamlined federal permitting proposal, federal return on equity "adders" for participating in regional transmission organizations or independent system operations.

Distribution development

State-based regulations and legislation for safety, investment, etc. (various)

Storage

As part of Assembly Bill 2514 and implemented by the California Public Utilities Commission (CPUC), set an energy storage procurement target of 1,325 megawatts (MW) by 2020.

Numerous hydrogen production, storage and blending demonstration projects and proposals are underway.

Interconnections

TBD

Value chain integrations

TBD

Electrification of end use (domestic, commercial, industrial)

Transport electrification: 100% of in-state sales of passenger vehicles to be zero emission by 2035, 100% medium and heavy-duty zero-emission vehicles (ZEVs) in California by 2045 where feasible.

Key integrations

Electricity and transport infrastructures

Advanced Clean Cars II Regulation sets 100% of in-state sales of passenger vehicles to be zero emission by 2035. Advance Clean Fleets Regulation 100% medium and heavy-duty ZEVs in California by 2045 where feasible.

Executive Order B-48-18 doubled the state's construction goal for hydrogen stations, establishing new targets of 200 stations, 250,000 light-duty EV chargers, and 5 million ZEVs by 2030.

Assembly Bill 841 requires utilities to cover the front-of-the-meter costs of grid upgrades and infrastructure related to EV charging.

Senate Bill 1505 requires no less than 33% of the hydrogen produced for, or dispensed by, fueling stations that receive state funds be made from eligible renewable energy resources.

Hydrogen Fuel Cell Yard Truck at the Port of Los Angeles: Public-private collaboration to develop and demonstrate two zero-emission hydrogen fuel cell yard trucks at the Port of Los Angeles. This project is part of the Zero-Emissions for California Ports (ZECAP) programme, funded in part by the California Air Resources Board.

Electricity and liquid fuels and chemicals

Incentives earned through the low carbon fuel standard (LCFS) provide steady financial support to low-carbon fuel producers, distributors and blenders in California. In 2019, about 81.3% of LCFS credits were granted for biofuels including biomethane, ethanol, biodiesel and renewable diesel.

Electricity and waste and recycling

Senate Bill 1383 requires the CPUC, CARB and the California Department of Food and Agriculture (CDFA), to direct utilities to implement at least five dairy biomethane pilot projects to demonstrate interconnection to the common carrier pipeline system. Requires diversion of 75% of organic waste by 2025, in partnership with Calrecycle.

Assembly Bill 2313 offers monetary incentives for biomethane projects for individual and dairy cluster biomethane projects.

Carbon-negative waste-to-energy technology: Private sector demonstration of technology designed to divert organic waste from landfills and convert it into carbon-negative hydrogen and RNG, which can be used for power generation.

Electricity and gas and storage

Senate Bill 1440: CPUC's decision to establish renewable gas standards has set targets for California gas utilities to supply 12.2% renewable natural gas (RNG) by 2030.

Senate Bill 32 requires state-wide greenhouse gas (GHG) emissions to be 40% below 1990 levels by 2030. SB 100 requires that renewable energy and zero-carbon resources supply 100% of the electric retail sales to end-use customers by 2045.

Senate Bill 1369 requires the CPUC, California Air Resources Board (CARB), and California Energy Commission (CEC) to consider green electrolytic hydrogen as an eligible form of energy storage and to consider other potential uses of green electrolytic hydrogen.

Joint IOU Hydrogen Blending Demonstration Application seeks CPUC authorization to establish multiple hydrogen blending projects in California to inform a future hydrogen injection standard and will test hydrogen blends between 5% and 20% hydrogen by volume.

Utility to construct first-in-US "hydrogen home" showcasing how a microgrid composed of solar arrays, a battery, an electrolyser and a fuel cell can provide clean, reliable energy to the homes of the future.

Angeles Link: Utility is proposing to develop the nation's largest green hydrogen energy infrastructure system to safely deliver hydrogen from outside of the Los Angeles Basin to industries that need it most.

Assembly Bill 2514, as implemented by the CPUC, set an energy storage procurement target of 1,325 MW by 2020.

In 2017, a utility completed what was then the largest lithium-ion battery storage facility in the world, Escondido Energy Storage project (30MW/120 MW-hour).

Reliability-related installations, such as a replacement for the decommissioning of San Onofre Nuclear Generating Station (SONGS), have led to significant additions to energy storage.

Electricity and digital systems

No clear targets

Electricity and water and storage

Hybrid direct air capture: Private sector demonstration of a technology that simultaneously captures CO_2 and water from the air.

Direct ocean capture: A university-backed startup is working to design, develop and demonstrate operation of an electrochemical system capable of capturing CO_2 from ocean water.

Key recommendations

- Companies are investing in digital and cyber on an individual basis, but there needs to be more central backing or policy to support the development of the digital systems required in the integrated energy system.
- Further clarity and support are required for the build-out of the transmission and distribution infrastructure to support the net-zero electricity backbone and enable tighter integration with other infrastructures, e.g. gas.
- Encouraging investments in the built environment's end use of electricity, particularly heating and cooling, is required to enable the electrification of end-use required in the integrated energy system.

Figure 3: California, US (continued)

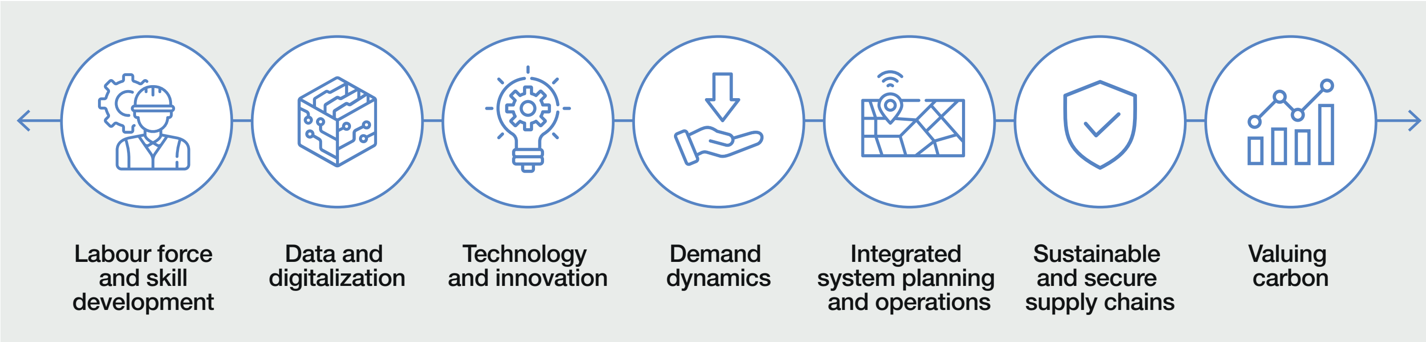


Figure 5: Enablers of an integrated energy system

assets. Digital will be a critical enabler of system integration by enabling predictive algorithms and automation.

TECHNOLOGY AND INNOVATION

Many technologies necessary for the integrated energy system exist today but need the effort to scale at speed. Moreover, there will be a need for ongoing innovation in technologies and other areas, such as business models and planning, to support the new system.

DEMAND DYNAMICS

Behavioural change from consumers (residential, commercial and industrial) to reduce waste, implement energy efficiency behaviours and technologies, and be more flexible across all infrastructures and technologies to optimise demand. Alongside this, energy communities are a powerful way for consumers to drive change in supply. Market design and regulatory and commercial reform should value actions to optimise demand side capabilities similarly to how supply is valued, incentivising consumers to flex load to support the grid, defer capital investment, reduce mismatch with the variable generation, and support distributed resilience and security of supply.

INTEGRATED SYSTEM PLANNING AND OPERATIONS

Markets must move away from one-off infrastructure project approvals. The development of holistic forward-looking, integrated system plans, combining and connecting different infrastructures by taking into account their different characteristics as well as considering flexibility and resilience solutions, is imperative. Non-wire options should be considered to ensure a holistic and technology-neutral approach. These types of long-term, integrated plans will help overcome supply chain cost increases and delays and allow for taking advantage of economies of scale. Integrated system plans also enable a "dig once" approach, e.g. installing or maintaining electrical cables and fibre optic cables and completing civil road works in parallel. In addition, other planning approaches, such as climate, cyber and physical risk-related resilience plans, must take an overall integrated energy system approach. This should consider the impact of an outage of one critical infrastructure on the broader ecosystem. A large-scale electricity outage would have ramifications on telecommunications, ports and airports, the role of water storage for flood management, energy system flexibility, and climate change-induced droughts on hydropower sources.

SUSTAINABLE AND SECURE SUPPLY CHAINS

Securing the supply of metals and materials critical to net-zero infrastructure, for example, nickel, copper or aluminium, is crucial to support the increase in renewables deployment, grid and network infrastructure development and modernisation, as well as demand electrification. These materials must be mined and produced sustainably, using clean power, with emissions profiles minimised across multiple locations. Sustainable working practices, particularly in mining, must be embedded. Circularity, recycling and disposal of materials, for example, batteries, must be considered. Longer-term visibility of project needs, e.g. larger tenders, will help suppliers offset delays and cost increases through innovative materials ordering.

VALUING CARBON

Carbon targets coupled with a negative value for carbon through carbon markets, carbon tax and carbon border adjustments need to be in place to incentivise investment in components of the integrated energy system economically. wn

ENDNOTES

1. "How district heating could play a key part in decarbonisation", Engineers Ireland, 23 February 2020.
2. E-fuels, like e-methane, e-kerosene and e-methanol, are all fuels in gas or liquid form that are produced from zero-carbon electricity.
3. "Case study (UK): Electric vehicle-to-grid (V2G) charging", Ofgem, 6 July 2021.
4. SPRI, Working together to achieve net-zero: Basque Net-Zero Industrial SuperCluster

Scaling Low-Carbon Design and Construction with Concrete

- ENABLING THE PATH TO NET-ZERO FOR BUILDINGS AND INFRASTRUCTURE

The world is in the midst of an infrastructure and buildings boom. In every part of the globe, especially in the developing world, urban commercial centres and residential housing are expanding as economies grow. At the same time, new roads and bridges are being paved and designed to provide logistics channels for moving parts, supplies, manufactured goods, and commuters while old infrastructure is being modernised. This is all potentially good news for the global economy, except for one glaring downside: buildings and infrastructure are responsible for approximately 40% of global carbon emissions each year, around 15 gigatonnes (Gt).[1]

Unabated, this number could grow dramatically, effectively undercutting decarbonisation efforts in other sectors.

A substantial share of these emissions is released before an asset is used. Materials production accounts for 15-20% of building emissions and 50-60% of infrastructure emissions (see Figure 1). Among building materials, concrete accounts for around 30% of building materials emissions (see Figure 2) and 7% of global carbon emissions.[2]

Yet, concrete possesses qualities that make it ubiquitous and important in construction – durability, resilience, thermal capacity, local availability, relative affordability and the ability to meet highly varying functional requirements. Therefore, to reduce the carbon footprint of buildings and infrastructure, it is critical to examine the manufacture and use of concrete. In 2021, the cement and concrete industry published its roadmap to net-zero concrete by 2050 through the Global Cement and Concrete Association, in which it identified the actions and policy enablers necessary to decarbonise the entire value chain of the sector. The roadmap identified the valuable role of low-carbon design and construction.

This paper examines how to scale this lever.

THE POTENTIAL

The decisions made by AEC firms about how to use concrete have an impact on – and, if decided with intentionality, can reduce – a structure's lifetime emissions in several ways. Most immediately, decarbonising the cement manufacturing process using near-term (available by 2030) technologies, specifying lower-carbon concrete formulations, and optimising the volume of material used, can reduce project-level carbon emissions from concrete by up to 40% (see Figure 4). Furthermore, how concrete is used in a structure's design can be optimised to improve its thermal efficiency, longevity and circularity, further reducing its carbon footprint.

THE OBSTACLES

Although reducing carbon emissions in buildings and infrastructure is an important opportunity requiring swift action, a series of obstacles prevent low-carbon design and construction with concrete from being deployed at scale today.

To begin with, the measurement of carbon emissions across the entire life cycle of a project, and the use of data to improve design decisions and track progress, is not the industry norm. This is partly because of the complexity of lifetime carbon assessment calculations and a lack of available data inputs. It can also be attributed to a lack of mandates for carbon measurement from governments, clients and firms.

Fragmentation in the design and building process also stands in the way of achieving lower-carbon outcomes. Different design and construction phases are handled by different teams and firms, often with minimal coordination, limiting visibility into supply chains and impeding exchanges of information and ideas.

Adding to these challenges, low-carbon design techniques and products are not always aligned with industry norms and documented codes and standards, making it risky for firms to deploy them.

Perhaps most importantly, many public and private clients are not prioritising carbon reduction (which can sometimes increase material and project costs) in their procurement decisions.

This makes it difficult for AEC firms to prioritise low-carbon design and creates uncertainty among cement manufacturers about the demand for low-carbon products, discouraging them from investing in decarbonising their production processes. This adversely affects the economics and supply of low-emissions cement and concrete products, creating circular challenges and making designers hesitant to specify them.

THE SOLUTION

This report offers a seven-part framework for overcoming the challenges and concerns that have impeded the low-carbon design of buildings and infrastructure projects with concrete. Enacting this framework requires action and support from AEC firms, cement and concrete manufacturers, project buyers and investors, and governments.

1. ADOPT CONSISTENT LIFE-CYCLE EMISSIONS MEASUREMENT
   AEC firms must consistently conduct project-level, life-cycle carbon assessments to inform responsible design decisions and create accountability. The cement and concrete industry, on its part, must more frequently provide detailed environmental product declarations (EPDs).

2. INCREASE COLLABORATION ACROSS THE VALUE CHAIN
   Enhanced communication between AEC firms and concrete manufacturers during the project

design process can improve supply chain visibility and facilitate lower-carbon project outcomes.

3. REDUCE RISK THROUGH PILOTING, DATA AND ENGAGEMENT
   When standards, codes and industry norms work against reducing carbon emissions on buildings and infrastructure projects, AEC firms and cement and concrete producers must be willing to push for change by participating in dialogues with clients, academia and industry bodies to run pilots, invest in research, gather durability data and update standards.

4. EVOLVE OPERATING MODELS WITH EXTENSIVE LEADERSHIP SUPPORT
   AEC firms must have clear mandates from leadership to prioritise low-carbon design so that they can effectively upskill and enable teams to achieve lower-carbon outcomes.

5. SIGNAL DEMAND AND SCALE SUPPLY
   By committing to specify and design for an increased volume of low-carbon materials and projects, AEC firms can help make a case for cement and concrete manufacturers to invest in the plant upgrades needed to produce these materials at scale, improving their economics and availability.

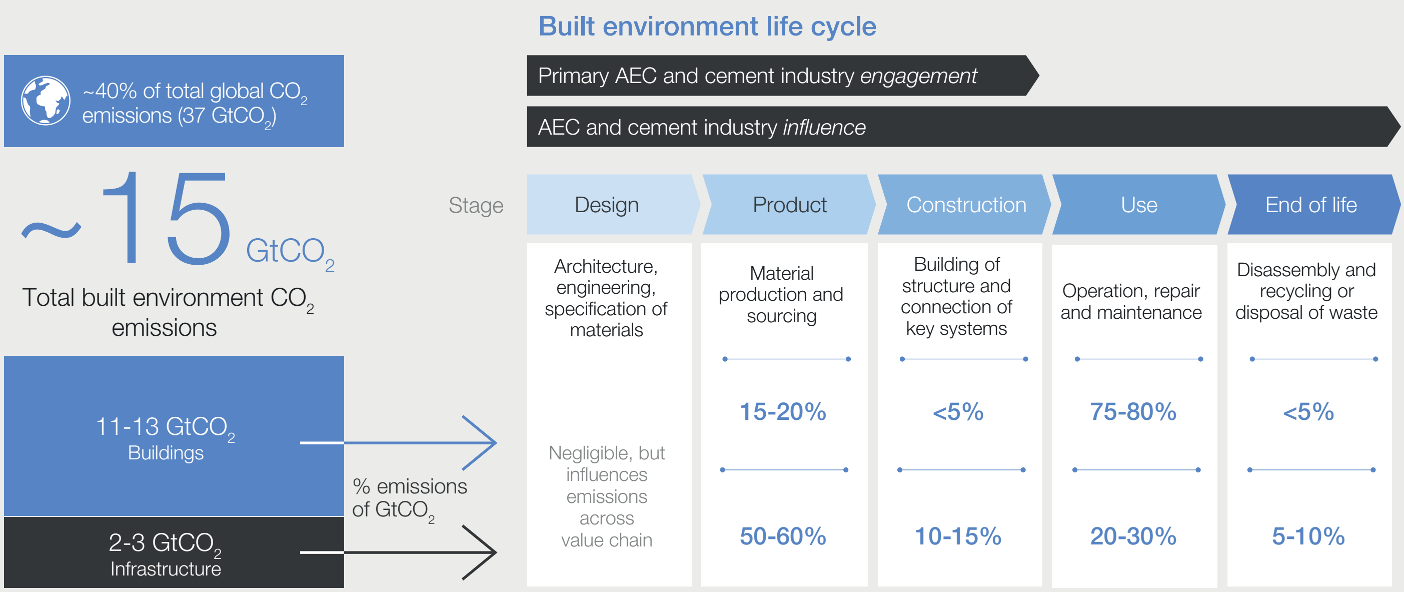
6. PRIORITISE CARBON REDUCTION IN PROCUREMENT
   Project buyers, both public and private, can have a meaningful influence in driving the AEC and cement manufacturing industries to act by requiring disclosure of project and materials emissions and prioritising carbon reduction in the partner selection and design process. Alongside demand signals from AEC firms, this can also help drive the necessary investments in technology and manufacturing.

7. ESTABLISH SUPPORTIVE PUBLIC POLICY
   Governments can support the above steps and accelerate progress through policy actions, including regulation, incentives and funding, and by providing leadership to address key industry challenges. Given the urgency of reducing emissions from buildings and infrastructure, and the potential of low-carbon design and construction using concrete, all stakeholders – AEC firms, cement and concrete manufacturers, public and private buyers of construction projects and governments – must take these actions earnestly and speedily.

1. INTRODUCTION

SCALING LOW-CARBON DESIGN WITH CONCRETE: A PATH TO NET-ZERO CONSTRUCTION.

Buildings and infrastructure are responsible for approximately 40% of the world's carbon emissions each year.



Sources: IEA, "2020 Energy Technology Perspectives"; IEA, "Tracking Report - Buildings"; BCG analysis.

Note: Life-cycle analysis based on European Standards EN-15978 – includes materials, construction, operation and end-of-life emissions; excludes credit of material reuse and recycling.

Figure 1: The built environment is responsible for around 40% of global emissions across the full project life-cycle

A meaningful share of these emissions is released before an asset is used – through the production of building materials (an estimated 15-20% for buildings and 50-60% for infrastructure, although it can vary widely by project and geography) and construction activities. The remainder is emitted during the use of an asset through energy consumption, repairs, maintenance and, at the end of its life, from demolition and waste. The design decisions made by project buyers and investors, architects and engineers before construction begins, and the choices that contractors make throughout the building process about which materials to use and how to use them have a meaningful impact on the total life-cycle emissions of an asset.

THE ROLE OF CEMENT AND CONCRETE

Concrete and cement (an essential material in concrete) are the most consumed human-made resources on Earth, responsible for approximately 7% of global carbon emissions and 30% of material emissions for buildings. The centrality of concrete and cement affects the carbon footprint of buildings and infrastructure in two crucial ways: directly through their carbon emissions generated during manufacturing and construction and indirectly through their positive contribution to the built project's energy efficiency, durability and longevity.

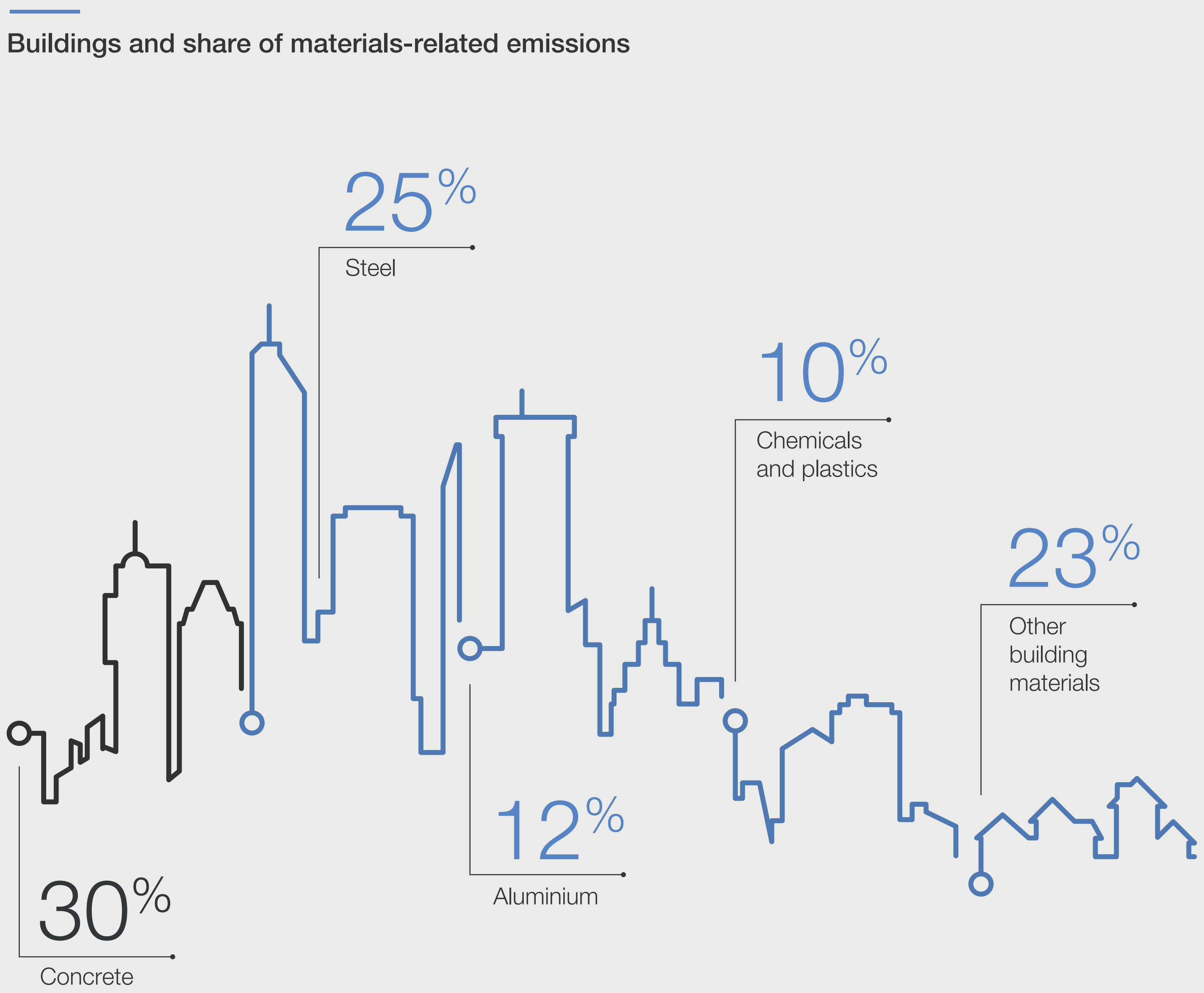


Figure 2: Concrete is responsible for approximately 30% of materials emissions from buildings

Global demand for cement is increasing, and in the absence of any action to respond to calls for net zero emissions, it is forecast to grow by 20% from 2020 to 2030.[3] Many of concrete's properties, including its strength, durability, fire resistance, circularity, availability, resilience, thermal properties and affordability make it indispensable for critical infrastructure and buildings, which ultimately impact the health, safety and quality of life of billions of people. Therefore, to reduce the emissions of buildings and infrastructure while meeting societal needs, it is imperative to examine the use of concrete and ways to reduce the carbon emissions related to it.

THE ROLE OF DESIGN

Along with materials producers that supply the cement, concrete and other materials used in construction, AEC firms can significantly influence a project's carbon emissions. The choices these firms make in the initial stages of a project determine the materials and construction techniques used, the energy consumption, repairs and maintenance during operation, and the resilience, longevity, circularity and recyclability at the end of life. These factors ultimately determine a project's total carbon emissions over many years. These design decisions are, of course, also influenced by project buyers (public and private), who set project priorities and budgets, and by governments that issue building and construction regulations.

By setting and working towards a goal to minimise carbon emissions from the beginning of a project, project buyers, AEC firms, and cement and concrete producers can collaborate to reduce carbon emissions across the building and infrastructure life cycle. There are obstacles to doing this and challenges to address, but this is a huge opportunity that could make a critical difference in reaching the goal of limiting the global average temperature increase to 1.5°C above pre-industrial levels.

To scale low-carbon practices in the industry, low-carbon design and construction must be recognised as a critical enablers for reducing the carbon footprint of buildings. They must be prioritised by AEC firms, cement and concrete producers, project buyers, investors and governments.

2. THE POTENTIAL OF LOW-CARBON DESIGN AND CONSTRUCTION

Large-scale deployment of low-carbon design tactics and the use of existing and upcoming manufacturing technologies

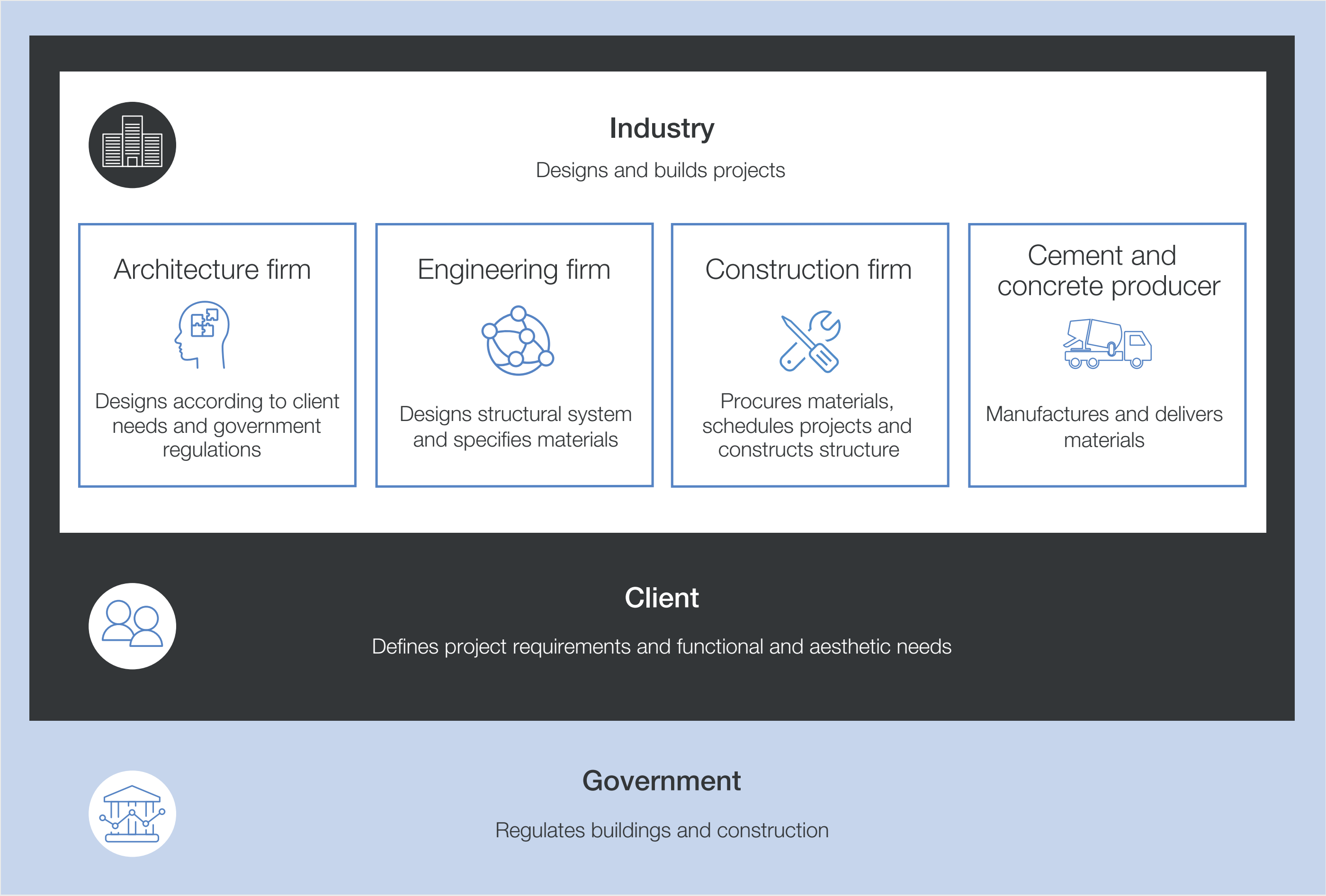


Figure 3: An illustrative view of the buildings and infrastructure value chain

can meaningfully reduce the carbon footprint of construction projects.

The total concrete emissions in a project can be reduced by up to 40% by 2030 (see Figure 4) by using existing or upcoming technology in the manufacturing process, specifying the use of low-carbon concrete products, and optimising the volume of materials used. Additionally, other techniques related to the construction, use and end-of-life stages can further shrink a structure's carbon footprint over its life cycle.

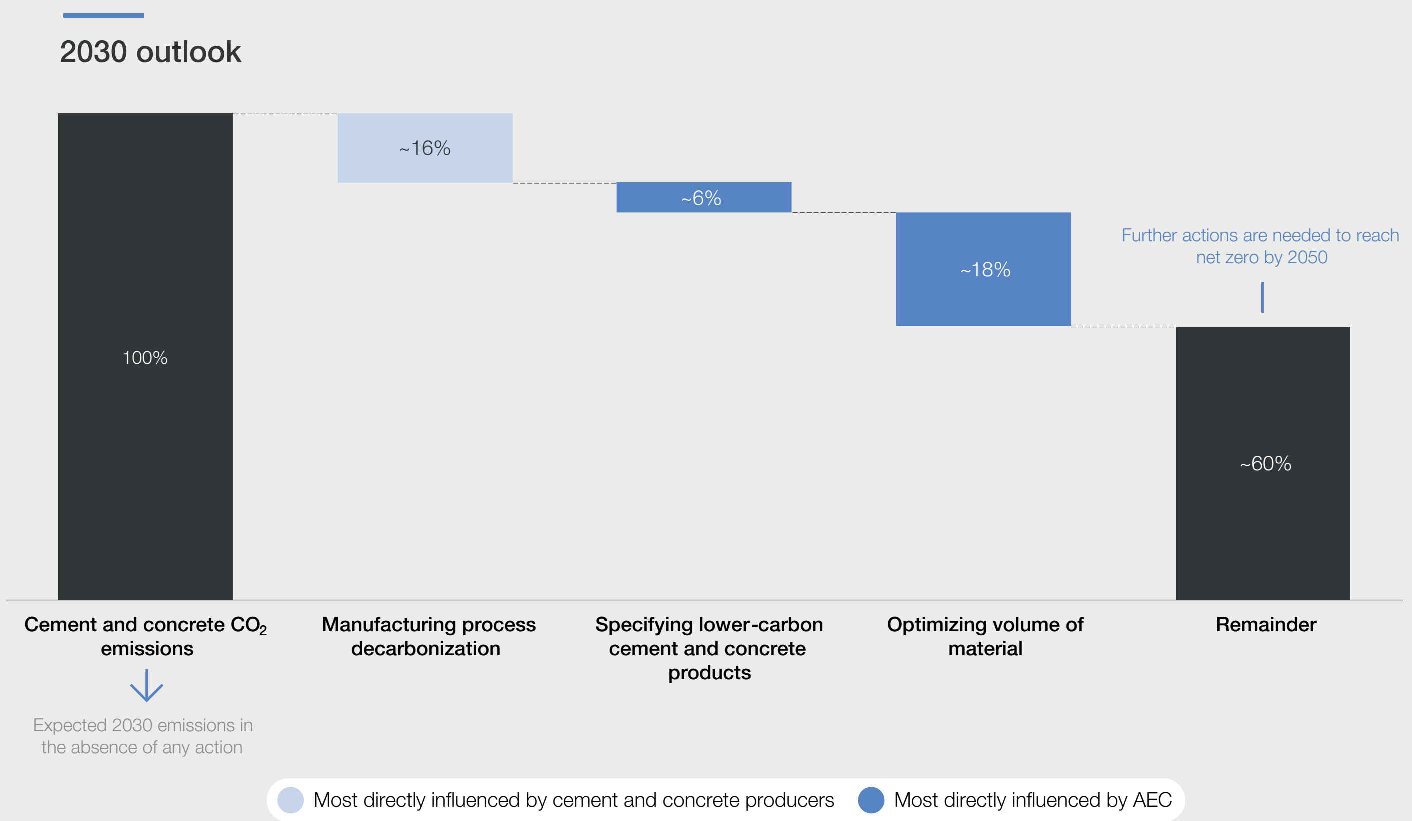
Four important low-carbon design levers include:

1. REDUCING THE CARBON FOOTPRINT OF MATERIALS

Manufacturing process decarbonisation: Several decarbonisation levers can be deployed in the cement manufacturing process that does not affect the properties of the end products other than their global warming potential (GWP, the standard unit of measurement of carbon emissions). Examples include the use of alternative fuels and renewable energy and efficiency improvements. While largely being deployed as first-of-their-kind projects, carbon capture and storage (CCS) technologies are also critical production-side decarbonisation levers. They are needed to decarbonise cement and concrete manufacturing fully. Although these decarbonisation levers fall largely on manufacturers to implement, AEC players can make specifications and purchasing decisions based on the GWP of materials.

Specification of lower-carbon concrete products: Architects and engineers typically specify the materials that should be used in the projects they design, sometimes with input from construction firms and materials producers.

Specifying concrete products with lesser GWP (while meeting technical performance and safety requirements) can significantly affect a project's emissions. The most common product of this type is blended cement, made with supplementary cementitious materials (SCMs), reducing the volume of clinker used. However, the use of SCMs at high percentages typically reduces the strength gain rate of concrete, which can impact construction schedules (and costs) – an element that engineers and construction firms must bear in mind.



Sources: Global Cement and Concrete Association, *Concrete Future – The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete*, 2021; Institution of Civil Engineers, *Low Carbon Concrete Routemap*, 2021; *A Project-Based Comparison Between Reinforced and Post-Tensioned Structures from a Sustainability Perspective*, 2011; University of Wollongong, *Environmental impact assessment of post tensioned and reinforced concrete slab construction*, 2013; BCG analysis.

Figure 4: Low-carbon design can reduce the cement and concrete emissions of construction projects by up to 40% in the near term

Optimisation of material volume: The overall quantity of concrete in a project can be reduced through design choices, such as the spacing and width of slabs and columns and the use of hollow spaces (most frequently applicable in buildings). Additionally, the carbon intensity and quantity of cement can be optimised for lower emissions. For example, using higher-strength concrete, which is often more carbon intensive, sometimes enables the use of lesser volume. These trade-offs have to be assessed on a case-by-case basis. Beyond the design phase, efficient use of cement and concrete during construction can also reduce the volume of material used and the associated carbon footprint.

2. ENABLING THERMAL EFFICIENCY

In many situations, designers can use concrete's high thermal capacity, that is, its ability to store heat, as part of a heating and cooling strategy to reduce operational energy. This is a complex and nuanced consideration as design tactics that incorporate thermal efficiency depend on geography, use, environmental design and other factors.

3. INCREASING STRUCTURAL RESILIENCE AND LONGEVITY

Given the increase in extreme weather events due to climate change, concrete is an especially valuable material since it has inherent properties that enable designers to deliver longevity and resilience with little or no extra materials. Concrete's high density and rigidity make it extremely durable against rain, flooding, humidity, strong winds, freezing, chemicals and other threats. Therefore, concrete can increase the overall lifespan of buildings and infrastructure and minimise repairs and maintenance, delaying or avoiding additional product- and construction-stage emissions.

4. DESIGNING FOR DISASSEMBLY

"Design for disassembly" (DfD) is an approach that uses modular building techniques to allow for reusing materials after building deconstruction. The DfD planning process makes material reuse and returns plans clear early in the design phase to maximise the reuse of elements and avoid waste at the end of life.

The framework described in this report focuses primarily on the first lever: reducing the carbon footprint of materials. This lever has the greatest impact on product stage emissions, representing a meaningful share of overall project emissions (See Figure 1). Moreover, it can make a significant difference in the short term compared to design tactics targeting buildings, infrastructure usage, or end-of-life emissions. In addition, this lever was the highest priority of many of the firms interviewed for this report. Nevertheless, many of the obstacles and solutions presented here also apply to other design decarbonisation levers.

3. OBSTACLES TO SCALING

AEC firms and cement and concrete producers face a series of challenges in delivering low-carbon materials and projects at scale.

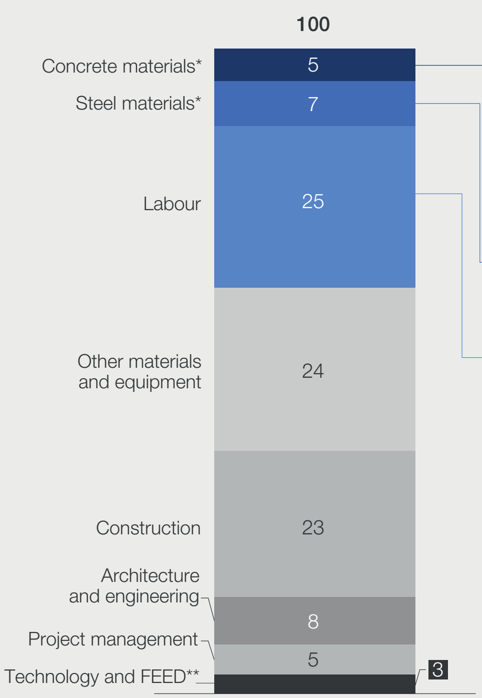
AEC firms are raising various interrelated concerns about the feasibility of implementing low-carbon design and construction approaches – many of which they feel are beyond their control. Although swift action is needed to address carbon emissions from buildings and infrastructure – and proven techniques can have a meaningful impact – low-carbon design strategies are not being used at scale today. The obstacles that remain significant barriers to scaling low-carbon design include:

- **Difficulty in measurement.** Assessing the entire carbon footprint of a project accurately and consistently is hard for many AEC firms because of major capabilities gaps related to technology, data, process and expertise. While software exists to estimate whole life-cycle emissions for entire projects, collecting and refining the data to make these assessments accurate is difficult. Despite concrete having more environmental product declarations (EPDs, which document the emissions of materials) published than any other material, EPDs with sufficient specificity are not always available. In addition, EPD formats and product category rules (PCRs), which define how EPD measures are calculated, can vary by region and materials, making interpretation and comparability of data troublesome. Project-level carbon assessments are typically conducted only when a client or a government demands it, or an AEC firm mandates it. For example, the French government requires carbon assessments for select types of buildings through its RE2020 regulation. However, this is far from a global norm today. Given this lack of consistency in assessing projects and the lack of infrastructure for utilising emissions data, teams are not consistently trained, structured and resourced to measure project emissions – or to use emissions data to inform design decisions.
- **Fragmentation of the design and build process.** Design and construction firms and concrete producers have expressed interest in more upfront collaboration to drive low-carbon outcomes. Still, many are unsure how to achieve this, especially when it is not part of a client's project requirements. AEC firms typically make design and construction decisions in separate stages of projects, with limited

coordination between them. Without a more collaborative approach, decisions made in the initial stages of the project may obviate the low-carbon solutions that can be used in later stages. And they are frequently made without sufficient visibility into local supply chains to understand options for low-carbon materials for the project's construction phase.

- **Established norms and potential risks' potential to hinder innovation.** AEC firms are often reluctant to choose certain techniques and products that would reduce project emissions because they run counter to the industry norm or, in some cases, are not compliant with industry standards and codes. Furthermore, it can be the case that some clients have in-house specifications, and these may not be updated to newer standards that permit certain blended cements and SCMs, as well as lower clinker factors. In other cases, standards and codes do not include newer innovations and less conventional products, such as recycled materials from construction and demolition waste (CDW), in their definitions and frameworks. In addition, testing these techniques and products to prove their safety and durability can be expensive and lengthy, further slowing their adoption.
- **Supply and demand imbalances and uncertainties.** Cement and concrete producers must invest capital in manufacturing lower-carbon materials at scale. Generally, new equipment is needed; older plants must be retrofitted or newer ones built to begin using new fuels or raw materials or to deploy new and innovative technologies. It is a chicken and egg situation: if AEC firms and their clients, as well as policy-makers, don't prioritise the use of low-carbon concrete in buildings and infrastructure projects, many

Example of building cost structure



Example of building project cost implications of low-carbon design

Cost component	No increase scenario	Low estimate scenario +10% material cost +2% labour cost	Medium estimate scenario +25% material cost +5% labour cost	High estimate scenario +50% material cost +10% labour cost
Concrete cost implication	+0%	+0.5%	+1%	+2-3%
Steel cost implication	+0%	+1%	+2%	+3-4%
Labour cost implication	+0%	+0.5%	+1%	+2-3%
Overall cost implication	**+0%**	**+2%**	**+4%**	**+9%**

Concrete and steel are the two materials with the largest carbon footprints in most structures and the focus of many embodied carbon efforts. **Labour costs** can increase due to the rate of strength gain and the complexity implications of low-carbon design.

Source: BCG analysis.
*Includes concrete and steel material costs only. Other labour and material costs typically bundled with concrete and steel (concrete framing, etc.) are included in other categories.
**Front-end engineering design.

Notes: Additional low-carbon opportunities within other categories could have corresponding green premia. Project cost structures vary across projects and geographies.

Figure 5: Example implications of low-carbon design on project costs

manufacturers will be unwilling to allocate capital expenditures for materials production. And until low-carbon cement and concrete products are produced at a greater scale, their availability and cost will be a concern for the industry.

- **Client's failure to prioritise low-carbon design.** Arguably the most significant obstacle impeding AEC firms from adopting low-carbon design is a lack of demand from clients such as real-estate developers, governments and corporations. Achieving low-carbon outcomes requires additional effort, adds complexity and sometimes increases costs. Although this is not always the case, lower carbon materials can be more expensive, and labour costs may rise as more hours are needed to build more complex designs and allow for longer concrete strength-gain rates (see Figure 5 for examples of how product and labour costs could impact project budgets). In the absence of client demand or willingness to pay more for a project, AEC firms often find it prohibitively burdensome to prioritise low-carbon design and construction.

4. SEVEN STEPS TO SCALE LOW-CARBON DESIGN AND CONSTRUCTION WITH CONCRETE

Achieving broad use of low-carbon design principles will require action from across the AEC and cement and concrete manufacturing industries, clients and governments.

Given the obstacles to scaling low-carbon design and construction, a collaborative and concerted effort by key players across the AEC and cement and concrete industries – as well as independent actions within these firms – is needed. To incentivise and enable these activities, the rest of the buildings and infrastructure ecosystem – clients, developers, investors and governments – will also have to support and demand the prioritisation of low-carbon projects. In turn, that will accelerate progress and provide AEC firms with the backing they need to prioritise low-carbon design.

Seven actions from AEC firms, cement and concrete producers and other public and private buildings and infrastructure stakeholders can propel low-carbon design and construction.

1. ADOPT CONSISTENT LIFE-CYCLE EMISSIONS MEASUREMENT.
   Conduct full life-cycle emissions assessments for all projects. Project-level, full life-cycle carbon assessments, using state-of-the-art software, must be conducted and shared with clients to inform responsible design decisions, establish baselines, compare options, create accountability, and in an

Industry
Architecture, engineering, construction, cement and concrete

1 **Adopt consistent life-cycle emissions measurement**
Conduct whole-life-cycle emissions assessments consistently using detailed product-level data (EPDs) to inform responsible design decisions.

2 **Increase collaboration across the value chain**
Engage other players early (e.g. an AEC with cement and concrete producers) to improve supply-chain visibility and understand partner capabilities and constraints.

3 **Reduce risk through piloting, data and engagement**
Increase testing, piloting and tracking of low-carbon solution performance and engage with clients and relevant organizations to update codes and standards.

4 **Evolve the operating model with extensive leadership support**
Prioritize low-carbon solutions, set company targets, measure carbon reduction progress, upskill the organization, and evolve processes and team composition.

5 **Signal demand and scale supply**
Signal demand by committing to specify and procure low-carbon materials and scale supply of low-carbon materials by investing in plants.

Clients
Public and private entities that commission projects and investors

6 **Prioritize carbon reduction in procurement**
Shift selection criteria so that carbon is a key consideration, require emissions assessments and establish project carbon reduction targets.

Governments
National, regional, local

7 **Establish supportive public policy**
Enact policies that accelerate progress and address economic gaps where needed, and update government codes and standards to support use of low-carbon solutions.

Source: BCG and World Economic Forum analysis

Figure 6: A framework for scaling low-carbon design and construction with concrete

ongoing fashion, track progress towards emissions reduction targets. Arup, a global engineering firm, is one example of a firm that has done this, committing to the whole life-cycle measurement of all projects (new and retrofit) beginning in 2022.[5]

Make more specific and widely available EPDs. For project carbon assessments to be most accurate and useful, EPDs (or environmental product declarations) made by materials manufacturers must become more widely available. Generic EPDs that are not manufacturer- or plant-specific can be useful early in the design and engineering process for initial estimates of project-level emissions. But for more accurate and detailed measurements, plant-level EPDs are necessary, particularly given the possible emissions level variations for the same product, depending on the plant at which it was made, among other factors. According to a survey by the National Institute for Environmental Studies, the cost of producing a single EPD can range from $12,500 to over $40,000.[6] Over half comes from preparation efforts; the rest goes towards verification and other fees. At this cost, producing specific EPDs for each product made, not to mention each order, can be prohibitively costly. To achieve the level of granularity in EPDs at a scale that AEC firms are seeking, manufacturers should adopt new digital tools to automate and capture data inputs for EPDs, such as energy sources and raw material components, since manual data collection and preparation is not scalable. This requires cement and concrete manufacturers to make capital investments. Consequently, demand signals from AEC firms and requirements from clients or governments are essential to justify EPD expansion.

Harmonize standards. Considering how important EPDs are to carbon measurement – and how much they can vary by region – efforts are underway to harmonise public category rules (PCRs) and EPD formats to make them more user-friendly. For example, the ECO Platform is a non-profit association that promotes the harmonisation and networking of all existing EPD programmes in Europe. It establishes standards for verification and regular audits to ensure its EPDs are consistent and user-friendly.[7]

Continued support of harmonisation work by the AEC and cement industries can help achieve more accurate and consistent project emissions measurement.

2 INCREASE COLLABORATION ACROSS THE VALUE CHAIN.

Engage partners early. More communication in the project design process between architectural, engineering and construction firms and cement and concrete manufacturers can improve supply chain visibility and ensure that design decisions, specifications and final material selections are made with a clear understanding of the lower-carbon materials available locally. Architecture firm Gensler says it frequently works to identify engineering and construction partners (and their suppliers) as early as possible in the design process so that they can begin a dialogue around the project's carbon footprint.

Greater collaboration also enables firms to become familiar with each other's capabilities and constraints relevant to a given project, enabling more coordinated decision-making and improving potential outcomes. Technology such as building information modelling BIM (building information modelling) software can further enhance this collaboration to improve efficiency and facilitate data exchange.

Build capabilities. To facilitate this level of communication, cement and concrete producers likely need to increase the support they provide to architecture and engineering (A&E) firms. Architects and engineers must understand the detailed characteristics of available low-carbon cement and concrete products (especially newer innovations) and how they can be used in projects. This can be done through a range of measures, such as upskilling existing commercial teams, creating new specialised support roles, and developing content such as fact sheets and videos on low-carbon materials and applications.

Use performance-based specifications. To avoid placing excessive limitations in the design stage on what type of concrete construction firms can use in the building phase, one approach is for A&E firms to craft performance-based specifications for materials. This gives construction partners the freedom to pick from available options that meet the performance criteria rather than be locked into specific blends of cement.

Additionally, A&E firms can also include requirements for EPDs and set GWP (global warming potential) limits in specifications to ensure that the carbon footprint is considered in the material procurement process. For this approach to be successful, construction firms must prioritise low-carbon material selection and be closely connected to the supply chain.

3 REDUCE RISK THROUGH PILOTING, DATA AND ENGAGEMENT.

When an industry or regional standards and codes work against reducing carbon emissions in buildings and infrastructure projects, AEC firms can be proactive in helping to change them. Standards and codes tend to follow the market rather than the reverse – and if companies can demonstrate that other approaches are more beneficial to the environment while achieving the necessary safety and performance requirements, standards bodies and policy-makers are likely to update their standards and codes.

Pilot low-carbon solutions. Risk-appropriate piloting is a way to approach changing standards that have not kept up with current conditions.

AEC firms can identify opportunities to use carbon reduction products and techniques not aligned with the prevailing standards in low-risk environments, such as non-structural applications, assuming that there is sufficient evidence of their safety (either through lab testing or other firms that have piloted them).

Establish performance data. It is important, though, that AEC firms monitor the performance of the pilot programme closely, which is not the norm for most projects – frequently, AEC firms only follow up on project efficacy and results if a problem arises. Further, firms should share the results of their pilots through industry channels and with materials manufacturers to showcase the successes of viable low-carbon solutions, thereby helping to inform future decisions. In part, this can be accomplished through the publication of case studies or the inclusion of application examples on product fact sheets.

Support updates to codes and standards. When sufficient data supports it, AEC firms and cement producers should argue for and encourage updating standards and codes by presenting pilot data to relevant committees in organisations such as the International Organization for Standardization, the European Committee for Standardization, and ASTM International. Often this is a lengthy process, which can be challenging to prioritise since it does not directly generate revenue.

However, this engagement is critical for making progress in reducing carbon in buildings and construction. Additionally, in cases where clients maintain their standards, firms can sometimes directly persuade clients to update such standards or allow exceptions through dialogue about an individual project. Firms can also similarly work with national standardisation entities dedicated to developing national building codes.

Government must play a role. Most often, industry associations maintain standards and codes, and government codes reference those. In such cases, governments should ensure that these codes point to the best-suited industry standards that meet safety and performance needs to allow the use of low-carbon solutions.

Moreover, when government agencies maintain their standards and codes (such as the US states' Departments of Transportation), they must play a more active role in working with industry to ensure that those codes don't unnecessarily impede low-carbon solutions.

4 EVOLVE THE OPERATING MODEL WITH EXTENSIVE LEADERSHIP SUPPORT.

Many AEC firms need to make changes to current operating models, which are typically not designed for the type of collaboration, consistent measurement and project requirements needed to deliver low-carbon projects. These changes will need clear mandates from the highest levels of leadership, championing low-carbon design as a priority.

Set targets and commitments. Once AEC firms have processes to assess project emissions, they can set targets and commit to emissions reduction. Commitments from leadership to prioritise low-carbon design provide organisations with meaningful directives. For example, as part of its Architecture 2030 pledge, global architecture firm Gensler says all design teams will analyse their life-cycle and embodied energy, discuss options with clients, and encourage selecting materials with less embodied energy.[10]

Evolve processes and teams. Targets and commitments are only valuable if project teams have the resources and skills to reach them. The organisational change led by top managers to upskill, recruit relevant talent, improve information-sharing channels and enhance team collaboration is vital.

5 SIGNAL DEMAND AND SCALE SUPPLY.

Commit to specifying and procuring low-carbon products: Increasing market demand for low-carbon concrete and EPDs is imperative to encourage producers to invest in the plant upgrades required to produce these materials and the processes needed to document their emissions levels through EPDs. Construction firms must make commitments to procure low-carbon products. While architecture and engineering firms don't buy materials directly, they can send demand signals through a commitment to low-carbon material specification. Demand signals can also come from low-carbon procurement policies established by project buyers, covered in part 6 of the framework.

Ensure credibility and impact: Low-carbon demand signal initiatives must balance ambition and practicality to be taken seriously and make a tangible difference. That is, they need to be aggressive enough to incentivise manufacturers to change their production processes and meaningfully reduce emissions while staying within reach technologically, logistically and economically so that companies can realistically agree to make low-carbon commitments.

Equally essential is that demand evidence be sensitive to regional variability. Materials availability, economic conditions and regulations diverge globally, impacting local baseline cement and concrete emissions levels and regional activities to reduce carbon.

Invest in scaling supply: Demand signals are, of course, intended to spur action from cement and concrete producers to invest in scaling the supply of low-carbon products. Producers must take action to increase the production of low-carbon materials (and EPDs to verify material emissions), which often requires plant capital investments. In some cases, this will increase material costs (which are expected to come down in the long run with technology advancements and scale). However, in other instances – for example, when using alternative fuels, renewable energy and SCMs – the unit costs

	Architecture and engineering firms	Construction firms	Cement and concrete producers
1 Adopt consistent life-cycle emissions measurement	– Assess whole life-cycle emissions consistently, adopt measurement software and processes, and set baselines for project-level emissions		– Invest in EPD automation
2 Increase collaboration across the value chain	– Identify and engage downstream partners early – Switch to performance-based specifications	– Align with upstream and downstream partners on emissions goals – Select materials optimized for carbon reduction	– Engage upstream to communicate low-carbon solutions
3 Reduce risk through piloting, data and engagement	– Increase participation in industry committees and to update codes and standards – Increase testing, piloting and tracking of new low-carbon solutions in risk-appropriate applications		
4 Evolve the operating model with extensive leadership support	– Set company targets and measure carbon reduction progress – Upskill organizations and evolve processes and team composition to support low-carbon design and measurement	– Train teams and update processes to evaluate carbon emissions in product selection	– Build capabilities to inform and consult with AEC firms about low-carbon products and solutions
5 Signal demand and scale supply	– Send demand signals by setting commitments to specify and procure low-carbon materials		– Invest in plant upgrades to scale production of lower-carbon materials

Figure 7: Actions can be taken across the AEC and cement and concrete production industries

of production will be neutral or even provide savings.

6. PRIORITISE CARBON REDUCTION IN PROCUREMENT.

AEC firms frequently argue that if clients – from both the public and private sectors – would demand, prioritise and be willing to pay for low-carbon design and construction in their project requirements, they would quickly follow their lead and deliver lower-carbon projects. AEC firms note that passing on incremental costs and charging more for low-carbon projects, at least at this early stage, could result in losing jobs to other bidders. And even if AEC firms keep cost increases down, they would expend time and resources altering their operating model – a substantial undertaking that is difficult to gain support for if not explicitly valued by customers.

Adopt green public procurement programmes. Governments account for approximately 25% of construction revenues.[14] Given their potential clout, some governments are moving towards minimising the carbon footprint in projects they procure. To support governments considering such actions, Low-Carbon Concrete & Construction: A Review of Green Public Procurement Programmes, published in 2022, outlines a framework for green public procurement policies. The first step is for governments to require disclosure of emissions, establish baselines and set targets for concrete purchases and construction activities.

Next, they can implement procurement policies, including requirements, scoring systems and incentives to ensure that those targets are reached.[15]

Evolve private procurement practices. Private developers and corporations commissioning projects can also make a difference in reducing the large contribution of buildings and infrastructure to global carbon emissions by prioritising low-carbon design in projects. Indeed, private developers will be increasingly pressured to minimise emissions in concrete and construction by the broad decarbonisation pledges they are making and by the growing number of investors attempting to hold these companies to their commitments. As decarbonisation goals expand and edge closer to their deadlines over the next decades, corporations will need to pull more abatement levers to meet these targets. Some companies are beginning to set specific targets for building projects they are responsible for. For instance, Salesforce has set a goal of an 80% reduction in embodied carbon in its construction efforts by 2030 and net zero by 2050. Real-estate investors such as IPUT and British Land have also set targets of a 40% embodied carbon reduction and 50% whole-life carbon reduction by 2030, respectively.

Another reason for the private sector to consider moving towards low-carbon design is its potential impact on asset values and revenues. Some analyses have shown that buildings that achieve certification in the US achieve 11% higher rents and 21% higher sale values per square foot compared to non-green buildings.[16] Furthermore, many investors speculate that less-green assets will be hit with "brown discounts" in the future. However, it is important to remember that certifications like LEED and analyses of green building asset values tend to consider a broad range of factors, such as water usage and energy efficiency, with embodied carbon playing a relatively small role in the overall assessment. A direct link between low-embodied carbon and its impact on asset values has not been established.

7. ESTABLISH SUPPORTIVE PUBLIC POLICY.

Beyond public procurement policies, standards and codes, governments can take action on national, regional and municipal levels to support the solutions outlined, accelerate progress and reduce economic barriers to low-carbon design as it relates to cement and concrete. These actions can range from wide-reaching, highly impactful measures, such as implementing a carbon price, to directed and more politically neutral measures, such as updating codes.

Examples of supportive policies include:

- **Regulation**: Regulation can be used to require disclosure of carbon emissions or set maximum limits for the embodied and operational carbon footprint of building materials or entire projects. – Example: France's RE2020 policy sets maximum embodied carbon GWP limits per square metre for new residential buildings, offices and schools.17
- **Incentives:** Providing tax credits and direct financial payment can reduce the economic burden of adopting low-carbon design and construction practices. Example: The US and Canada provide tax credits for carbon capture and storage through the Inflation Reduction Act (2022) and the Investment Tax Credit for Carbon Capture, Utilization and Storage, respectively.
- **Funding:** Allocating funds to innovative projects that require large capital expenditures can spur breakthrough low-carbon

innovations. Example: Between 2020 and 2030, the European Commission's Innovation Fund will award €38 billion to low-carbon innovation projects, such as carbon capture and storage or industrial process technologies that reduce emissions.[18]

- **Leadership and guidance:** Spearheading collaboration in areas such as testing and measurement standardisation can help accelerate progress by providing the industry with common definitions and frameworks. Example: The US National Institute of Standards and Technology (NIST) created the Low Carbon Cements and Concretes Consortium to evaluate and develop methods to characterise and quantify carbon in low-carbon cement and concretes.[19]

CONCLUSION

Architects and engineers have a massive opportunity to reduce the carbon footprint of the buildings and infrastructure they design. But they can only do so with the support and collaboration of the clients who commission these structures, the construction firms that build them, the manufacturers that produce the required building materials, and the governments that choose whether and how to regulate and engage in these matters.

Some crucial steps that can be taken to scale low-carbon design are outlined below.

AEC firms:

- Conduct full life-cycle emissions assessments, pilot new low-carbon solutions, and prioritise low-carbon design and construction within their firms, altering the operating model and culture to fit.
- Collaborate and cement and concrete producers to further low-carbon goals.

Cement and concrete producers:

- Increase the support and education provided to AEC firms.
- Invest in EPD production and scaling up the supply of low-carbon materials.

Project buyers (both public and private):

- Prioritise low-carbon designs in their requirements, bid selection and design process.
- Governments:
- Provide leadership to accelerate progress and incentivise the adoption and innovation of low-carbon solutions.

Much can be achieved if participants across the value chain are willing to step up, contribute, and work collaboratively. Now is the time to act. wn

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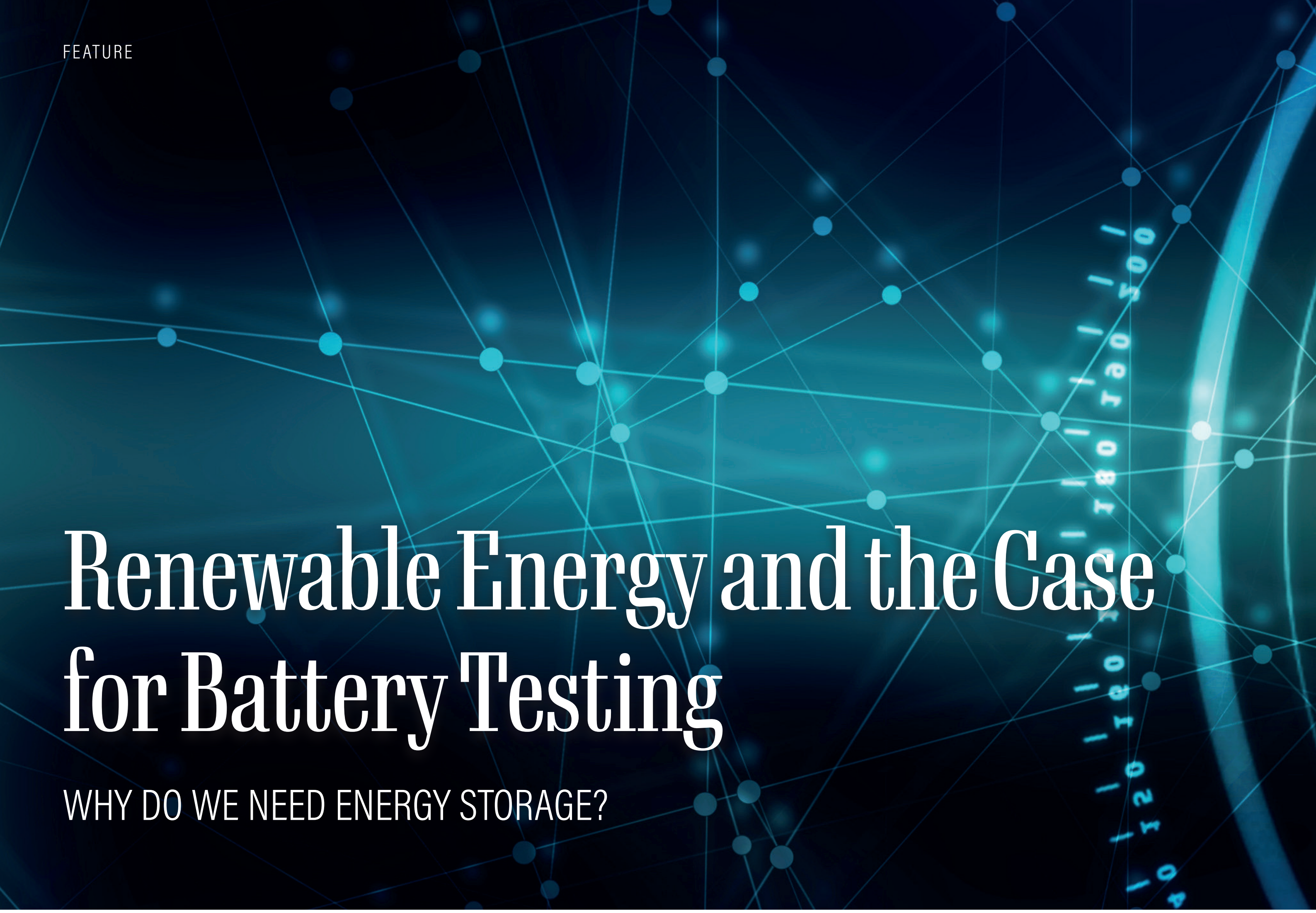

Renewable Energy and the Case for Battery Testing

WHY DO WE NEED ENERGY STORAGE?

Electricity generation in South Africa and worldwide mainly consists of centralised generation. Renewable energy generation has been on the rise recently. However, due to intermittent energy production, it cannot provide a regular supply that can be easily adjustable to network load demands. The solution to this is energy storage.

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Energy storage applications can be used for PV smoothing, which involves storing solar energy generated from PV panels during the day and then dispatching during peak load demands. In UPS (Uninterrupted Power Supply), energy storage can be used as a backup power supply. Energy storage can be deployed with renewable energy production in a decentralised grid arrangement. A scalable application is microgrids.

WHAT ARE SOME ENERGY STORAGE SOLUTIONS?

Numerous energy storage technologies have their characteristics and applications[1], including,

- Batteries
- Flywheels
- Compressed air energy storage (CAES)
- Superconducting Magnetic Energy Storage (SMES)
- Hydrogen storage
- Pumped Hydropower

BATTERIES

In a chemical battery, charging triggers electrochemical reactions that result in the chemical storage of energy from a generator. Reverse chemical reactions allow electricity to leave the battery and return to the grid on demand[1].

The flooded lead-acid battery, utilised for stationary, centralised applications, was the first commercially available battery. The most recent commercially available solution is the valve-regulated lead-acid (VRLA) battery which is spill and leak-proof.

Electric batteries produce direct current (DC) power and store electric energy in electrochemical form. An electrolyte is used to assist ion transfer between

electrode plates, which are typically made of chemically reactive materials. In the oxidation phase of the oxidation-reduction electrochemical reaction, the negative electrode, or anode, "gives up" electrons during discharge.

After that, electrons are sent to the cathode, the positive electrode, for electrochemical reduction. The process is reversed during charging. Battery systems use cells, each of which has a certain operating voltage and maximum current capacity, arranged in different series and parallel array configurations to produce the desired voltage and current. Lead acid, Lithium-ion, Vanadium Redox Flow, and Sodium Sulphur are some common types of batteries.

Lithium-ion batteries dominate in fields such as portable electronics and the electric vehicle market and are close to entering the utility market for grid-energy storage[2]. A lithium-ion battery is constructed by connecting lithium-ion cells in series, parallel, or combined configurations[3].

An electrolyte containing lithium ions connects the cathode (positive electrode) with a typical Li-ion cell's anode (negative electrode). A separator, commonly a microporous polymer membrane, separates the electrodes preventing internal short-circuits and permits the exchange of lithium ions between the two electrodes but not electrons. The electrodes generate heat while operating, which could result in a battery malfunction[4].

Damage to a separator causes the battery processes to switch from regulated to uncontrolled electrochemical reactions, generating a significant amount of heat[5]. In these situations, the electrolyte serves as a fuel source for more heat generation, so it is crucial for proper safety regulations.

WHAT ARE SOME APPLICATIONS OF BATTERIES?

Batteries have a variety of applications that can be implemented, and some areas include residential, microgrids, grid-connected, and electric vehicles.

- **Residential** - In the residential space, when coupled with roof-mounted solar panels, batteries can be implemented to help alleviate grid reliance on daily energy usage. Lead acid batteries may be the most cost-efficient, and lithium, disregarding cost, maybe the best solution for this application.
- **Microgrids** - Microgrid (MG) is a small-scale entity comprising distributed energy resources (DERs)

and supports local power supply stability and sustainable energy consumption. Due to their capacity to store energy during off-peak hours and deliver energy during peak hours, the MG paradigm or renewable energy technologies integrated with energy storage to resolve the intermittency of power generation, have grown in popularity[6]. Flow and Lithium batteries may be the most suitable for this application.

- **Grid-connected** - When distributed generation is integrated with the electricity grid, quick frequency management, load tracking, and ramp services can be provided without using fossil fuels thanks to energy storage solutions like batteries[7]. Lithium batteries are the solution when considering energy storage for grid applications in terms of energy density and efficiency. The main applications include peak shaving and energy arbitrage.
- **Electric Vehicles** - High-income countries (HICs') electric vehicles (EVs) have several factors in common: They are perceived as high-quality, mass-produced private passenger cars that are used in cities, supported by government subsidies, and introduced in the assurance that there will be sufficient generation to meet the demand they create[8]. There are three main reasons why HIC approaches to vehicle electrification should not be implemented in Sub-Saharan Africa (SSA) based on comparisons between these characteristics and the region's context:
  - The mobility patterns and vehicle characteristics of the transportation systems
  - Unreliable electricity generation systems
  - The availability of capital

Most of the population in SSA use paratransit, a method of on-demand, privately run public transportation[10]. In SSA cities, 50-90% of trips are made using paratransit vehicles[11]. In contrast to HICs, SSA has a much lower capital availability. HIC purchases and uses most vehicles due to a lack of funding. Around 60% of annual registrations in Africa are for second-hand cars[12]. And lastly, many SSA nations have inadequate and unstable electricity systems[13]. Rolling blackouts are commonplace, even in South Africa, one of the wealthier SSA nations. Power is assumed to be accessible in HICs when required, and the same cannot be said for SSA nations. The electric grid and transportation electrification must be developed simultaneously.

None of those mentioned considerations rules out the implementation of EVs in SSA. Still, they explain their historically low adoption in this region[4] and highlight the necessity for novel strategies created with the context in mind. EVs may help SSA in ways beyond anticipated with appropriate adoption, such as implementation in public transportation. EVs which are already excelling in South Africa, are delivery E-bikes. Pathway Cycles/ViziCube have integrated into UBEREats, BoltFood, and KFC in Cape Town and expect an annual profit of over R 69.7 M by 2024[14].

WHAT ARE SOME SAFETY ISSUES REGARDING LITHIUM-ION BATTERIES?

Battery heat cannot be eliminated even under typical working conditions, especially on hot days or in a large battery pack[15]. This increase in battery temperature can trigger parasitic reactions leading to thermal runaway[16]. Thermal runaway will occur more rapidly in cases with mechanical damage, such as compression, punching, and twisting of cells; electrical damage, such as overcharge and short circuit; and thermal abuse, such as thermal shock and local heating during accidents.

WHAT ARE SOME STRATEGIES TO IMPROVE LITHIUM-ION BATTERY SAFETY?

A cooling system to control the system temperature is essential for maintaining an optimal battery temperature of 15-35 ˚C, prolonging battery life and reducing costs[17]. A typical battery thermal management system includes air-based, liquid-based, phase-change material-based, and heat pipe-based cooling systems[18].

WHAT ARE SOME LITHIUM-ION BATTERY SAFETY STANDARDS?

Lithium-ion battery safety standards ensure that the components meet a specific safety criterion. Most countries have developed safety standards as follows:

- Chinese standard GB/T 31,485[19]
- Society of Automotive Engineers (SAE) standard 2464[20]
- International Electrotechnical Commission (IEC) standard IEC62133 Edition 2.0[21] and (IEC) 62619[22]
- United Nations (UN) standard UN38.3[23]
- Japanese Industrial Standard (JIS) C8714[24]
- Underwriters Laboratories (UL) standard UL2580 Edition 2.0[25]
- International Standardization Organization (ISO) standard ISO 16750–2[26]

WHAT ARE SOME LITHIUM-ION BATTERY TESTS?

There are several types of battery tests as follows[25]:

- Electrical Performance
- Battery lifetime and ageing
- Heating
- Short-circuit
- Overcharge
- Over-discharge
- Nail penetration

Tests are performed before the batteries enter the market as follows[25]:

Electrochemistry performance: Overcharge and over-discharge, high- and low-temperature discharge, external short circuit, and forced discharge.

Mechanical properties: Drop, heavy impact, nail penetration, shake and squeeze, acceleration, and crush.

Thermal performance: Heating, thermal shock, and spark

Surroundings: Low pressure, high altitude, and soaking

BATTERY TESTING

Battery testing enables new storage solutions to make their way to the market and allows for the validation of existing battery technologies. Through testing, battery use can be optimised. This can be seen in vehicle batteries which consist of 18650 batteries. At a certain point, a cell in an EV battery pack will become unsafe and unusable in an EV. It is at this point the cell is often discarded. Testing will determine whether this cell may be used in an electric bicycle.

NON-DESTRUCTIVE TESTING

Performance and reliability testing

Battery performance testing refers to the electrical testing of battery packs, modules, and cells with the addition of thermal and environmental conditioning. Evidence regarding the effects of these conditions on your battery, such as the impact of mechanical stresses brought on by thermal or electrical loads, can be gathered by simulating a variety of external influences in special testing chambers, such as climatic conditions, including arctic temperatures and humid tropical climates.

Battery calendar life

A battery's calendar life is when it may be kept idle or unused, and its capacity exceeds 80% of its initial value. The state of charge (SOC) at which a battery is stored impacts the battery's calendar life. The storage temperature of the batteries also impacts it. High temperatures reduce the calendar life of the battery.

Storage capacity

Batteries are manufactured to provide current for a specific period (Ah). The capacity test, also known as the discharge test, can accurately measure the battery's true capacity.

Cycle life

Cycle testing is a process that determines how long a battery will survive by completely draining the battery and then recharging it in the same way. This determines whether the battery capacity remains robust and sturdy or drops below 80% of its typical operation.

Depth of discharge

The amount of energy that can be processed in and out of the battery during a cycle is called the depth of discharge. Typically, it is stated as a percentage of the battery's overall capacity. The battery's lifespan will be shortened by repeated charging and discharge. Lithium batteries have the highest DoD ranging from 80-100% depending on the chemistry.

Verification and validation

Manufacturers of battery technologies often provide a datasheet together with their products. This normally includes the min/max voltage and current and other useful information. The battery is tested by charging and discharging according to the voltages and current to verify and validate the manufacturer's datasheet. This is a good method to resolve any unforeseen issues that may occur while charging and discharging the battery.

Aged Battery services

A cell defect occurs in the last stage of battery ageing, such as a cell becoming short-circuited. A battery is often worn out when it has lost over 50% of its initial capacity. However, different thresholds can be established by a particular application.

Battery Aftermarket services

Batteries, in general, need to be replaced or upgraded after some use. What happens to second-life batteries can improve their viability, especially when recycling and re-purposing. For example, second-life EV batteries may be implemented for grid support[27].

Post-mortem analysis (Part of root cause analysis)

There are several steps involved in the post-mortem analysis of a battery which includes pre-inspection, discharge to end-of-discharge voltage, transfer to a controlled environment, cell opening, separation of components, and physio-chemical analysis[28].

DESTRUCTIVE TESTING

Non-Destructive tests, such as performance or ageing tests, are always done within the batteries' specifications (within the "Safe Operating Area"). Violating the specifications is considered a destructive test.

Destructive testing of lithium metal oxide and lithium metal phosphate cells

The battery cells placed in the test chamber are subjected to three harsh circumstances that might cause electrical and physical failures, namely overcharge, thermal, and combined thermal overcharge stress. These abusive techniques put the battery in a charged or ambient state outside of its intended operating range, causing the cells to heat up and experience high internal pressures. Internal battery components continue to deteriorate under conditions of rising pressure and temperature inside the cell, which is characterised by thermal runaway[29, 30].

In a current-controlled power supply mode of operation, overcharge tests are conducted. As long as the battery is in a closed loop, the power supply regulates the output current to a constant value in this mode[31]. The power supply is automatically increased to a maximum value of 12 V and maintained in the case of an internal battery failure or the activation of internal safety systems that cause a refusal to charge. Charge rates are kept significantly closer to manufacturer specifications because initial testing at high charge rates did not result in any physical cell breakdown, just activation of the intended Current Interrupt Devices (CID).

Thermal failure tests, in contrast, require manual control, and heating will proceed even if the batteries' electrical system fails. The heat output can be modified by changing the voltage. When the visual venting of gases from the cells has stopped[32], which can be viewed by real-time security camera footage, individual testing is finished.

Combination tests utilise both previous tests simultaneously. Based on factors related to the failure technique being evaluated, operator observations of real-time data and images are used to determine battery failures. Physical cell failure brought on by thermal runaway is anticipated by the elevation of the cell's surface temperature, and data recording continues after a cell failure[33].

Countless tests can be performed, and a few include[34]:

- Casing:
  Strength, rigidity, and flammability
  Venting/Insulation
  No leakage, explosion, or fire risk
- Protection from:
  Short circuit
  Over-charge/discharge
  High/low temperature
- Mechanical tests:
  Crush tests
  Nail penetration tests
  Shock/impact test
- Environmental tests:
  Heating
  Humidity
  Exposure to fire

FLYWHEEL

A flywheel is a spinning mass composed of composite or steel secured inside a vessel with low ambient pressure. The low pressure maintains the momentum of the spinning mass and generates electricity for longer periods[35]. The flywheel stores energy in a rotating mass, and depending on the inertia and speed of the rotational mass, kinetic energy is produced and stored as rotational energy. The flywheel is encased in a vacuum containment to eliminate any energy loss caused by friction. To ensure stable functioning, it is additionally hung by bearings[36]. It is mainly used for short-period UPS and frequency regulation on city level.

COMPRESSED AIR ENERGY STORAGE (CAES)

The basic gas turbine (GT) technology is modified by CAES, which uses inexpensive energy to store compressed air in a subterranean cavern. In a gas turbine, the air is heated and expanded to produce energy during peak demand periods. CAES is widely accessible and reliable because it is a derivative of GT technology. CAES is one of the utility-scale technologies with the best economic viability that could help develop a flexible energy system that makes greater use of varying renewable energy sources[37]. Nevertheless, few spots may need a favourable underground for large caverns.

SUPERCONDUCTING MAGNETIC ENERGY STORAGE (SMES)

The SMES is a coil that superconducts at cryogenic temperatures, meaning its operating ohmic losses will be almost zero. This energy storage device has rapid charge and discharge times, allowing it to absorb or distribute large amounts of electricity[38]. The coil of this system has a long life cycle because it can withstand tens of thousands of charging cycles resulting in decades of operation[37]. To achieve a superconducting state, the coil must reach temperatures less than 9.8 K[39]. Liquid helium is used to lower the temperature to 4.2 K. Although the necessity for cooling reduces efficiency, the power required for cooling is far lower than the SMES's output power[40]. The efficiency can reach 90% when combined with ohmic losses in non-superconducting devices[41].

Due to its high discharge rate, energy density, and efficiency, SMEs are crucial technologies to include in modern energy grids and green energy initiatives. Control, emergency, and power supply systems are three primary applications[42].

HYDROGEN STORAGE

The cleanest fuel is hydrogen, which has a heating value three times greater than petroleum. Since hydrogen is a fuel produced artificially rather than from a natural source, its price is three times greater than that of petroleum fuels[43]. Compression, liquefaction, physisorption, metallic hydrides, and complex hydrides are the hydrogen storage techniques. Compression is the simplest way to store hydrogen in a pressure cylinder under 20 MPa.

PUMPED HYDROPOWER

Utility-scale energy storage using the well-established and commercially-acceptable pumped hydro energy storage (PHES) technology has been practised since the 1890s[44]. Water that is pumped from a lower reservoir to a higher reservoir and then stored as potential energy is known as pumped hydroelectric energy storage. This system pumps water from the lower to higher reservoirs by using off-peak, inexpensive electricity or renewable energy from solar or wind farms. The stored water is then released through hydro turbines to meet peak demand requirements.

South Africa already has four pumped-storage schemes, namely,

- Ingula Pumped-Storage Scheme
- Drakensberg Pumped-Storage Scheme
- Palmiet Pumped-Storage Scheme
- Steenbras Pumped-Storage

Notably, Ingula and Drakensberg provide additional grid support through frequency control. These power stations also possess black start capability.

Renewable energy adoption is accelerating. There are numerous energy storage technologies for various applications. The selection of the energy storage type depends on the application. Different entities in South Africa, such uYilo and the CSIR, assist in research and testing in this respect as good entities worldwide, such as VITO (dutch: Vlaamse Instelling voor Technologisch Onderzoek) in Belgium.

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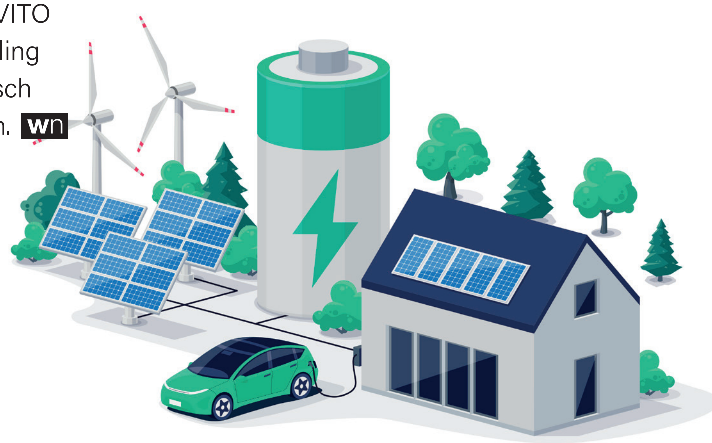

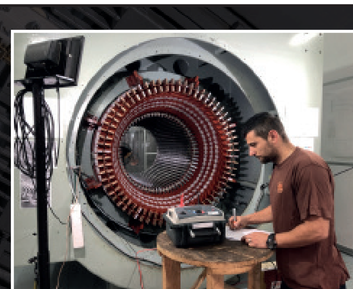

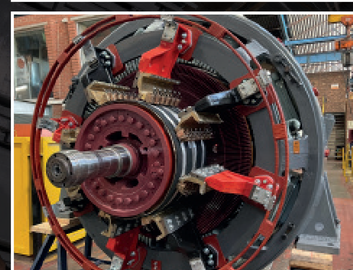

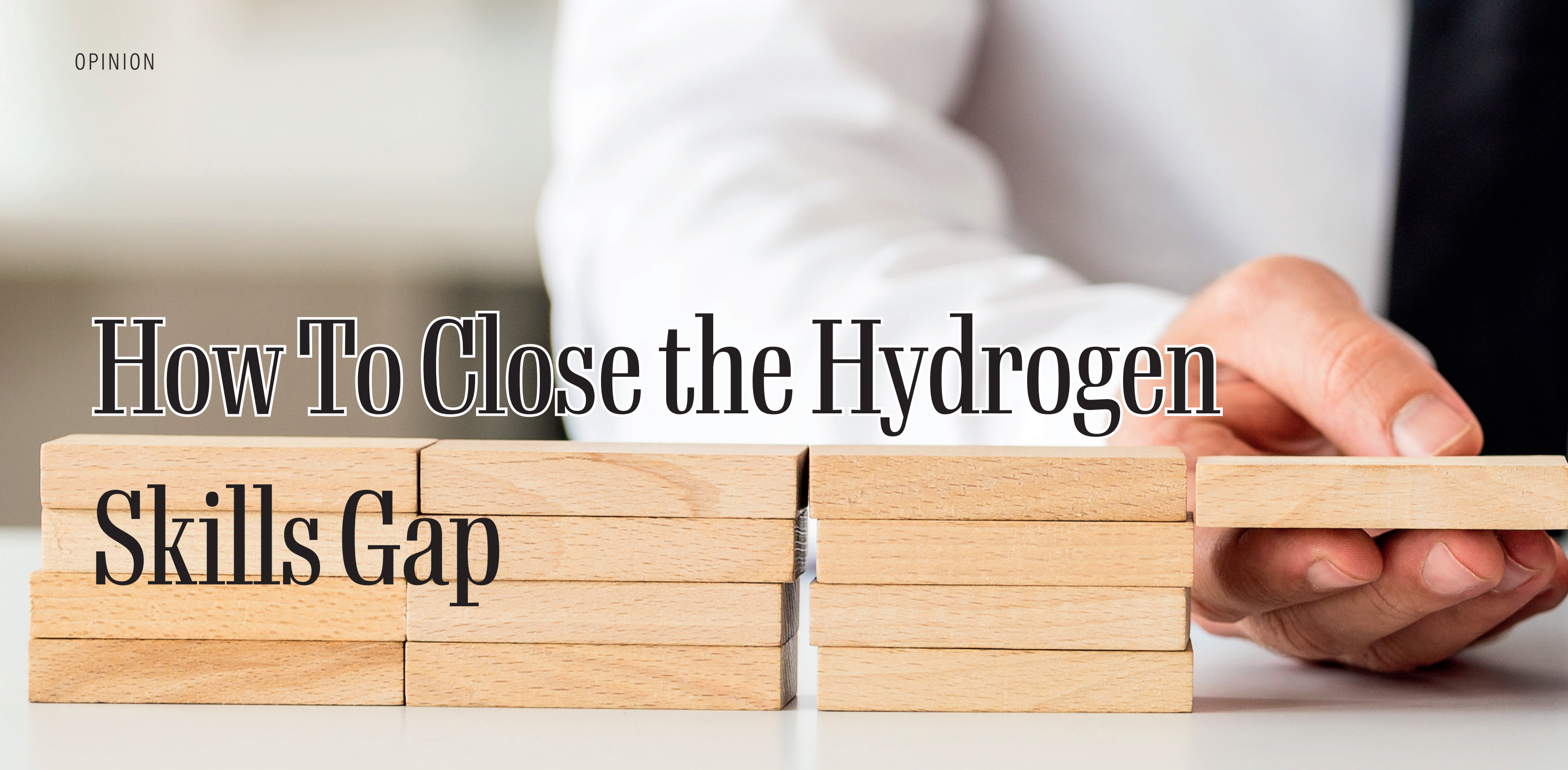

How To Close the Hydrogen Skills Gap

In 2016, South Africa signed the Paris Agreement on climate change at the United Nations in New York. Signing the agreement meant that the country is committed to reducing greenhouse gas emissions and collaborating with the global community to reduce global temperatures below two (2) degrees Celsius. The country's problem is how best to accelerate the reduction of carbon emissions to meet its commitments to the Paris Agreement.

By: By Yershen Pillay

One way of accelerating the reduction of carbon emissions is using green hydrogen as a zero-emissions energy carrier. In 2021, the International Energy Agency (IEA) declared that hydrogen would be an essential energy source for reducing carbon emissions. According to a recent report by the Hydrogen Council in collaboration with McKinsey & Company, 40 countries have developed national hydrogen strategies to tap into hydrogen's potential to decarbonise, and the industry has announced 680 hydrogen project proposals as of the end of May 2022.

However, the emerging green hydrogen industry is facing a multitude of challenges. One significant challenge is the skills needs and training for a hydrogen-ready workforce. This pertains to both current and future skills needs and training requirements. A recent study on reskilling the green hydrogen economy found that 80% of industry employees would require new hydrogen skills and further education about electrolysers, fuel cells, hydrogen storage, and future refuelling stations. The lack of skills development and training is the biggest challenge to growing South Africa's hydrogen economy. It's not just accessibility to hydrogen training that poses a challenge, but receiving the education and skills to meet industry needs.

We need to plan for the future growth and expansion of hydrogen energy. The main barriers to closing the hydrogen skills gap in South Africa are a lack of expertise, funding, and a lack of training facilities and equipment such as electrolyser simulators. For this reason, more must be done to develop South Africa's education infrastructure and physical infrastructure to support current and future demand. If we cannot develop this infrastructure in the next five years, we may miss the opportunity to be a leader in this rapidly growing industry.

In the future, a more comprehensive assessment of skills requirements will be needed. The current desktop modelling places a greater emphasis on engineering qualifications, with extraordinarily little attention paid to occupational qualifications. Hydrogen safety training has been less of a priority, yet safety skills programmes will be vital

to hydrogen education. Hydrogen can be an extremely dangerous gas to work with as it is highly flammable; hence, appropriate training is essential.

In attempting to close the hydrogen skills and training gaps in South Africa, research by the Chemical Industries Education and Training Authority (CHIETA) has identified 17 specific training and skills requirements. Approximately 14 000 jobs are likely to be created, including hydrogen systems engineers, technicians, gas fitters, and other associated trades and services.

The technical and regulatory uncertainties in South Africa provide a major challenge for effective skills planning. For this reason, leadership must be provided to enable policy and regulatory changes. The education sector needs to work more closely with the industry for collaborative skills planning and the co-creation of future training courses and learning materials. What is needed is more cross-sector collaboration and research development by engaging with industries such as transport, mining, manufacturing, energy, infrastructure, and agriculture.

South Africa lacks cross-sector collaboration to support skills development and training on green hydrogen. Cross-sector collaboration and joint skills planning between the government, the private sector, and training authorities should be an apex priority for a hydrogen-ready workforce. Without cross-sector collaboration, a fragmented and piecemeal training landscape may evolve in which all hydrogen training is expensive, exclusive, and inaccessible.

Digital skills are the foundation for hydrogen skills. For this reason, South Africa needs to prioritise digital literacy skills programmes. A coherent digital literacy skills curriculum is required for hydrogen education. To this end, CHIETA has prioritised digital literacy skills by launching SMART Skills Centres nationwide. CHIETA SMART Skills Centres provide free digital literacy skills programmes, including experiential learning using virtual reality technology for certain occupations. This first-of-its-kind SMART centre in Saldanha Bay has been open to the public since the 1st of February this year. Eight new centres are planned over the next two years.

The biggest risk facing South Africa is the inability to seize the moment and implement green hydrogen at scale because of the lack of adequate skills and appropriate expertise. Mitigating this risk and closing the hydrogen skills gap in South Africa requires a multipronged strategy that includes better coordination from the government, cross-sector collaboration with industry, digital literacy programmes, and specialised training on electrolysers, fuel cells, and hydrogen systems. The relevant expertise must be sourced to develop and deliver the training the industry requires. The country needs an explosion of training to become a leader in the global hydrogen economy. wn

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