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THE FUTURE OF WORK

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RENEWABLES

SAIEE

THE OFFICIAL PUBLICATION OF THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS | MAY 2021

WHO WE ARE...

PROF SUNIL MAHARAJ
2021 SAIEE President

PRINCE MOYO
Deputy President

PROF JAN DE KOCK
Senior Vice President

PASCAL MOTSOASELE
Junior Vice President

SY GOURRAH
Immediate Past President

STAN BRIDGENS
Honorary Treasurer

COLLIN MATLALA
Honorary Vice President

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SAIEE

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Dear Valued Reader

This issue focuses on Renewable Energy.

The generation of hydropower, a renewable energy source, is not complex; however, making the generation process efficient and cost-effective is the real challenge. Read more about it in our first feature article, on page 28.

Our second feature article, "How Floatovoltaics might reshape the renewable energy industry", discusses how co-location is a growing trend within the energy industry, with sources such as wind, solar, geothermal and battery storage solutions being joined to optimise power generation. Read it on page 38.

Page 48 gives you an insight into why 2020 was the best year in history for the global wind industry showing year-over-year (YoY) growth of 53%. Installing more than 93 GW of wind power in a challenging year with disruption to both the global supply chain and project construction has demonstrated the incredible resilience of the wind industry.

Dudley Basson shares a global overview on "A surge of Wind Power. Read it on page 58.

The SAIEE has inaugurated a new President and Office Bearers as well as Council Members. Please read through the President's inaugural article on page 6, or watch the video here.

Herewith the May issue. Enjoy the read!

Minx

SAIEE Coffee table book

In 2001 the SAIEE published a coffee table book titled "Sparkling Achievements". The book was compiled and edited by Michael Crouch, a Past President of the Institute and published for the SAIEE by Chris van Rensburg (Pty) Ltd.

This first book surveyed Electrical Engineering in South Africa and included material from 43 local organisations. The second edition's objective is to include new companies and their history and achievements during the past two decades from 2001 to 2021.

Second Edition

Work contacting organisations started in February 2019 and went well until the onset of the Covid 19 pandemic, after which it gradually became challenging to entice companies to participate. Numerous companies had retrenched staff and were in serious financial difficulties. However, we eventually gathered together sufficient material to make the book viable.

One of the most outstanding inputs is from the Square Kilometre Array (SKA) Radio Telescope organisation in the Western Cape. All inputs are exciting, and we feel confident that the book will be an outstanding success.

This softcover book will be available at R350 (incl. VAT) from the Institute and uploaded onto the SAIEE website. The book will be ideal to grace the company entrance foyer and CEO's office and will go to press during April 2021. The cover of the book is shown here.

To order your book, please contact Dudu Madondo either via email: reception@saiee.org.za or contact her on 011 487 3003.

PROF SUNIL MAHARAJ 2021 SAIEE PRESIDENT

The Dean of the University of Pretoria's Faculty of Engineering, Built Environment and Information Technology, Prof Sunil Maharaj, delivered his inaugural address as President of the South African Institute of Electrical Engineers (SAIEE) for 2021/22 via a virtual webinar held on 31 March 2021. The topic of his address was "The future of work".

Prof Maharaj, who has been a member of SAIEE for the past 25 years, is also a Fellow of the South African Academy of Engineering and was the founding chair of the South African section of the Institute of Electrical and Electronics Engineers (IEEE) Vehicular Technology Society Chapter. He is the first African Dean to be elected as chair to the Global Engineering Dean's Council, a position he will assume for two years from November 2021.

His address, which focused on the disruptive trends that are emerging in the workplace and the impact of new technologies on society, was particularly pertinent given the present digital transformation that is being experienced worldwide. With the advent of the Fourth Industrial Revolution (4IR), the world as we know it has altered fundamentally. This digital transformation has triggered essential changes to the way we live, work, socialise and study, and has been exacerbated by COVID-19.

The future of work is a topic of growing concern for industry, academics, scholars, leaders and unions throughout the world. Technological transitions have seen the conception of robotics, artificial intelligence (AI), drones, the internet of things and virtual reality – all of which are taking over the workplace at a rapid rate. These changes raise important questions about job security and the skills required for future employment in the 4IR and beyond.

In contemplating the nature of work and the workplace of the future, Prof Maharaj considered the primary skills required for the future of work, and the impact of automation and digital transformation on employment prospects. He considered the skills identified by the World Economic Forum (WEF) as being essential for the world beyond the 4IR against both a global and a South African perspective. He highlighted the fact that "technology is the catalyst to change in the workplace, but humans are the sustaining force behind the machines". Skills like leadership, deliberation and debate, conflict resolution and ethical considerations for decision making will be vital for companies to thrive in the future.

As the COVID-19 pandemic drives profound societal and organisational shifts, leaders have the opportunity to return to work by designing the future of work, building on the lessons and practices of their organisations executed during this time. This crisis has presented a unique opportunity for organisations to overcome the instinct of viewing man and machine as equals, but instead to build connections that can pave the way forward.

The future of work

SAIEE PRESIDENTIAL ADDRESS

"COVID-19 has challenged business leaders to do three things at once: stage the return to work, understand and leverage the advancements they enacted during the crisis, and channel a new path forward," he said.

According to a study that assessed countries' readiness for automation in terms of their innovation environment, as well as education and labour market policies, South Africa fared relatively poorly in comparison to Germany, France and the UK. An action plan is required by government, business and individuals to address this deficiency. Government should embrace digitisation, invest in human capital and mitigate the impact of automation on jobs. Business should rethink its strategies, upgrade workforce planning and reskilling, and embrace new ways of working. Individuals should focus on skills (not just qualifications), embrace lifelong learning and find opportunities for entrepreneurs. Careers should built around learning instead of around jobs.

The expectation, according to the WEF's 2020 report, is that 85 million jobs may be displaced by the shift in the division of labour between man and machine by 2025, while 97 million new roles may emerge globally. From a South African perspective, although the impact of digital transformation is disruptive, it presents enormous opportunities to rekindle throughput, income and fiscal growth. It also has the potential to create millions of high-quality jobs, improve operational efficiency and help deliver better outcomes for businesses and the public, while addressing the triple challenge of unemployment, poverty and inequality.

Prof Maharaj concluded his address stating that, although there is ongoing debate about the changing face of the workplace, there is a clear consensus that these changes are fundamental and evident. Organisations should strategise their employment policies to accommodate the changing world of work, bearing in mind the expectations and needs of a diverse workforce.

To survive in the future world of work, we not only need to embrace digital transformation, but also develop cross-disciplinary skills, such as engineering combined with data science, and embrace diversity and cultural interaction in the workplace. This can enable us to continually upskill and reskill ourselves to adapt to the changing workplace of the future.

The SAIEE, with a membership of more than 6 000 professionals, is ideally placed to make a distinct contribution to the worker, workplace and future of work in South Africa and beyond. wn

WATCH THE REVISED RECORDING HERE

Prof S Maharaj | SAIEE President 2021
Pr. Eng | FSAIEE

The SAIEE announced the

2021 Office Bearers

DEPUTY PRESIDENT PRINCE MOYO

Prince Moyo (FSAIEE) joined the SAIEE in 1996.

His academic qualifications include an MBL, 2015 (Unisa); MSc Eng (2001), GDE (2000) [Wits]; BSc Eng Hons (1993) (Univ Zimbabwe) and has 24 years work experience.

Prince specialises in the specification of all low voltage and high voltage AC and DC equipment up to 765 kV. His team comprises of ± 420 engineers, technologists and technicians. His key experiences include rural electrification designs, distribution project portfolio of R1,7 BN annually and reviewing maintenance strategies for all asset classes.

Prince is actively involved as an SAIEE Council Member and is the Chairman for the Cigre SANC.

SENIOR VICE PRESIDENT PROF JAN DE KOCK

Prof de Kock (FSAIEE) has served on council for the last four years. He became an SAIEE Member in 1986.

Jan de Kock received his B Eng, M Eng and PhD in electrical engineering from Stellenbosch University. He is a registered Professional Engineer in the South Africa.
In 2001 he was appointed Professor in Electrical Engineering at North-West University. From 2005 to 2015 he was the Director of the School of Electrical Engineering and has previously acted as Dean of Engineering for 14 months. He has taught power electronics, electrical machines and final year project to undergraduate students, and advanced protection and power system dynamics courses to postgraduate students. Since January 2016 he has returned to being a lecturer and researcher within the School of Electrical Engineering.

JUNIOR VICE PRESIDENT PASCAL MOTSOASELE

Pascal is a Fellow of the Institute, and has been a member for 22 years. He is a member of Council for 5 consecutive years, and an Exco member for 3 consecutive years. Previously he served as Chair of Events & Marketing Committee, and Chair of the Power & Energy Section. He is the Institute's Engineer of the Year 2018. Pascal is a Consultant Engineer and currently the Acting Automation Asset Manager at Rand Water's Strategic Asset Management division. His academic qualifications include a BSc(Eng) degree from University of Cape Town, MEng degree from Wits University, an Innovation Management Development Programme (IMDP) from the Da Vinci Institute for Technology Management, the Management Advancement Programme (MAP) from the Wits Business School (WBS), and is currently enrolled for the MBA with Unicaf University.

IMMEDIATE PAST PRESIDENT SY GOURRAH

Sy Gourrah has been part of the energy industry in South Africa for over 25 years. She started her career as a Consultant and later was appointed as the City Electrical Engineer for East London. With more than two decades of experience as an electrical engineer, Sy achieved numerous qualifications including a Bachelor in Engineering (Electrical & Electronics), Masters in Business Administration and Government Certificate of Competency. Currently, she is the Business Development Specialist for Transmission & Distribution & EPC within Actom.

Sy served as the Association of Municipal Utilities (AMEU) President from 2008 to 2010 and served on the executive council until 2011. She was the first female president of the AMEU.

TREASURER STAN BRIDGENS

Stan Bridgens (FSAIEE) became a member in 1963 and served as SAIEE President in 1998. He served the SAIEE as CEO from 2007 - 2018.

He started his career as an Apprentice at the Johannesburg City Council in 1958. He worked his way up to Director: Technical Service for Johannesburg Electricity. From 1995 to 2000 he worked as Executive Officer: Technical Support at the Metropolitan Electricity. From June 2000 to 2005 he managed the Khanya Project at City Power as Programme Manager. During this time he continued to represent the Engineering Council of SA in the forums created by the Department of Minerals and Energy regarding the National Restructuring of the Electricity Distribution Industry. In 2019 Stan received the SAIEE President's Award for his excellent service and contribution to the Engineering Fraternity.

HONORARY VICE PRESIDENT COLLIN MATLALA

Collin Matlala started his engineering career in 1976. Collin's engineering experience includes Telecommunications, Railway Signalling, Automatic Fare Collection, Security Systems and Power Systems. He is a Fellow of the SAIEE, Fellow of South African Academy of Engineers, Member of Institute of Railway Signal Engineers and Member of Institute of Directors in Southern Africa.

Collin is a professional engineer registered with the Engineering Council of South Africa. Collin's qualifications include MBA from Wits Business School, M. Sc in Electrical and Computer Engineering from University of California, B. Sc in Electrical Engineering from Wits University and B. Sc in Maths and Physics from University of the North.

SAIEE INAUGURATES 2021 SAIEE PRESIDENT

The 25th of March saw the SAIEE inaugurating a new SAIEE President and electing its 2021 Council members at the Annual General Meeting.

Mrs Sy Gourrah, 2020 SAIEE President, said: "The 2020 AGM and the year that followed was an unprecedented year as it was a year of a global pandemic, a year of adversities and the restrictions of physical contact had forced us to transform digitally immediately."

The SAIEE, like many companies, had to reinvent itself in going digitally, and we produce weekly webinars and offer online CPD Training Courses.

To stay in contact with our members, the SAIEE had also reinvented itself by not circulating more than 600 000 emails just in September, but to condense the weekly newsletter into a Chronicle sent to members twice weekly. This is to keep our members informed of upcoming events, i.e. webinars, CPD training courses, vacancies and industry news. This was well received.

The Chronicle is sent to members every Tuesday and Thursday. If you want to share industry news to our members, then sent an email to chronicle@saiee.org.za.

The SAIEE wanted to attract new members and have in 2020 launched a few chapters and interests groups. These are:

- Nuclear Chapter
- Energy Storage Chapter
- Cybersecurity Chapter
- Computing Chapter
- Control & Automation Chapter
- Railway Chapter
- Women in Engineering Chapter
- Asset Management; and
- Entrepreneurship & Innovation

These chapters were launched online and offer at least one webinar per month.

With the inauguration of Prof Sunil Maharaj as the 2021 SAIEE President, he said, "Sy, I thank you for your stellar work during your presidency. I know that you are not a virtual person, but your whole year as the SAIEE President was a virtual event. All our meetings took place online, and we didn't have an opportunity to meet physically. Thank you, and I hope that you will continue being productive within Council and the various committees to take the SAIEE forward in this 'new-normal'."

Prof Sunil introduced the 2021 SAIEE Office Bearers as:

- Deputy President, Mr Prince Moyo;
- Senior Vice President, Prof Jan de Kock;
- Junior Vice President, Mr Pascal Motsoasele;
- Honorary Treasurer, Mr Stan Bridgens;
- Immediate Past President, Mrs Sy Gourrah;
- Honorary Vice President, Mr Collin Matlala.

Under normal circumstances, the newly inaugurated SAIEE President will give his opening address. His theme for 2021 is "The Future of Work". This event took place on the 31st of March via a webinar. Please read about it on page 8, or watch the recording here.

Please visit page 68 & 69 for the 2021 Council Members, Chapter and Section chairman.

Page 70 will introduce you to the new SAIEE Centre Chairpersons. wn

2021 SAIEE-IEEE JOINT DISTINGUISHED VOLUNTEER AWARD

Prof Pat Naidoo
Recipient of the SAIEE-IEEE Joint Distinguished Volunteer Award

At the recent SAIEE Annual General Meeting, hosted online on the 25th of March 2021, Dr David Oyedokun, Chairperson, IEEE South Africa Section, presented the SAIEE-IEEE Joint Distinguished Volunteer Award.

This award was established in 2013 and promotes the spirit of volunteerism by recognising a volunteer active in the IEEE, SAIEE or both organisations. The award criteria require that the volunteer has made a valuable contribution to the electrical engineering profession in South Africa.

He/She should promote the electrical/electronic engineering profession in South Africa within IEEE/SAIEE designated fields or meaningfully contributes to one of the social challenges in South Africa through electrical/electronic engineering. A duly constituted joint committee was set up in 2020 to prepare the call for nominations, review nominations, and decide who the recipient will be.

Dr Oyedokun said: "The committee is convinced that the recipient is an authentic professional volunteer who seeks to enhance the lives of the community by encouraging and training strong specialist engineers involved with and driven by the ethos of Voluntary Institutions like SAIEE and IEEE."

We are proud to announce that the 2021 recipient of the SAIEE - IEEE Joint Distinguished Volunteer Award is SAIEE Past President, Professor Pathmanathan (Pat) Naidoo.

Dr Oyedokun asked Prof Naidoo to activate his video, and Naidoo's first words, with a beaming smile, was, "Why me?"

"Chairman of the IEEE, Mr SAIEE President, Ladies & Gentlemen, thank you for the nomination and thank you for the election, thank you for the recognition, I am deeply humbled," he said.

He added, "in the words of the founding CEO of ABB, Percy Barnevik 'Think Global, Act Local', I think that is very appropriate. The issues of the day are challenging and complex.

Most of the challenges are outside the mainstream of engineering. As we advance, the boundary conditions for our members to work in will get more strenuous for the delivery of results to society. But together, the IEEE and the SAIEE, both our Sister Institutes, Cigre and the South African Power Pool and the other disciplines of the Mechanical Engineering, Civil Engineering, Chemical Engineering and the Academy of Engineering - I think we can rise above the challenges. We can undoubtedly give body to our collective vision of advancing technology for humanity.

So let me say thank you to my colleagues, thank you for the confidence in our workings and let us continue to serve and deliver a quality of life for all our people". wn

BI continues to support agri industry with quality products

BI Business Development Leader – Agriculture Gerhard Pienaar.

With Nampo Harvest Day 2021 officially anticipated to take place from 17 to 20 August at Nampo Park in Bothaville, leading supplier Bearings International (BI) will use the flagship event to showcase the importance of the agricultural industry and the wide range of products it offers to the farming community.

Organiser Grain SA reports that while Nampo is expected go ahead in a physical format in August, the show would be smaller than before due to the Covid-19 pandemic, and is likely to be run at 70% capacity. In the past, the highly successful event has attracted about 15 000 to 20 000 visitors a day.

Farming is not only one of the largest contributors to South Africa's Gross Domestic Product (GDP), but a relatively stable market segment showing steady year-on-year growth. BI has had an agricultural product focus for 40 years now. It has also invested significantly into developing new products and improving its stock levels where the farming community needs it the most.

The main products supplied are bearings and seals, sprockets and chains, power take-off (PTO) shafts, v-belts and pulleys, electric motors, gearboxes and couplings. In conjunction with Jonnesway, BI has even developed an agri toolbox specifically for farmers under its Agri-Smart banner of solutions designed specifically for the agricultural industry. The toolkit includes spanners, screwdrivers, an electric-current testing pen, pliers, punches, files, a hacksaw with spare blades and a large hammer. The tools are safely stored in a compact and sturdy case that can fit comfortably behind the seat of a vehicle.

The agricultural industry presents a very harsh operating environment for bearings, as farmers plant in extremely dusty conditions, explains BI Business Development Leader – Agriculture Gerhard Pienaar. To prevent premature bearing failure, BI has designed special agri hub units with tri-ply seal ball bearing arrangements to prevent the ingress of dust and dirt.

This feature ensures an extended operating life, which is a critical factor as farmers have a limited planting period. Tri-ply seals are a one-piece design incorporating three seals moulded to a shroud cap. This not only provides excellent protection against contaminants, but prevents the loss of lubricating grease to ensure a longer service life. wn

One tool for installing, testing, maintaining solar panels or photovoltaic systems

Fluke IRR1-SOL Solar Irradiance Meter

COMTEST, Fluke's local channel partner, has their new IRR1-SOL Irradiance Meter, designed from the ground up to simplify the installation, commissioning, and trouble-shooting of photovoltaic arrays, measuring irradiance, temperature, inclination and direction of the solar array in a single handheld tool. With a rugged, compact design, a protective carrying case, and an easy-to-read, high-contrast LCD screen to read measurements in direct sunlight, the IRR1-SOL can go anywhere users go. The simple user interface, instantaneous solar irradiation measurements and built-in temperature sensor make it easy to meet the IEC 62446-1 requirements for testing, documenting, and maintaining photovoltaic systems.

Additionally, the integrated compass and inclination sensor allow users to measure and document roof and site orientation, pitch, and panel tilt while surveying, installing, or adjusting an installation. wn

Say goodbye to gas maintenance headaches

If you purchase gas detectors, you're responsible for ensuring that the instruments are working properly and will alert workers to potential hazards. But it can be difficult to know when there is an issue, what the issue is, how long it could take to fix it, and how much it will cost. The good news is you have options to reduce or eliminate maintenance pains.

COMTEST, leading local distributor of test and measurement instrumentation to industry, represents Industrial Scientific, leading global provider gas solutions, who are offering iNet® Exchange, that allows customers to say goodbye to gas maintenance, warranty claims, unexpected costs, and downtime and say hello to an always-ready fleet and more time to focus on what matters.

HOW IT WORKS

iNet Exchange uses the DSXi Docking Station to predict when an instrument will need maintenance or repair, performing bump tests, calibrations and record keeping. Every time the monitors are docked, Industrial Scientific reviews the performance of the monitor, sensors, the circuit board, the microprocessors, and the pump, and tells customers whether a monitor needs to be replaced soon - before it fails, and it's replaced automatically. Before you know it, an iNet Exchange box is delivered to you with a new unit. Now customers can spend more time managing their safety program and less time repairing gas detectors. It's really easy to get started, simply contact COMTEST and one of our iNet Exchange experts will be in touch to answer any questions you may have. For more info email sales@comtest.co.za. wn

Electrical industry pump acceptance testing from the comfort of an armchair

Local pump manufacturer, KSB Pumps and Valves has launched an innovative online acceptance test procedure that no longer requires customers nor their engineering teams to be present when acceptance testing takes place.

The service was initially implemented to curb expenses that are usually incurred through travel and accommodation to test centres. The remote pump acceptance testing has also allowed business to continue as usual during the ongoing Covid-19 pandemic.

According to KSB Pumps and Valves technical manager, Friedrich Görgens, acceptance tests and final inspection are an essential proof of compliance when purchasing pumps and equipment to ensure the guaranteed values are met. In the past, customers always had to travel to the test facility to witness their purchased pump being tested.

"Online acceptance testing is KSB's answer to improve the ease and convenience of acceptance testing. They are transmitted live via the internet and are encrypted to be accessible only to required users. It allows the customer to see a live camera view of the pump in the test facility as well as the characteristic curve being generated live from readings taken and displayed during testing.

"We provide the customer with organisational information, order data sheets and a precise description of the acceptance testing prior to the acceptance test. This includes details on the measuring instruments used including the corresponding calibration certificates. After the acceptance test KSB display the results for comment and then e-mails the customer with the certificates within minutes, says Friedrich.

Online acceptance testing is available at KSB Pumps and Valves South Africa's test centre in Germiston and the facilities can accommodate pump sets with a drive rating of up to 550kW and flow rates of up to 3000m^3/h and discharge pressures up to 60 bar. String tests with the customer's original motors, transformers and frequency inverters can also be performed. A YouTube video is available that shows the online tests in operation. wn

SYNCHRONOUS CONDENSERS

– SUPPORTING GRID STABILITY FOR RENEWABLE ENERGY

There can be no doubt that renewable energy will have an ever-increasing role to play in the future of power generation, both in South Africa and the world. Hydro-generators, wind turbines and solar power (both Photo Voltaic [PV] and Concentrated Solar Power [CSP]) are currently at the forefront of the renewable energy generation technologies, with others such as wave power being developed in the background.

BY I D C H TARRANT PR.ENG, SMSAIEE

Hydro power, energy from water-driven turbines, is well established, but relies on a useful and preferably permanently available source of running water that can be dammed and harnessed to produce electricity. Hydro-turbines and generators are typically massive machines with large amounts of inherent inertia – but if there is insufficient water (as in water-scarce countries like South Africa), they have a limited potential to provide sufficient energy for a country's needs. Distributed solar PV is wonderful at providing localised electricity supplies to homes, small businesses, office parks and even remote villages – but is heavily dependent on some form of storage to be completely reliable. Rapidly improving battery technology is assisting in this regard but is not there yet. The control of such distributed micro-sources of energy into the grid is also a major headache for grid operators.

CSP plants have huge potential to provide a stable renewable energy source, as they heat 'energy storers' such as molten salts or special oils which are then used to transfer the heat to water to create steam. The steam then drives a conventional steam turbine and generator, some in excess of 100MW. This technology combines the best of both worlds – readily available and reliable renewable energy and tried and tested turbine-generator technology with significant fault current capability and inertia to support grid stability.

Wind turbines have been around for a while and are abundant throughout

Synchronous condenser being installed, showing synchronous condenser, flywheel and starting motor.

the world as probably the most prolific source of renewable energy at the current time. Technical reliability has been a challenge in the past, although it is improving, but of course they do have the big disadvantage of relying on ann erratic source of energy – the wind. They cannot operate in too little wind, or too much wind. And rapid swings in wind strength need to be addressed both from an instant availability of energy point of view as well as long term reliability of the rotating equipment – cycling of any sort is not good for any rotating equipment's longevity (although more recent designs do address this). Also, the ability of wind farms (and more generally, non-synchronous generation) to provide fault ride-through capability for various network events varies significantly. The consequence could be that under certain network contingencies (i.e. faults), non-synchronous generators may not be able to ride-through faults and may trip, which potentially worsens network security by reducing the amount of generation able to support the network, affecting the balance between load and generation.

Excessive reliance on wind turbines (and to a lesser extent solar PV) can present a challenge to a grid operator. Maintaining grid voltage and frequency at required levels with minimum variance in both absolute level and rate of change of level requires a sufficient amount of reliable base load energy, significant system inertia (in the case of faults anywhere on the grid) and adequate Reactive Power control to maintain system voltages. All of these are currently available in South Africa through the reliance on Eskom's coal-fired generator fleet (and of course Koeberg, the only nuclear power plant in Africa). These massive machines are generally reliable (when well maintained), provide solid base load energy, huge amounts of fault current and of course inertia. However, as the fleet continues to age and the older stations get mothballed, we may start to rely increasingly on renewables as is happening in a number of other countries around the world. This is ultimately a good thing if done properly, but needs to be implemented in the context of an important and often poorly studied aspect of power generation – grid stability.

In South Australia, the gradual displacement of the conventional generators had the effect of a progressive reduction in system strength and inertia. On 28 September, 2016, a severe storm had resulted in localised power outages throughout the day. Shortly before 15h15, 2 transmission lines tripped due to faults. Shortly thereafter the Hallet Wind Farm lost 123 MW. Four seconds later, a third 275 kV line had a fault, resulting in five to six voltage glitches which stressed the ride-through capability of most of the remaining wind farm capacity, causing nine to shut down. Finally, within one second, the Hornsdale Wind Farm lost 86 MW, the Snowton Wind farm lost 106 MW, one of the interconnectors to the neighbouring state of Victoria increased loading to over 850 MW and both of its circuits tripped. Supply was then lost to the entire South Australian region as the two remaining base load power stations, the remaining interconnector and all remaining wind farms tripped.

We in South Africa are familiar with how well blackouts are received, and indeed the political and public backlash in South Australia as a result of the incident was huge. Studies subsequently undertaken by the Australian Energy Market Operator (AEMO) identified a system strength gap in South Australia, as well as a shortfall in the system inertia. In order to address these, the decision was taken to invest in the deployment of synchronous condensers in the South Australian network to shore up the system strength as well as inertia.

Two sites for the synchronous condensers were identified, each with two units consisting of a synchronous condenser (2 x 129 MVA at the first site and 2 x 125 MVA at the second), a flywheel for added inertia, a start-up ("pony") motor and Variable Speed Drive (VSD), along with required auxiliaries for oil supply and cooling.

The Transmission companies in Australia responsible for the operation of the grid do not have internal rotating machine skills, not actually operating any power generation themselves, and so Sebenzana was requested to provide support for various aspects of synchronous condenser projects. This included up front support on the compilation of a suitable specification, design review, technical quality control inputs throughout the manufacture and Factory Acceptance Testing of the new machines in Europe, and installation and commissioning support. Synchronous condensers supported by Sebenzana will be progressively connected to the network in the first half of 2021.

A synchronous condenser is essentially a generator operating in the 'motoring' half of its capability diagram. In other words, it is run up to synchronous speed (3000rpm in this case) by the pony motor and VSD, synchronised to the grid, and then the synchronous condenser draws a small amount of power from the grid in "motor mode" in order to continue spinning at synchronous speed. At this stage the VSD is shut down, and the pony motor idles, being driven by the synchronous condenser until needed to safely and quickly run the unit down (regenerative braking). Adjusting the current supply (excitation current) to the synchronous condenser's rotor results in either the generation of Reactive Power which can be exported to the grid as required, or the absorption of Reactive Power from the grid, both of which helps the System Operator to control system voltage.

In the case of a short circuit on the grid requiring the rapid supply of large amounts of fault current to prevent the grid voltage from dipping, potentially collapsing the grid completely, the synchronous condensers can almost instantaneously change into "current-generators", and for several seconds supply large amounts of fault current. If the synchronous condensers have been designed and sized correctly, this will allow the grid to 'ride through' most faults.

Synchronous condensers can also help support transmission voltage and improve transmission line capacity and efficiency in the case of long transmission line distances. Wind farms, which typically have low reactive power generation characteristics, low inertia and limited short-circuit power capacity, can benefit hugely by a synchronous condenser being installed close to the generating units in order to facilitate the transmission of the generated energy to consumers. This also allows them to provide more active power by removing the burden of reactive power support, which can raise the rated plant capacity significantly. The science tells us that integrating intermittent renewable energy to a grid that was not designed to deal with it brings a host of significant technical problems. South Africa is a long way from losing sufficient base load energy for lack of inertia and reactive power to be a concern – however, these considerations must be borne in mind from an early stage as the Energy supply and grid evolves going forward.

Localised small networks could also come into play in future, based around renewables, and in remote locations grid instability would be a real concern. The introduction of grid support in the form of synchronous condensers (as well as Static VAR Compensators where appropriate) can go a long way towards providing much needed stability both on large-scale as well as localised networks. wn

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- Operation and maintenance engineering on site

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No wind or sun? There's a battery for that!

- HOW LITHIUM IRON BATTERIES SUPPORT THE RENEWABLE ENERGY SECTOR

South Africans joined the rest of the world in marking World Earth Day to the backdrop of an electricity grid that is still under immense pressure and still dominated by coal, despite large mining houses announcing divestment in the fossil fuel source.

While there are positive moves in the country around renewable energy investment and generation, there is also a marked uptick in business and private investment in sustainable energy solutions to give them some level of energy independence but there is a need to educate the public on just how energy from renewable sources is stored, says REVOV MD Lance Dickerson.

REVOV supplies first life and second life lithium iron batteries in South Africa and the rest of Sub-Saharan Africa. The company has gained widespread recognition through its second life batteries, which are built from repurposed electric vehicle (EV) batteries. After a few years an EV battery must be replaced as its weight doesn't justify its performance. Ordinarily, these end up in landfills.

"We said from the beginning - what is the point of supporting something good like e-mobility if the after-effect is yet more damage to the environment? Rather repurpose the cells to supply lithium power to the renewable energy and uninterrupted power supply (UPS) market in Africa," says Dickerson.

He says that a common misconception in the general population about renewable power is that the sun constantly needs to be shining or the wind needs to always be blowing for it to be a viable investment. "While it is true that solar generates power when the sun is shining and turbines when the wind is blowing - it is the battery that stores this power for continued power supply," explains Dickerson.

This makes batteries, and the choice of batteries, vital in the discussion of getting the most out of renewable energy, especially if the motivation is to contribute to lowering our carbon footprint, he says. There are an array of lithium iron batteries, which by the nature of their chemistry, make them very appealing to be used with renewable energy installations. On this front, REVOV, for example, has various first and second life batteries that are each designed to deliver the best

performance in various environments. One of the common criticisms about renewable energy is that it is unreliable precisely because of the unpredictability of nature. Renewable energy is collected using wind or solar devices that are installed for that purpose.

"In simple terms, a renewable energy system that relies totally on alternative energy production without energy storage in place is interrupted by cloud cover or a lack of wind. The system cannot supply energy to the load, unless it is capable of augmenting the renewable supply with either some grid supply or some battery power.

"To be able to power loads reliably it is important to have reliable continuous power which is supplied continuously regardless of the state of the renewable supply," explains Dickerson.

"The most effective way to do this is to store the energy in a storage system which will allow the energy to be used to supplement the irregular supply from the renewable side. So when there is good renewable supply, store the excess in batteries, and then when supply reduces use those batteries to supplement the supply and provide a continuous level of energy," he says.

Usually businesses or individuals don't have much information on the types of batteries that installers suggest when they invest in their own renewable energy sources, such as solar, says Dickerson. "This is why it is imperative for us to educate both the installers and the general public on lithium iron, and why and how it has surpassed traditional lead chemistries," he says.

There are a number of variables that go into choosing the right type of battery, says Dickerson. These include the charging time - first life LiFePO4 batteries, for example, can be charged up to five times faster than traditional lead chemistries, weight of the battery system and longevity and safety. "Every battery has a lifespan based on the number of charge and discharge cycles it can support," he says. "Again, if we use the LiFePO4 lithium iron batteries as an example, they can go through 6,000 to 7,000 cycles compared to the 1,000 to 1,500 cycles in traditional lead batteries," he says.

"The point is that by educating both installers and the public about the performance of lithium iron batteries, that they are not only more environmentally sound than traditional batteries but also by being fit for purpose they alleviate a lot of the hesitancy around investing in renewable power."

He says there needs to be an understanding that how one stores power in a renewable set up will ultimately play a massive role in determining the return on investment. As lithium iron becomes more well-known, he hopes the public will redouble its efforts in advocating for renewable energy, both on a national level and in smaller projects in their businesses and homes. "Our planet depends on it," he says. wn

5.2m euros investment for osmotic energy technology

Sweetch Energy's new high efficiency eco-membranes can turn osmotic energy into a bankable renewable power source for the first time in 50 years.

Sweetch Energy, a European company that pioneers advanced nanotechnology and eco-material science to harness osmotic energy, announced today that it has secured 5.2 million euros to initiate its industrialization phase and develop a first full-scale prototype. Osmotic energy represents a breakthrough in renewable energy as a non-intermittent and abundant source of clean electricity.

The investment round was supported by a group of deeptech and cleantech investors with a strong track record in backing highly disruptive industrial companies such as Ÿnsect, Meatable or McPhy Energy. It was led by new investor Future Positive Capital, and co-led by existing investors Demeter and Go Capital. Other investors such as Dominique Gaillard, co-founder of Ardian, and Fabio Ferrari, founder of Symbio, one of Europe's pioneers in the hydrogen industry, also participated. ADEME, the French environmental and energy management agency, provided additional funding as well.

Osmotic energy represents a revolutionary addition to existing renewable energy technologies. Naturally available from the difference in the salt concentration when river fresh water meets sea water, osmotic power provides a non-intermittent and abundant source of clean energy. Unlike wind or solar energies, and similarly to hydropower, it can deliver electricity continuously, and is easily dispatchable to meet the grid baseload power requirements. With an estimated 27,000 terawatt-hours liberated every year in deltas and estuaries around the world – equivalent to today's global electricity demand – osmotic energy offers an abundant, but so far untapped, clean energy source.

Sweetch Energy's proprietary system combines recent breakthroughs in nanofluidic sciences with low-cost eco-friendly materials to create next-generation membranes, coupled with specifically engineered electrodes and innovative cell designs.

The technology yields unrivalled performances in the field and can harness osmotic energy with a level of cost-efficiency never achieved before, opening the door to large-scale deployment of osmotic energy as a competitive market solution.

Lyderic Bocquet, CNRS researcher, director of the Institut Pierre-Gilles de Gennes (PSL University) and one of world's foremost authorities on nanofluidics, is the original inventor of nano osmotic diffusion and one of the company's co-founders.

He stated: "Sweetch Energy's engineering team has managed to convert in a record-time the results of our fundamental research into a complete system ready to be scaled up. This is a clear demonstration of how the alliance of academic research and private entrepreneurship can lead to new solutions to fight climate change."

Nicolas Heuzé, CEO and co-founder of Sweetch Energy, stated: "After three years of laboratory research successfully validating our technology, this new funding brings Sweetch Energy the resources necessary to initiate our industrialization phase. This includes expanding our engineering team, developing manufacturing capacities and building a first full-scale prototype within the next three years. We are currently exploring partnerships to identify the ideal location to install

our prototype. Our ambition is to pioneer a new era for the osmotic energy industry. Our next-generation membrane technology, based on state-of-the-science nanotechnology, will be its key enabler."

Leading the investment, Alexandre Terrien, co-founder at Future Positive Capital and newly appointed member of the Sweetch Energy Board, said: "Our mission is to back the sharpest and most ambitious minds that use advanced technologies to bring solutions to some of the world's most pressing challenges. The Sweetch team is truly exceptional in that regard – led by 3 complementary co-founders who previously built and sold companies in complex industries, supported by a founding scientist who is globally-recognized for his work. This company has the potential to finally make osmotic energy a reality."

Olivier Bordelanne, Partner at Demeter added: "We are pleased to continue our support for Sweetch Energy and welcome new investors to our side to help the company industrialize and commercialize its technology, which is one of the most disruptive and most promising we have recently financed in the clean energy sector." wn

Mattel Unveils First-of-its-Kind, Carbon Neutral Matchbox® Tesla Roadster Die-cast Vehicle

The goal is to use 100% Recycled, Recyclable or Bio-based Plastic Materials across all Matchbox® Cars, Playsets and Packaging.

Mattel, Inc. announced a drive toward a Better Future, its commitment to make all Matchbox die-cast cars, playsets and packaging with 100% recycled, recyclable or bio-based plastic. Featuring innovative electric vehicles and environments that model the real world, the toys are designed to engage kids in a greener future of driving. The commitment supports Mattel's goal to achieve 100% recycled, recyclable or bio-based plastic materials across both its products and packaging by 2030.

To illustrate these principles, the brand is unveiling the Matchbox Tesla Roadster, its first die-cast vehicle made from 99% recycled materials and certified Carbon Neutral. Built from 62.1% recycled zinc, 1% stainless steel and 36.9% recycled plastic, the Matchbox Tesla Roadster will be available starting in 2022.

The reimagined broader Matchbox brand includes new product lines and packaging that feature:

- More environmentally friendly and innovative materials across vehicles, playsets and packaging
- Enhanced consumer recycling through product design and packaging labeling
- An overall eco-friendly themed approach to play, with more e-vehicle product offerings and e-vehicle chargers in fuel station playsets

"Since the inception of the modern-day die-cast car nearly 70 years ago, Matchbox has been using design and innovation to connect kids with the real world around them through play," said Roberto Stanichi, Global Head of Vehicles at Mattel.

"Matchbox is committing to using 100% recycled, recyclable or bio-based plastic materials to do our part in addressing the environmental issues we face today, and empower the next generation of Matchbox fans to help steer us towards a sustainable future."

Fans will see the brand's commitment realized through products with zero-plastic packaging, using Forest Stewardship Council® (FSC)-certified content in the paper and wood fiber materials, on shelf starting now.

The first die-cast vehicle to have zero-plastic packaging includes the popular Matchbox Power Grabs® assortment featuring a variety of licensed and original 1:64 scale Matchbox die-cast vehicles, while an EV-themed five-pack is now available with a paper foam inner tray.

In addition to introducing zero-plastic packaging, the brand is promoting proper recycling and waste recovery. Designed for recyclability with recyclable parts, electronics in playsets are consolidated into a single, easily removable module to help make the local e-waste recycling process easier. wn


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DEHN Protects Wind and PV Installations

In recent decades, there has been a steady shift towards more environmentally friendly and sustainable practices. The amount of Carbon Dioxide (CO2) in the atmosphere reached record levels in 2020, hitting 417 parts per million in May.

The world's reliance on fossil fuels for energy has had major geopolitical implications since humans first started burning coal thousands of years ago.

Fortunately, developments in technology has allowed us to start leveraging on smarter, cleaner energy sources to power our homes and businesses.

Solar and wind energy have been areas of increasing interest for countries across the globe.
The favourable weather conditions in many countries across the Africa continent make the usage of solar and wind energy viable. Traditionally reliant on hydropower and coal, the continent is steadily turning to solar photovoltaics (PV) to bolster energy security in order to facilitate rapid economic growth in a sustainable manner. Setting up a solar park is extremely capital intensive; therefore, investors need to ensure that their financial interests are protected, so that they can shorten the time to profitability.

Photovoltaic (PV) systems, by nature, are extremely exposed and therefore especially vulnerable to direct and indirect damage as a result of lightning strikes. Climate change has also brought about new challenges, warmer conditions have contributed to a global increase in the lightning flash density, making it even more vital to invest in Lightning Protection Systems. In fact, South Africa has a particularly high lightning density (strikes/km^2).

Lightning strikes and surges often lead to the destruction of system parts such as modules, inverters and monitoring systems, which are costly to repair, and even more costly to replace. Lightning is a common cause of failures in photovoltaic (PV) and wind-electric systems. A damaging surge can occur from lightning that strikes a long distance from the system, or even between clouds. But most lightning damage is preventable. Plainly stated, the financial consequences of not having a lightning and surge protection solution far outweigh the cost of completing a risk assessment and getting the right protection.

Since the investment outlay is high, operators need to maintain permanent system availability to ensure profitability of the plant. As an industry expert for power distribution grids, DEHN offers special protection solutions, ranging from power generation to power distribution with a focus on PV systems and wind turbines. Our interaction starts off with a comprehensive risk assessment to determine the level of risk, informing how much external lightning protection is required.

The lightning-related risk is calculated according to the The South African National Standard PV lightning standard (IEC/SANS 61643-32), which is the standard to be observed for protecting PV systems in the event of a lightning strike. The standard states that surge arresters are mandatory, along with an external Lightning Protection System (LPS) for PV installations. This risk analysis completed by DEHN provides the basis for planning a comprehensive lightning protection solution. This is all done with the goal of protecting the workers on the plant, the assets as well as the actual panels along with all the components, all while ensuring high system availability.

A lightning protection system for free field systems and solar parks typically has two main goals:

1. Protection of the power plant area from lightning-related damage Protection of the modules, inverters and
2. monitoring systems from the effects of electromagnetic impulses

A suitable lightning protection system consists of external and internal lightning protection. External lightning protection includes air-termination systems and down conductors which discharge the lightning current via defined paths to the ground. To ensure internal protection, it is recommended to use surge protective devices (SPDs) in all areas that are deemed to be at risk.

For a more proactive approach, DEHNdetect can reliably detect lightning events, preventing losses as a result of system downtime and expensive repair work, specifically on wind turbines. The revised standard IEC 61400-24 (July 2019) Wind turbines Part 24: Lightning protection recommends the installation of measuring systems which can also measure long stroke currents in order to determine the intensity of lightning strikes.

Damage resulting from a lightning strike is not always evident and does not necessarily lead to the immediate failure of a turbine, as a result, lightning events often remain undetected. Especially in the case of upward flashes the initial long stroke current flowing is only a few 100A and can be the main cause of melting, e.g., on the receptors of rotor blades. The resulting subsequent damage may be severe.

DEHNdetect is a lightning current measuring system for detecting lightning events. It has been designed to register these long stroke currents on wind turbines, as well as impulse current, in order to prevent the need for expensive maintenance work and long downtimes. DEHNdetect can also be equipped with optional rotor blade detection.

The system keeps you informed about what is going in your wind turbines, whether this is for an individual turbine or an entire wind park, giving you continual data on the condition of your components. This includes the option of setting up push messages that would be sent directly to your smartphone or tablet. The system allows you to invest in availability and make your wind turbines a reliable source of power, both now and in the future. wn

Zest WEG Gives Motor Users Another Efficiency Boost

In the face of rapidly rising electricity costs in South Africa, Zest WEG is phasing in IE4 super premium efficiency motors in its WEG W22 range from April 2021 – which will save on customers' bottom lines and help reduce the load on the national grid.

Fanie Steyn

According to Fanie Steyn, electric motors manager at Zest WEG, 2021 will see local energy prices rising above R1/kWh for the first time. This makes it the ideal time for the introduction of WEG IE4-rated motors, which will be available in the size range between 37 kW and 375 kW.

"Unlike many countries around the world, South Africa has not regulated the use of energy efficient motors at the level of IE2 or IE3," says Steyn. "Nonetheless, we have taken the proactive step of making the IE4 level of efficiency available to customers at no premium on the IE3 units."

Some years ago, Zest WEG introduced its WEG IE3 motors to the country at little or no additional cost relative to its IE2 motors, with the same goal in mind: making both customers and the country more energy efficient.

Specified under the International Electrotechnical Commission (IEC) 60034-30-1:2014 standard, IE1 refers to standard efficiency and IE2 to high efficiency; the IE3 and IE4 ratings are for premium efficiency and super-premium efficiency motors respectively.

"The efficiency of 96.3% on an IE4-rated 110kW motor, when compared to 94.1% on an IE1-rated motor, can save users hundreds of thousands of rand in energy costs over a 10 year period," he says. "Not only will these IE4 motors be more cost effective to run, but they have been designed with a number of new features that bring considerable benefits."

Steyn emphasises that WEG IE4 super-premium efficiency motors meet IEC efficiency levels when running on 50 to 100% of load; efficiency is kept constant, which saves energy and ensures minimal losses through various loading points. The innovative frame design also allows maximum heat dissipation.

"Motor frame design plays a crucial role in thermal performance, as it is responsible for the outward transfer of heat generated inside the motor," says Steyn. "Running cooler means that our motors have increased life spans, allowing Zest WEG to offer a five year guarantee on our WEG W22 electric motor range."

The motors' increased mechanical rigidity – achieved by integrating the front and rear feet sides – affords easier installation, higher mechanical stiffness and improved distribution of the mechanical thrust imposed by the load.

"As a first of its kind, our flexible terminal box mounting means reduced inventory and quicker modification," he says. "The terminal box can be rotated in 90° increments to facilitate supply cable connection orientated to the front, rear, top or either side of the motor."

In addition to the benefits brought by WEG super premium efficiency motors a substantial increase in energy savings can be reliably achieved using WEG Variable Speed Drives (VSDs), which comply with the European Extended Product standard EN50598. This ensures the system efficiency of the motor and VSD combination. As an additional feature, WEG VSDs have energy savings settings which can be user activated, achieving an automatic saving under any reduced load conditions.

"We are excited to build on the phenomenal reputation of the existing WEG W22 electric motor range by offering an even more efficient motor that is truly "next level" state of the art in electric motors, having the same rock solid quality and reliability," Steyn concludes. wn

Evaluating the Efficiency of Hydropower as an Alternative Energy Source

The generation of hydropower, a renewable energy source, is not complex; however, making the generation process efficient and cost-effective is the real challenge.

BY I DR RAJ SHAH, MS SHARIKA HOQUE, MR STANLEY ZHANG
KOEHLER INSTRUMENT COMPANY

Humans have been utilising the abundance of water for thousands of years. For example, the ancient Greeks used water mills as a form of hydroelectric power to grind wheat into flour and perform other tasks. Today, hydroelectricity accounts for 73% of global renewable energy generation through three main hydropower facilities: impoundment dams, run-of-the-river dams, and pumped storage facilities. The most common type of hydroelectric power plant is an impoundment facility. This type of plant uses a dam to store river water and then releases the water into a turbine which causes it to spin. Unfortunately, dams can potentially disrupt the river ecosystems on which they are built, but modifications can limit these harmful effects.

Over the past several decades, electricity generation escalated due to rapid industrialisation, modernisation, and urbanisation worldwide. More specifically, electricity generation had increased 15-fold from 351.4 TWh in 1983 to 5347.4 TWh in 2013. The International Energy Agency predicts that by 2030 the electricity demand will annually increase by 2.5% [1]. Renewable energy will become the primary source of energy to support this demand and avoid environmental problems. The generation of hydropower, a renewable energy source, is not complex; however, making the generation process

efficient and cost-effective is the real challenge. The electricity generation rate and water utilisation rate must be evaluated to assess the efficiency of hydropower facilities.

Hydropower is an attractive form of energy because of its low carbon emission, low costs, and of course, the abundance of water. However, building a dam in a river is similar to building a roadblock in the middle of the highway; it disrupts traffic flow in both directions. This "roadblock" can disrupt species populations, water quality, the river food web, and the surrounding environment.

Declining fish populations can result in significant complications for communities dependent on fishing for food and income. The reservoirs can also cause floods which can force communities to relocate. Although hydropower is labelled as "renewable," specific forms of hydropower and its effect on the ecosystem must be explored before we continue to develop more dams.

WHERE IS HYDROELECTRIC POWER USED?

Hydropower is the most important and widely used renewable energy source. The two main requirements for producing hydroelectricity are a constant water stream and an elevation drop. Countries all over the world can make use of hydroelectricity.

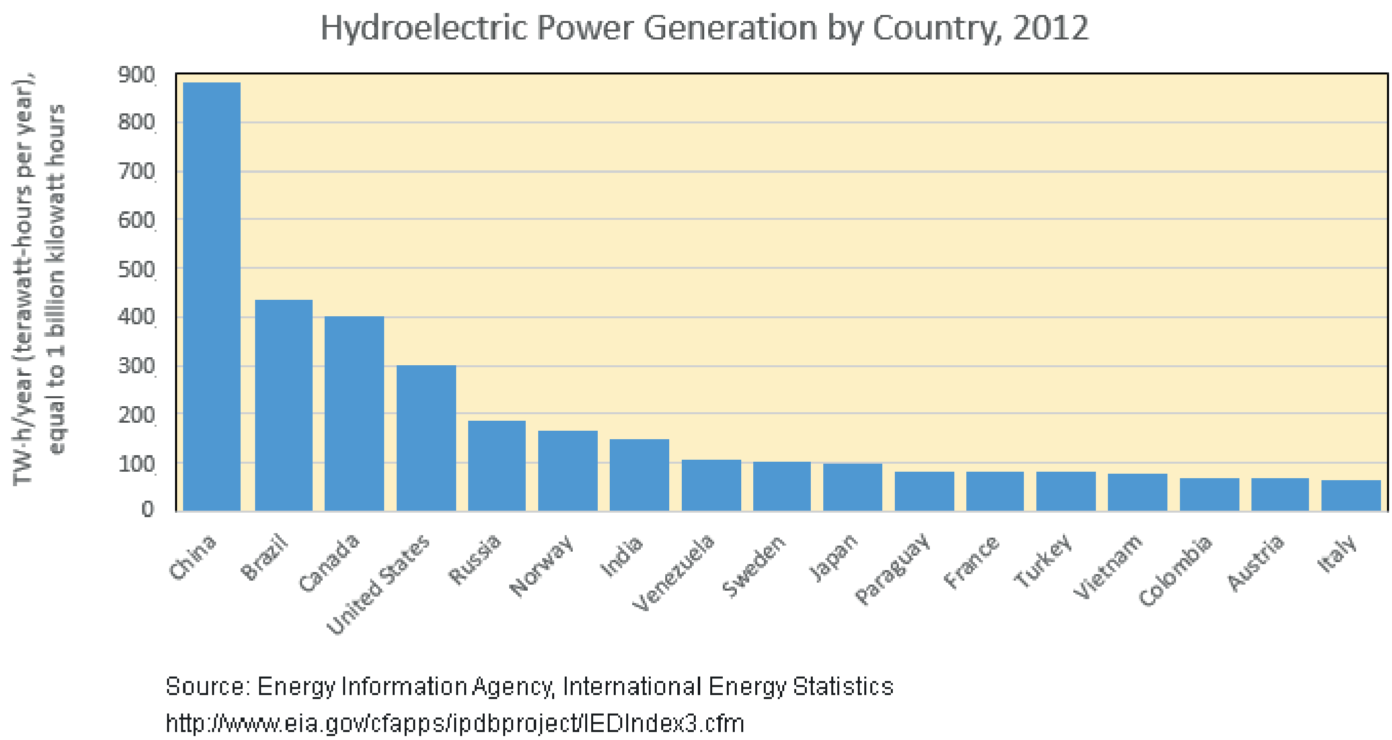

Figure 1: Hydroelectricity generation by country in 2012 [2].

China, Canada, Brazil, and the United States are the most significant hydroelectricity users globally, and 17% of the total energy production is represented by hydroelectricity [2]. Although most of the energy generated in the United States comes from fossil fuels and nuclear power, hydroelectricity is still an important domestic energy source.

Figure 1 highlights that China is the world's leading producer of hydroelectricity with a generation of about 900 billion kilowatt-hours in 2012. Even with all of these countries producing hydroelectricity, two-thirds of economically feasible hydro-resources remain untapped [2]. Latin America, Central Africa, India, and China have a lot of undeveloped hydro resources.

IMPOUNDMENT DAMS

The impoundment dam is the most common hydropower facility. These dams store river water in a reservoir. This stored water can be released according to electricity demands or to maintain a constant reservoir level. The released water travels through the penstock to a turbine, where the mechanical energy is converted into electricity by a generator. The energy produced is conducted through transmission lines to areas that need electricity.

THE EFFICIENCY OF THE LONGYANGXIA RESERVOIR

In 2013, China's hydropower capacity reached 280 GW, exceeding the

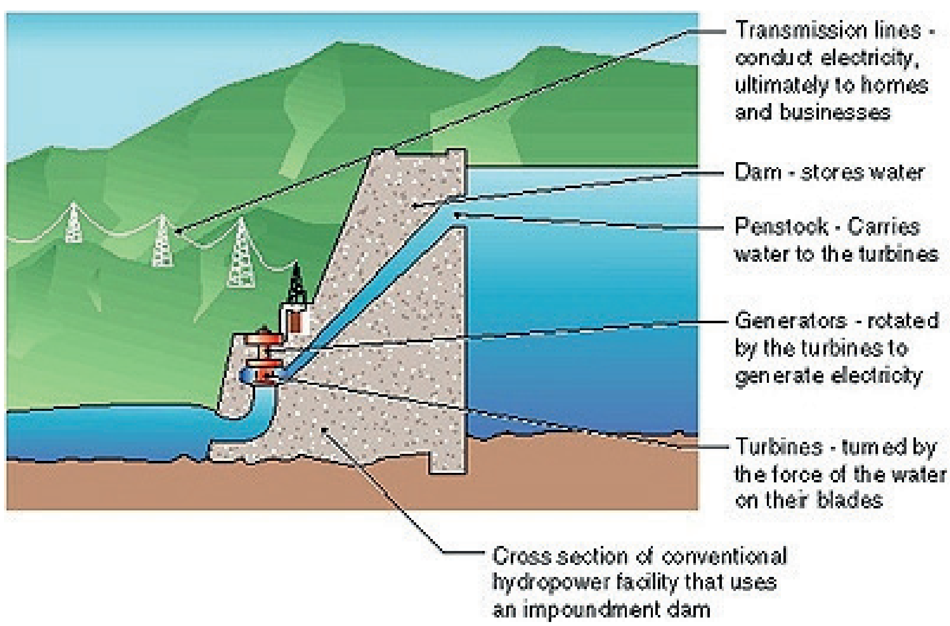

Figure 2: Impoundment dam structure [3].

A

Month	Inflow	Releasing discharge (m³/s)		Releasing water ($10^8 m^3$)		Surplus water ($10^8 m^3$)		Water level (begin) (m)		Water l (m)
		actual	calculation	actual	calculation	actual	calculation	actual	calculation	actual
1	144	438	480	11.52	12.62	0	0	2565.91	2565.91	2565.04
2	168	493	520	12.97	13.68	0	0	2565.04	2562.64	2560.06
3	190	456	575	11.99	15.12	0	0	2560.06	2559.49	2557.26
4	323	449	400	11.81	10.52	0.01	0	2557.26	2555.26	2555.94
5	470	574	300	15.10	7.89	0.1	0	2555.94	2554.45	2554.94
6	804	582	345	15.31	9.07	0	0	2554.94	2556.31	2557.15
7	586	578	460	15.20	12.10	0	0	2557.15	2561.05	2557.27
8	537	575	465	15.12	12.23	0	0	2557.24	2562.28	2556.84
9	769	439	485	11.55	12.76	0	0	2556.84	2562.98	2560.21
10	755	383	405	10.07	10.65	0	0	2560.21	2565.65	2563.96
11	378	631	390	16.60	10.26		0	2563.96	2569.06	2561.52
12	198	594	415	15.62	10.91	0.01	0	2561.52	2568.95	2557.39
Total	5322	6192	5240	162.8	137.8	0.22	0	/	/	

B

W_{Lo} ($10^8 m^3$)	W_{Lc} ($10^8 m^3$)	E_{Lo} (10^8 KWh)	E_{Lc} (10^8 KWh)	E_{LK} (10^8 KWh)	RC	RU (%)	RI (%)
162.85	137.85	40.12	34.36	40.64	1.20	98.72	–1.26

Table 1: (a) The comparison results between actual and calculated running conditions of the Longyangxia Reservoir in 2001. (b) Efficiency evaluation results of economic operation in the Longyangxia power station [1].

cumulative value of Canada, Brazil, and the USA [1]. The Longyangxia power station is the largest reservoir in the Yellow River Basin and was selected to perform an efficient evaluation of the economic operation. The three evaluation indexes that are being observed are the relative water consumption rate (RC), the relative hydropower utilisation rate (RU), and the relative hydropower utilisation increasing rate (RI).

Table 1(a) shows that the calculations are not a reliable source to predict the efficiency of the Longyangxia hydropower facility. The calculated final water level was 2568.95 m which exceeded the initial water level of 2565.91 m, but this observation was not observed through actual measurements. This emphasises the need to make actual measurements to assess the efficiency of the hydropower stations. Also, according to Table 1(a), there is a surplus of water that was never predicted from the calculations. This surplus suggests that the water consumption was higher than it should have been and was not utilised effectively. Table 1(b) highlights the three essential evaluation indexes previously mentioned, RC, RU, and RI. The result showed that the economic operation of this power station was not reasonable with RC> 1, RU < 1 and RI < 0 [1].

Operational changes can improve the efficiency of the Longyangxia hydropower facility. During flood seasons, the idle units should be operated accordingly, and flood control measures should be put in place to prevent surplus water. Likewise, during dry seasons, an increase in the output can improve power generation and increase profits. The power generation and water supply should be coordinated with ecological regulations. Lastly, the reservoir water level is linked to the water resource utilisation, so it deserves special attention. Although water is a plentiful resource, inefficient usage of this resource can have adverse effects on the freshwater ecosystem.

BIODIVERSITY CONCERNS

Along with the efficiency of the dams, the environmental concerns resulting from them must be studied as well. Freshwater ecosystems have more endangered and extinct species compared to terrestrial or other marine environments. River systems around the world are fragmented by dams which can affect fish assemblages. Impoundment facilities contribute to the biodiversity crisis by disrupting the river ecosystem. The physical impacts of changes in freshwater ecosystems include riverine fragmentation, sediment retention, enhanced evaporation, and increased greenhouse-gas production [4]. These impacts must be addressed when designing and developing dams.

In addition, impoundment dams facilitate the introduction of aquatic invaders into freshwater ecosystems. Invading species are 2.4 to 300 times more likely to occur in impoundments than in natural lakes [4]. After combining information on the boating activity, water body physiochemistry, and geographical distribution of 1080 sampled water bodies (combination of natural lakes and impoundments), Figure 3(a) depicts the invasion's likelihood of impoundments exceeded that of natural lakes. The most common non-indigenous species include zebra mussels, Eurasian watermilfoil, and rusty crayfish. According to Figure 3(b), impounds are also more likely to support multiple invaders. These findings suggest that reservoir construction and conversion of lotic to lentic water stream conditions may have promoted the spread of invasive species across the landscape.

Although dams significantly impact freshwater ecosystems, other environmental factors such as river size, flow and thermal regimes, and land uses must be considered. Studies observing fish assemblages in Wisconsin rivers show a negative relationship between distance-to-

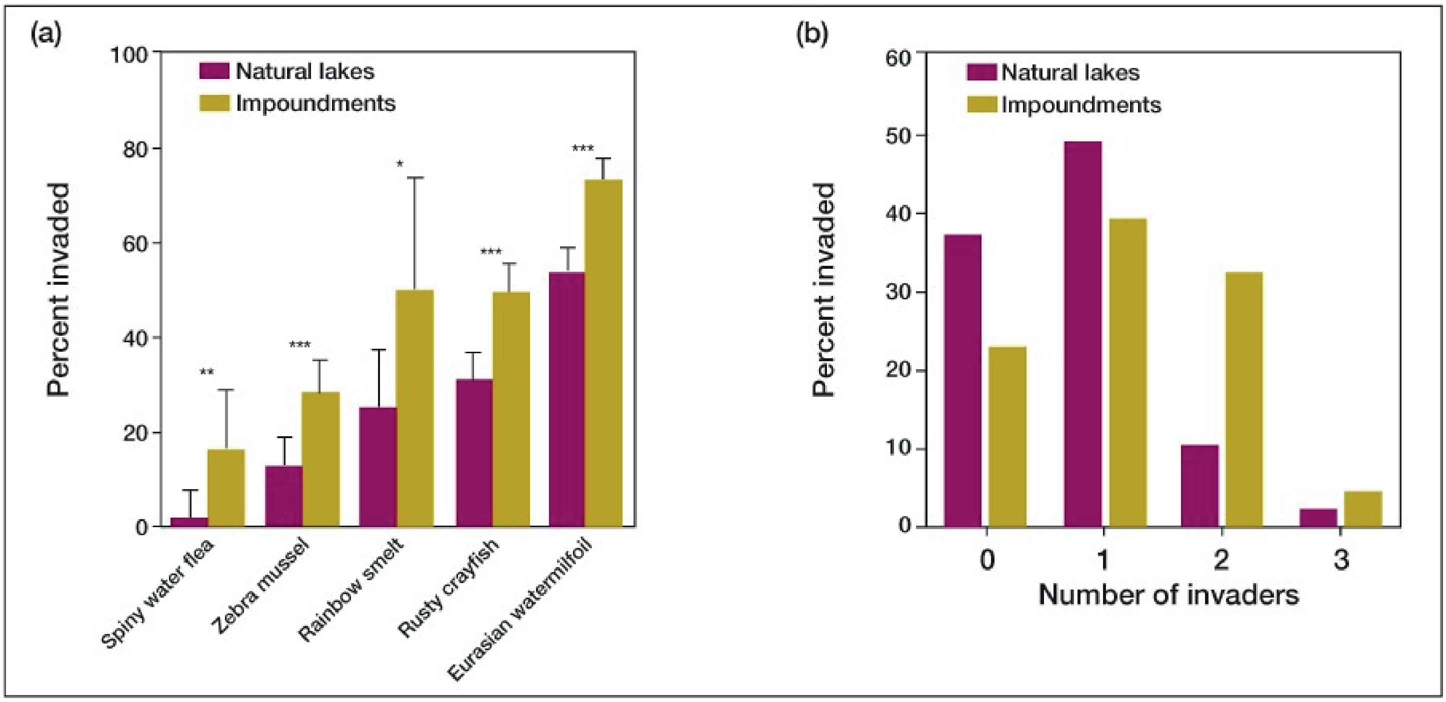

Figure 3: (a) Percentage of surveyed lakes and impoundments that supported spiny water fleas (n = 341 sampled water bodies), zebra mussels (n = 353), rainbow smelt (n = 83), rusty crayfish (n = 567), and Eurasian watermilfoil (n = 682). (b) The invaders in lakes and impoundments for the 189 water bodies sampled for the three most common invaders [4].

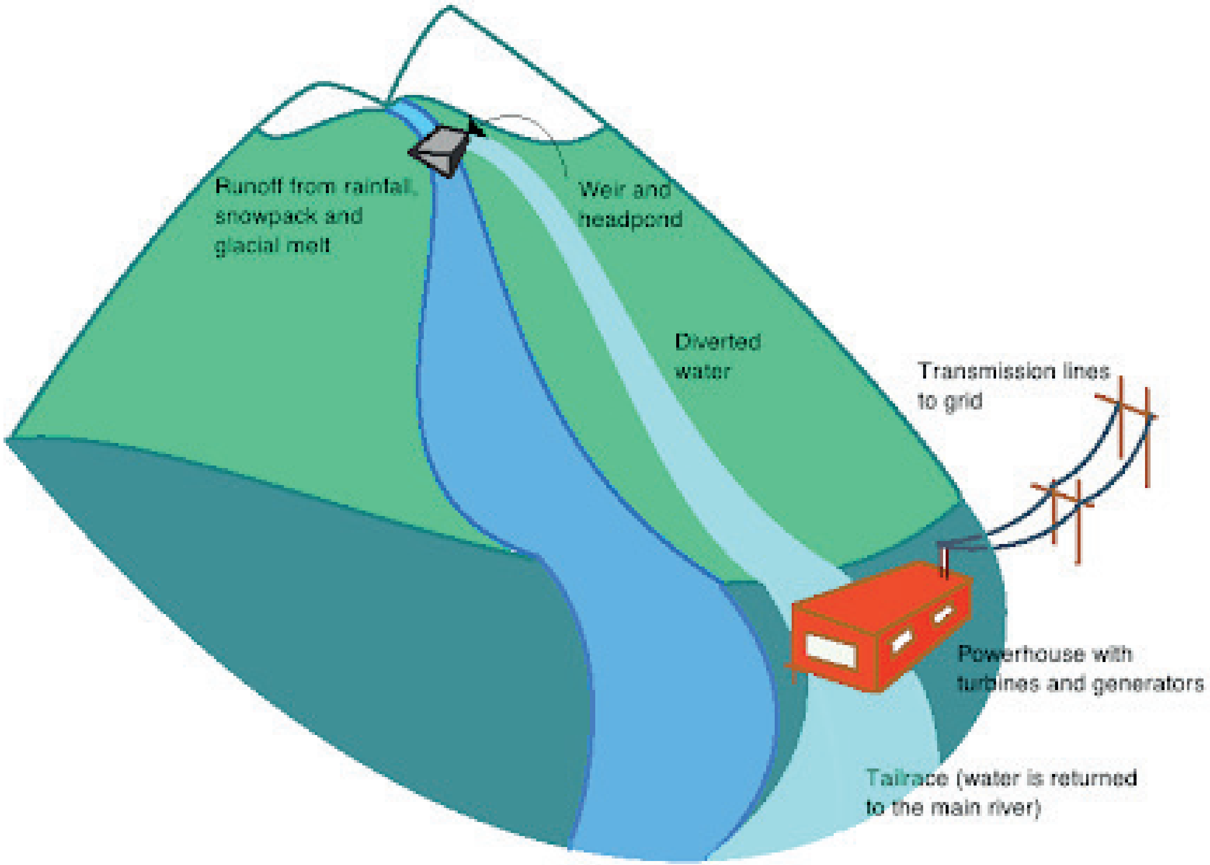

Figure 4: Diversion facility structure [6].

dam measures and species richness and diversity. This relationship could be a result of the fishes developing a tolerance to lentic conditions [5]. Overall, this finding emphasises the need to consider other environmental factors when judging the effects of impoundment facilities on these complex freshwater ecosystems. Furthermore, compared to natural lakes, the impoundments were 1.4 times lower in average water clarity, 2.1 times higher in conductivity, 4.3 times higher in the number of boat landings, 8.7 times larger in surface area, and 44.6 times larger in the watershed area [4]. Impoundments are also more likely to be accessed by humans. Nonetheless, the impoundment still had a significantly higher likelihood of invasions compared to natural lakes.

DIVERSION DAMS

Diversion dams, sometimes called run-of-river dams, transport a portion of the river stream from its natural course to a powerhouse. The powerhouse contains turbines and generators to produce electricity, and the water is fed back into the river. This type of facility requires substantial water flow and a significant elevation drop.

Unlike impoundment facilities, diversion facilities do not have large reservoirs to store water for future use, so they depend on precipitation. If the water levels of the river are depleted, then the entire facility can become inoperative. As a result, diversion facilities produce less electricity and lack consistency when compared to impoundment dams.

OPTIMISATION OF CUT-OFF WALLS

Cut-off walls are used to prevent the percolation of water through the foundation of the diversion dam. The cut-offs are sheet walls or concrete curtains that preserve the dimensions of the dam structure. The seepage water exerts an uplift pressure and may carry soil particulates with it, resulting in erosion. If the thickness of the floor is insufficient, its weight will fail to resist the uplift pressure and result in an inoperative hydraulic structure. Studies showed that cut-off walls reduced the uplift force by 63% compared to a hydraulic structure without seepage control and likewise decreased the exit gradient by 79% [7]. Furthermore, it was revealed that the pressure is reduced when the inclination of the cut-off is towards the downstream side of the dam [8].

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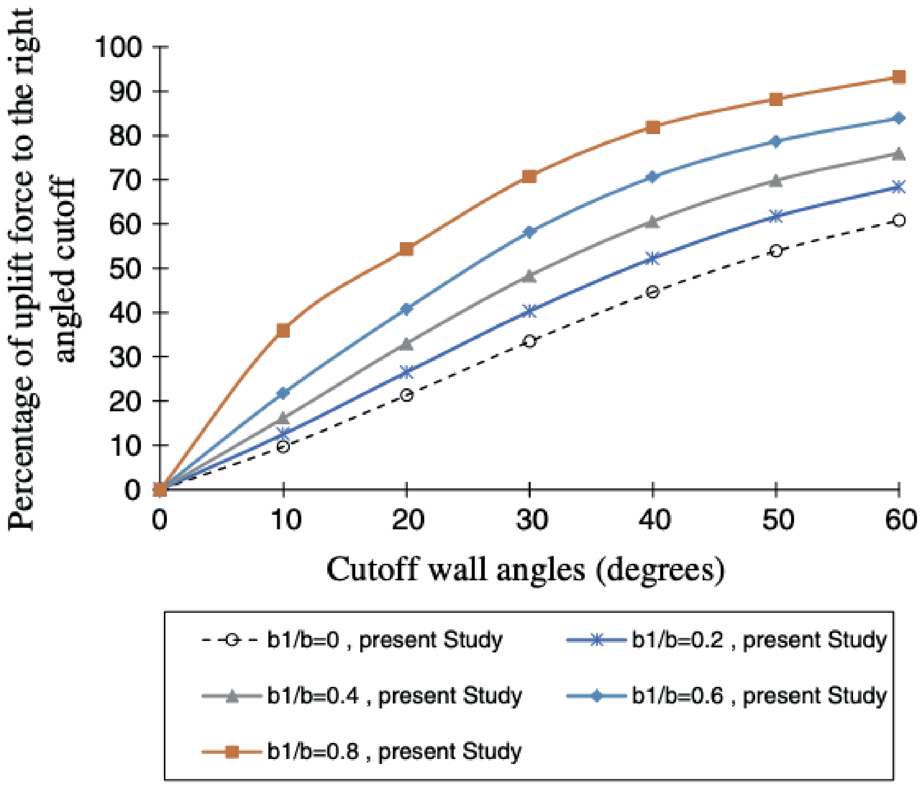

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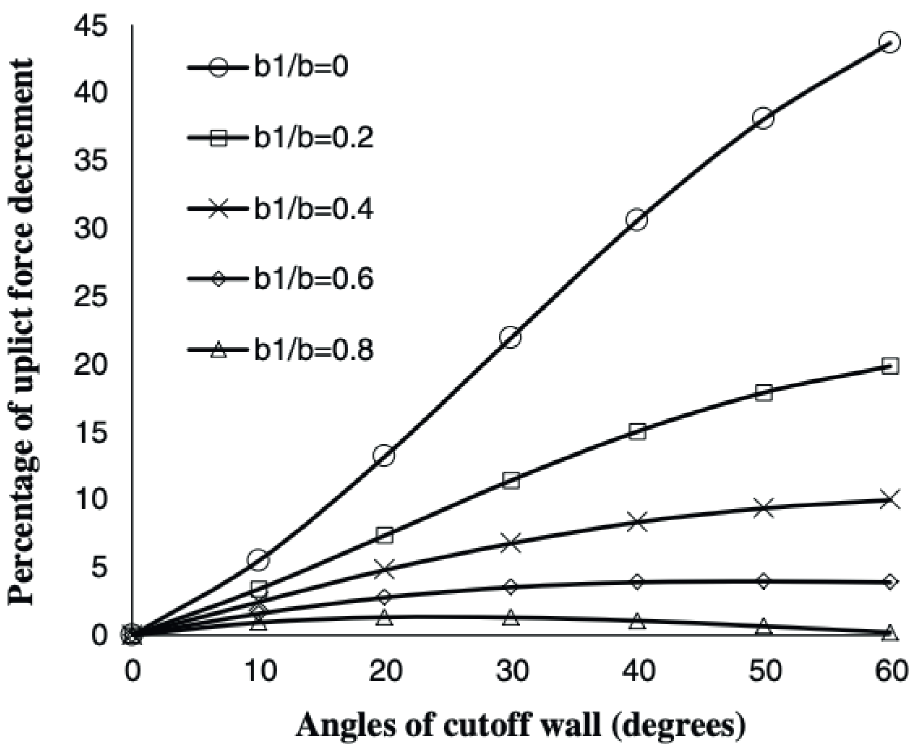

Figure 5: (a) Comparing the effects of the location and the angle of the cut-off wall for uplift force. (b) Comparing total uplift force on the different angles of the cut-off wall to the right-angled condition [7].

The effect of different angles at different positions on the uplift force was studied, and the results are displayed in Figure 5. The relative positions of 0, 0.2, 0.4, 0.6, and 0.8 from the upstream end are observed at angles of 10°, 20°, 30°, 40°, 50°, and 60° for each position. According to Figure 5(a), the closer the cut-off wall is placed to the downstream end of the river, and the more angled the wall is, the lower the uplift force is. This confirms that cut-off walls should be placed near the downstream heel with a large angle. Similarly, Figure 5(b) shows that when the cut-off wall is placed near the downstream heel, and the angle is increasing, the percentage of total uplift force decrement decreases. The per cent decrement of the uplift force will increase at higher positions and larger angles. A significant decrement in seepage would occur when the cut-off wall is placed at the upstream heel and the downstream heel. When the cut-off wall moves closer to the downstream hill and the angle gets larger, the uplift force decrement percentage will increase, and the total uplift force decrement percentage will decrease.

EFFECT OF DIVERSION DAM CONSTRUCTION ON WATER TEMPERATURE

Although diversion facilities are often regarded as environmentally friendly due to their lack of reservoirs, the cut-off walls change the flow patterns of the river. The diversion of water causes drops in water flow and changes in water temperature, which can result in declining local fish populations.

In 2013, the Pacific Salmon Foundation studied the salmon population near diversion projects in British Columbia. In 2016, the salmon populations dropped to their lowest level due to

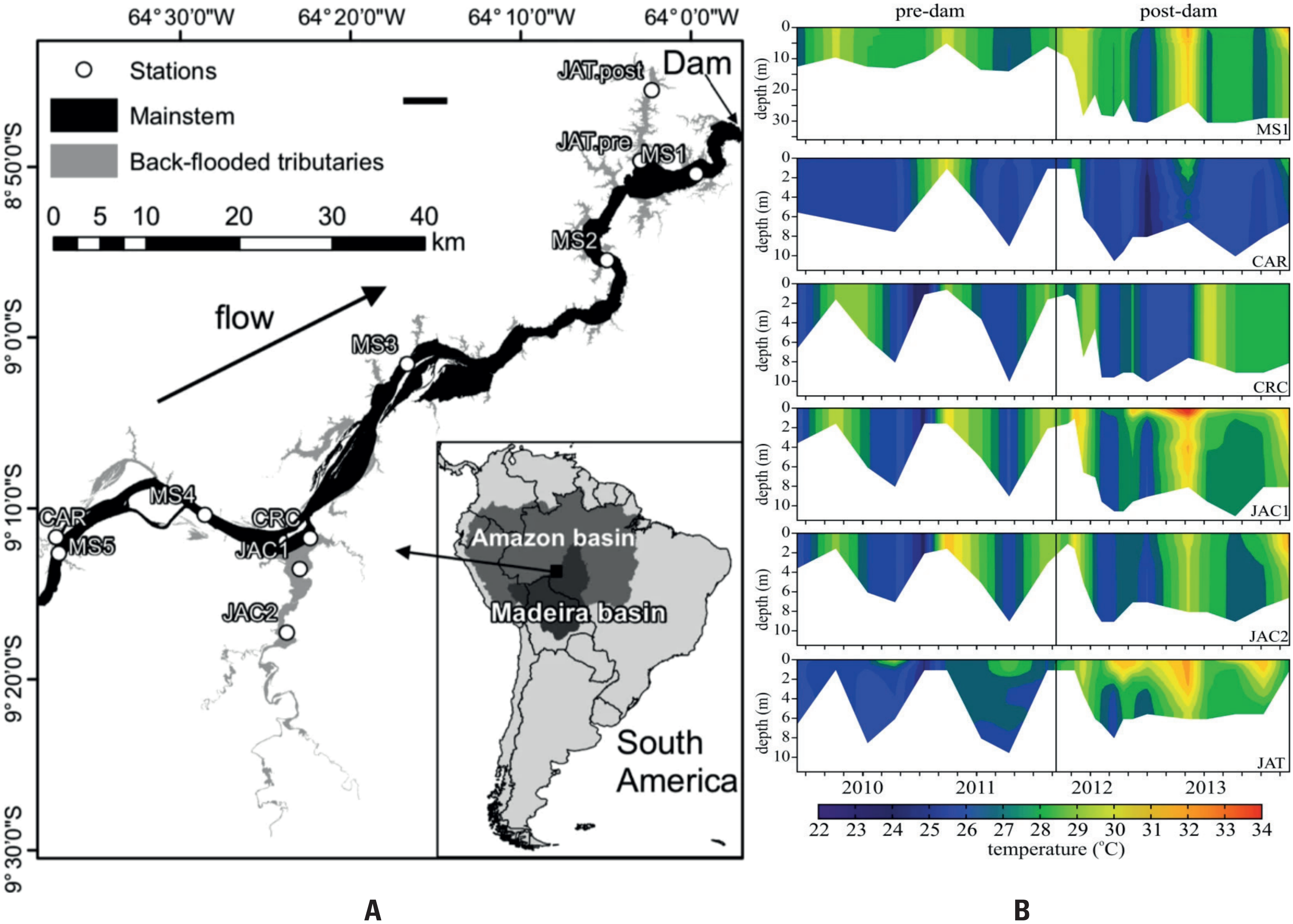

Figure 6: (a) Map of the Santo Antônio reservoir.
(b) Depth vs Time thermal profile before and after damming in Madeira River.
The vertical black line indicates dam closure. Note that the JAT station was moved further upstream after damming [9].

change in the Pacific Ocean's water temperature [6]. The main reason for this was most likely climate change and not the run-of-river facilities, but this emphasises the consequences of minor changes in water temperature.

Studies were done on the Santo Antonio reservoir on the Madeira River to show the effects of damming on the thermal profile. The dams created lentic conditions in the back-flooded tributaries, while the mainstream maintained lotic conditions. According to Figure 6(b), the mainstream remained isothermal, while the back-flooded tributaries (JAC1, JAC2, JAT) developed thermal stratification after damming. Of the three tributary valleys, JAT was the most strongly stratified [9]. The mainstream maintained its fast water flow, while the back-flooded tributaries became lacustrine. These results demonstrate that the change in the water flow of the river post damming can alter the thermal profile. As previously mentioned, the salmon population dropped to its lowest point after changes in water temperature. With that in mind, it can be assumed that the population of the species in the Madeira River were affected by the change in temperature.

PUMPED STORAGE FACILITIES

Pumped storage facilities are another form of hydropower that functions like a battery. This system functions by pumping water from a lower elevation to a higher elevation, which increases the stored water's potential energy. When electricity is needed, the water is released to the lower reservoir where it turns a turbine and generates electricity. Two types of pumped storage facilities exist, closed-loop and open-loop. Open-loop systems are connected to a naturally flowing water

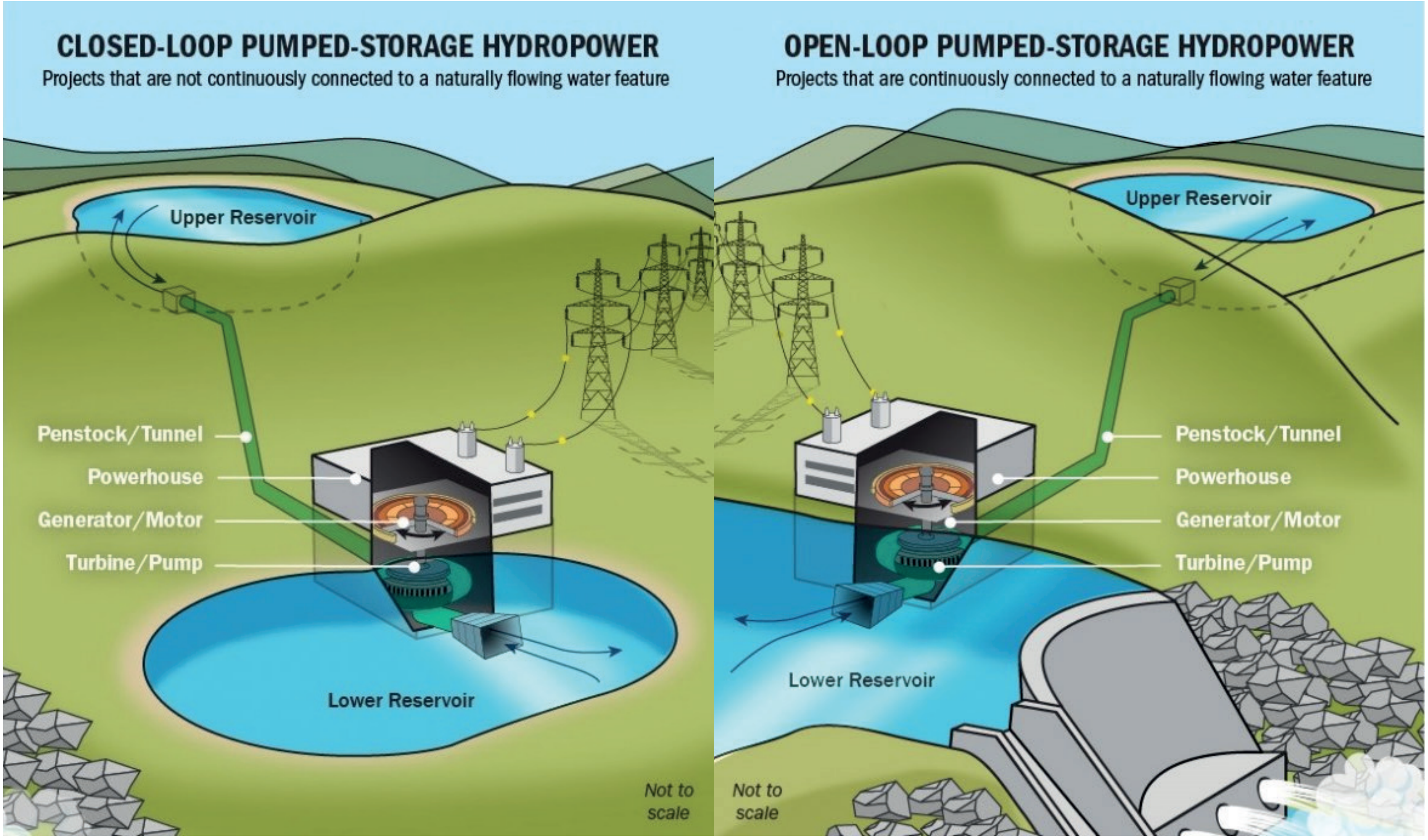

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Figure 7: Pumped storage facility structures.
(a) Closed-loop pumped storage hydropower. (b) Open-loop pumped storage hydropower [10].

feature, while closed-loop systems require a second reservoir.

The effects of a closed-loop pumped storage system are usually less severe than that of an open-loop system. This is because closed looped systems are situated off-stream, minimising aquatic and terrestrial impacts, and often have greater siting flexibility than open-loop system projects [11]. However, the geological effects of constructing two above-ground reservoirs rather than one outweigh the open-loop system because it impacts the soil and groundwater more.

ENHANCED-PUMPED-STORAGE

Brazil is heavily reliant on hydroelectricity to meet the energy needs of the country. In recent years, climate change has made it difficult for the country to keep up with its energy demand. The Amazon water basin has a hydropower potential of 106 GW, and if developed, it would generate 60% of Brazil's total hydroelectric capacity [12]. However, this would create a hydropower imbalance because more than half of the capacity would generate most of its energy during wet periods. This is an unreliable form of energy because there will be a shortage of energy during dry periods. A proposed solution is watersheds with an increased storage capacity [12]. This will allow the energy generated during the wet period to be stored so it can be utilised during the dry period.

Enhanced-Pumped-Storage is another proposal to improve the operation of dams and increase the energy storage capacity in Brazil. A combination of a pumped-storage site and a series of dams in cascade will increase the water storage capacity and utilise the dams' extra capacity to pump water to an upper reservoir [12]. The pumped-storage site is located at the top of the river, and this placement changes the seasonal hydroelectric power generation of the whole river. The enhanced-pumped storage stores energy during the wet season and generates electricity during the dry season. The reservoir can also store surplus energy generated from other intermittent renewable sources like wind and solar power [12]. Overall, this type of pumped-storage facility improves the operation of dams in cascade.

FUTURE DEVELOPMENTS IN HYDROELECTRICITY

The increase in the human population and economic growth is tightly linked to the rising demand for electricity. From 1993 to 2010, electricity production increased by 72%. 20% of the global electricity is accounted for by renewable energy, with hydropower contributing 80% to the total share [13]. Future hydropower is being pursued in developing countries and emerging economies like Southeast Asia, South America, and Africa. In March 2014, 3,700 dams with a capacity of 1 MW were either planned or built, and these dams are predicted to increase the global hydropower capacity from 980 GW to 1,700 GW within the next 10-20 years [13].

To maintain the value and contribution of hydropower, cost-effective solutions are needed to maintain the existing hydropower facilities and assess new opportunities for hydropower energy production. The US Department of Energy's Wind and Water Power Technologies Office plans to evaluate future low-carbon, renewable hydropower pathways.

The US is working on new designs and approaches to make hydropower more competitive with other energy generation technologies. Actions like standardising the equipment components, developing scalable structure designs, and exploring alternative hydropower design philosophies will lower costs, faster production, and less maintenance of the system [14].

The environmental impacts of hydropower must be considered when discussing the future development of this energy source. The re-accelerating of dams will lead to the fragmentation of 25 of the 120 large rivers, reducing the number of large free-flowing rivers by about 21% [13]. Before and after developing these dams, the flow regimes, water quality, sediment transport, habitat connectivity, fish passage and mortality, and culturally sensitive lands need to be closely monitored. Environmental stressors need to be observed with metrics and monitoring methodologies. Developers can apply the metrics to the siting, design, and post-construction monitoring phases [14].

CONCLUSION

Hydropower is a constantly evolving energy production system. Countries around the world are utilising this type of renewable energy. The three types of hydroelectric generating systems are currently not perfect, but it is a global mission to find ways to make the process more efficient and cost-effective.

Operational changes such as flood control and energy storage can substantially improve the efficiency of these facilities. Large-scale improvements like developing dams in series with a pumped-storage site can also significantly impact the overall efficiency.

Hydroelectricity is commonly viewed as a "clean" energy source; however, the environmental effects are concerning. River systems around the world are fragmented by dams which can be detrimental to the river ecosystems. Changes in riverine fragmentation, sediment retention, enhanced evaporation, and increased greenhouse-gas production have a significant impact on fish assemblages. Although hydropower is a better alternative to fossil fuels and nuclear energy, we must consider the environmental impact. The environment surrounding a potential dam structure should be studied, and proper precautions should be taken when designing and constructing these facilities to protect the ecosystem. wn

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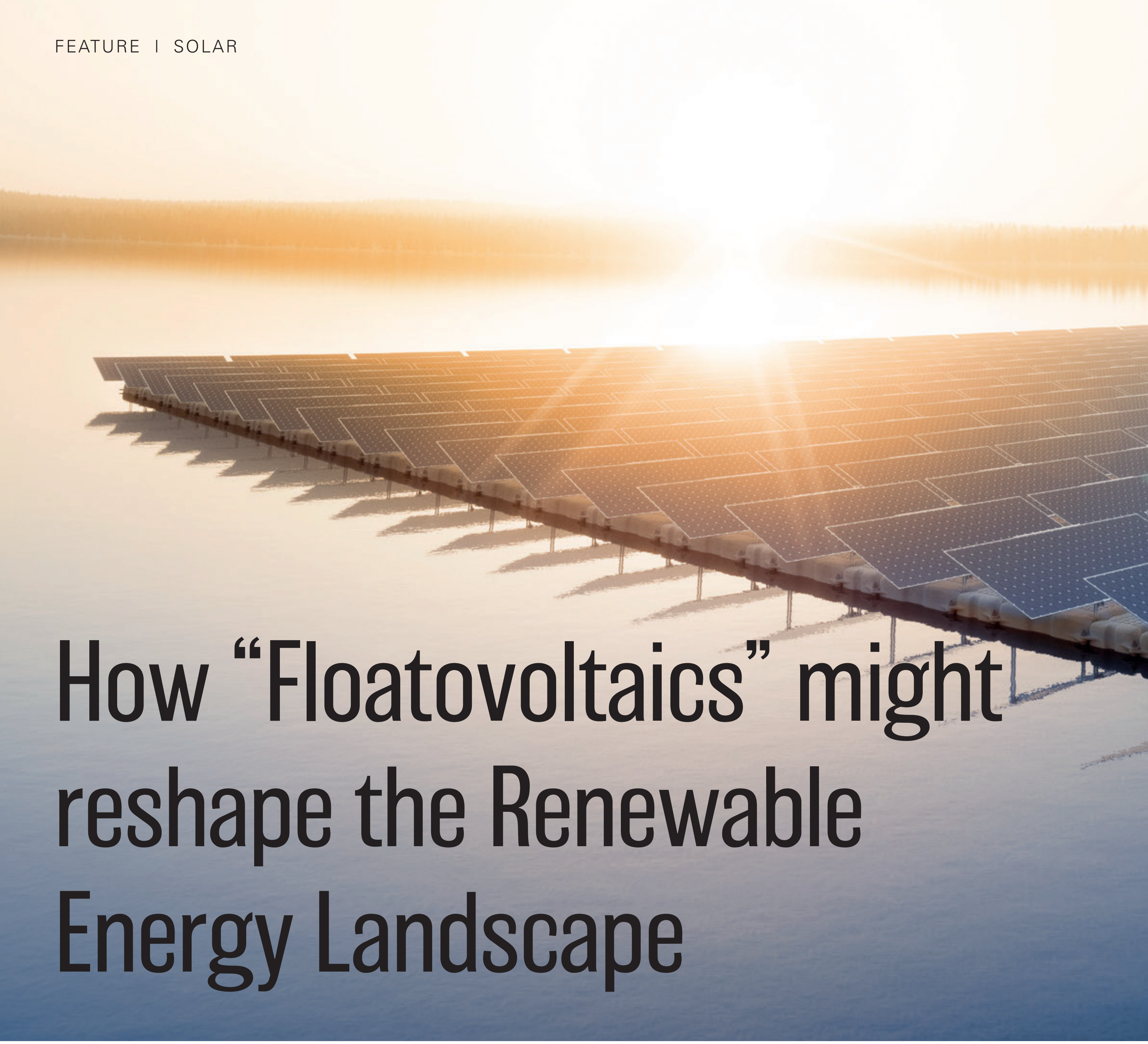

How "Floatovoltaics" might reshape the Renewable Energy Landscape

If a recent study from the US National Renewable Energy Laboratory is any indicator, one pairing that might become increasingly popular is solar and hydropower.

Solar and hydropower are two of the most utilised sources of sustainable energy globally. According to NREL, combining the two into a hybrid model could unlock thousands of terawatts of power. At the heart of this proposed hybrid model is an emerging technology called floating photovoltaics. Also known as floating solar or "floatovoltaics,"
FPV is when a solar array is designed and installed to float on a body of water instead of on land or building structures.

According to the NREL report, installing FPV systems on the world's hydropower station reservoirs could hypothetically provide 10,600 terawatt-hours of solar-only power. That figure

represents nearly half of the world's energy requirements, based on estimates that in 2018 the world consumed 22,300 terawatt-hours of electricity.

Regardless of the Hydro-FPV hybrid's potential impact, combining the two energy generation systems seems logical given their prominence.

Hydropower is responsible for almost 60% of the world's green power, while solar is the world's fastest-growing renewable energy source.

ADVANTAGES OF THE HYDRO-FPV HYBRID MODEL

The build-out of transmission lines can be one of the most cost-intensive aspects of installing any solar array.

The Hydro-FPV hybrid eliminates most of that cost by sharing the transmission infrastructure in place as part of the existing hydropower plant.

The second benefit of Hydro-FPV is that it makes two renewable energy sources that are inherently intermittent less so. Hydropower plants work best when it rains, and water levels rise, but cloud cover reduces the performance of solar. During dry and sunny seasons, hydro packs less punch, but solar generation increases. Though solar generates power only during the day, energy can be used to pump water up to storage reservoirs to be released at night to provide hydropower.

There are also advantages in how the hydro and solar power generation systems interact with each other. Solar arrays partially shade the water, which can reduce evaporation and keep water levels more consistent. They also decrease the growth of water-polluting algae.

Meanwhile, resting on water cools the solar panels, which can improve energy yields. Hydroelectric reservoirs also offer vast areas with minimal shade, which can help optimise solar power generation.

"Floating arrays can be easily oriented towards the sun direction and follow the sun's orbit during the day to have optimal coupling," said Dr Joop Mes, senior scientist at hydrology, meteorology and solar energy specialist OTT HydroMet.

Dr Mes added that FPV needs the same sort and amount of solar irradiation and weather instruments as land-based systems.

With few competing uses for the water surface behind reservoirs, the area may come at a bargain price for solar developers, compared with neighbouring land prices.

This cost reduction could make the Hydro-FPV hybrid model particularly appealing in urban areas serviced by hydropower.

FPV OPERATIONS AND MAINTENANCE

As the FPV sector grows, innovations drive down costs and address challenges that arise as part of the maturation process for any new energy generation system.

Streamlined production processes are driving reductions in the cost of FPV installations to the point where some can compete with land-based arrays. For example, because the support systems for FPV primarily consist of air, some developers are opting to have them fabricated locally rather than pay for shipping from a central manufacturing centre.

FPV can present unique logistical challenges when it comes to maintenance. For example, solar panels placed over water can experience increased bird soiling, so special care must be taken when selecting cleaning tools or solutions to reduce bird traffic.

Meanwhile, operations and maintenance tools already used for land-based arrays — such as inspection drones and smart inverters – are being adjusted for use with FPV.

Dr Mes said selecting the suitable kit of devices is essential for measuring water levels and monitoring data specific to the PV panels. "As the site might be difficult to access, low maintenance and proven stability of instruments help," he explained.

REAL-WORLD APPLICATIONS

Portugal was the first to create a Hydro-FPV hybrid system. In 2016, a 218-kilowatt floating solar array was installed at Alto Rabagão hydroelectric station in Portugal's Peneda-Gerês National Park.

In Brazil, the Sobradinho Dam's 1-megawatt FPV is expanding to provide 5 megawatts. A 30-megawatt FPV project is now being designed for Brazil's Batalha hydropower plant.

In the US, NREL estimates that putting FPV on about 24,000 reservoirs could generate enough power to account for 10% of the nation's energy production.

While the US lacks a history with the Hydro-FPV hybrid model, the nation's first FPV dates to 2008 and often is cited as the world's first commercial use of FPV.

Far Niente winery in California's Napa Valley wanted to use solar to power its entire facility, but it didn't want to give up 1.5 acres that could hold vineyards. So, instead, it floated almost 1,000 solar panels on its irrigation pond.

With an additional 306-panel, land-based solar array, solar provides all the electricity required by the winery and 13-acre estate.

The latest FPV installation in the US is part of an energy security and efficiency strategy at one of the world's largest military bases — Fort Bragg in North Carolina. Work on an FPV installation on a lake at the fort was slated to begin in November 2020. A 2-megawatt battery storage system is being built in tandem with the 1.1-megawatt FPV.

At 4.4 megawatts, the nation's largest FPV plant became operational in 2019 on a retention pond in Sayreville, NJ. The 12,700 floating solar panels provide all the power needed to run the Bordentown Avenue Water Treatment Plant.

These projects track with research from the World Bank, Energy Sector Management Assistance Program and the Solar Energy Research Institute of Singapore, which found FPV projects ranging from 1 to 5 megawatts, mainly for water utilities and commercial and industrial customers installing FPV systems onsite consumption, offer the most market potential.

WHAT'S NEXT

While NREL, the World Bank and other entities tout the potential of the Hydro-FPV hybrid model, challenges remain. Any operation that includes water and power generation is bound to require enhanced safety protocols, but the US does not yet have regulations specific to FPV.

The permitting process for the 4.4-megawatt FPV project in New Jersey took two and half years, but that process is expected to be streamlined as more projects come online soon.

Be it small commercial projects that power the operations of an individual business or large Hydro-FPV hybrid projects that help power entire regions, FPV technology is positioned to play a vital role in generating energy across the US and around the world.

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The new era of energy management

HOW TO REDUCE YOUR OPEX WHILE ACHIEVING SUSTAINABILITY

—Most companies today are lacking an effective strategy to manage their energy consumption and keep costs under control. This white paper will help energy and facility managers understand why data-driven energy management solutions are gaining traction for optimising energy efficiency, availability and environmental sustainability.

THE GROWTH OF ENERGY CONSUMPTION

To compete effectively, organisations must adopt revolutionary plans to manage and optimise their operational performance, utilising cutting-edge digital technologies and leveraging the power of the Internet of Things (IoT).

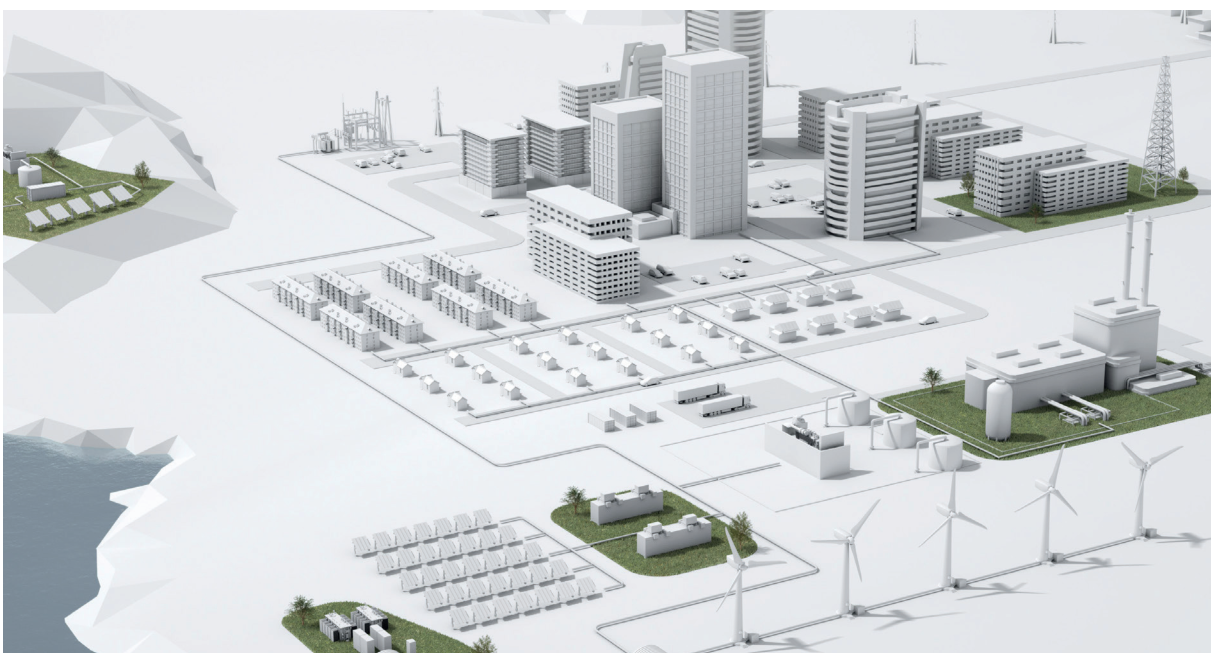
The buildings where we live, work and entertain, absorb more than 42% of the world's energy consumption due to heating, cooling and lighting systems. Over the next 25 years, worldwide energy demand is expected to grow by over 40%, calling out an urgent need for energy efficiency and sustainability.

This strong growth in energy demand is shaping the complexity of power distribution systems at all levels. Power grids are becoming more dynamic to manage distributed energy resources (DER), while private and public companies are taking up the challenge by creating environments capable of self-sustaining.

Additionally, more than half of power-outage events in buildings, both commercial and industrial, can be attributed to problems with equipment and inadequate electrical distribution systems that absorb more power than required. Given this situation, the need to optimise energy consumption and costs and power reliability is more prevalent now than ever. This especially applies to critical sectors such as public health buildings, data centres, public infrastructures and continuous-process manufacturing facilities.

Digitalisation enabled by the IoT is pivotal to support the growth of energy demand and its challenges. Turning data into productivity gains while lowering consumption and costs could help organisations achieve environmental sustainability through reduced emissions.

Figure 1: A conceptual smart city that utilizes distributed energy resources such as solar and wind power



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MEASURING AND MONITORING ELECTRICAL SYSTEMS

Often, organisations do not have control over their energy consumption nor an accurate methodology to inform them how their site or building operates. To reap the full benefits of digitalisation, organisations must first understand how much energy is being consumed. Thus, the first and most important step in energy management is to identify a baseline and the behaviour of the electrical system.

Metering provides energy managers and operators reliable information, real-time or aggregated, on energy usage. Most often, an energy data and analysis backbone coupled with a robust plant-energy model will reveal patterns of energy waste that would be impossible to see otherwise.

Moreover, depending on the organisation's needs, adding more measuring points can significantly increase the reading accuracy, thus providing better insights about installation and more data on optimisation actions. Meters should be installed at different installation levels to measure individual loads or groups of loads (homogeneous) to cover at least 70% of power consumption.

Improvements based on metering have been shown to reduce energy consumption by as much as 45%.2 But while most organisations understand the importance of measuring and monitoring, only a small number of organisations implement an effective strategy for energy management. Organisations typically undertake independent and uncoordinated projects, primarily small and short-term, due to a lack of knowledge and methodology. Such an approach leads to outcomes that are well below expectations. Energy monitoring is seen of little value, even though a well-organised system of measuring and monitoring would pay back in a short time due to lower energy and maintenance costs and negligible power outages.

Measuring technologies, applied to monitoring a building for efficiency purposes, can be extended to water, gas, and heat metering, providing a comprehensive visualisation that could give an overall picture of operating conditions. Sensors that read conditions such as temperature, pressure or humidity, coupled with analytics and, in some cases, machine learning (ML) technologies, are also starting to play a crucial role, unlocking the potential to understand more in-depth, unexpected behaviours.

Benchmarking energy consumption and electrical-system parameters is generally based on annual history, while observation is most relevant in a year-over-year comparison. Short-term analysis, such as month-over-month comparison, could also be valuable for identifying specific events occurring in a determined period. But benchmarking cannot be accurate without constancy: continuous monitoring is necessary to tell if a sample represents a good or inferior status. Such an approach is also the base for energy-efficiency processes and strategies in production environments.

For example, Energy Performance

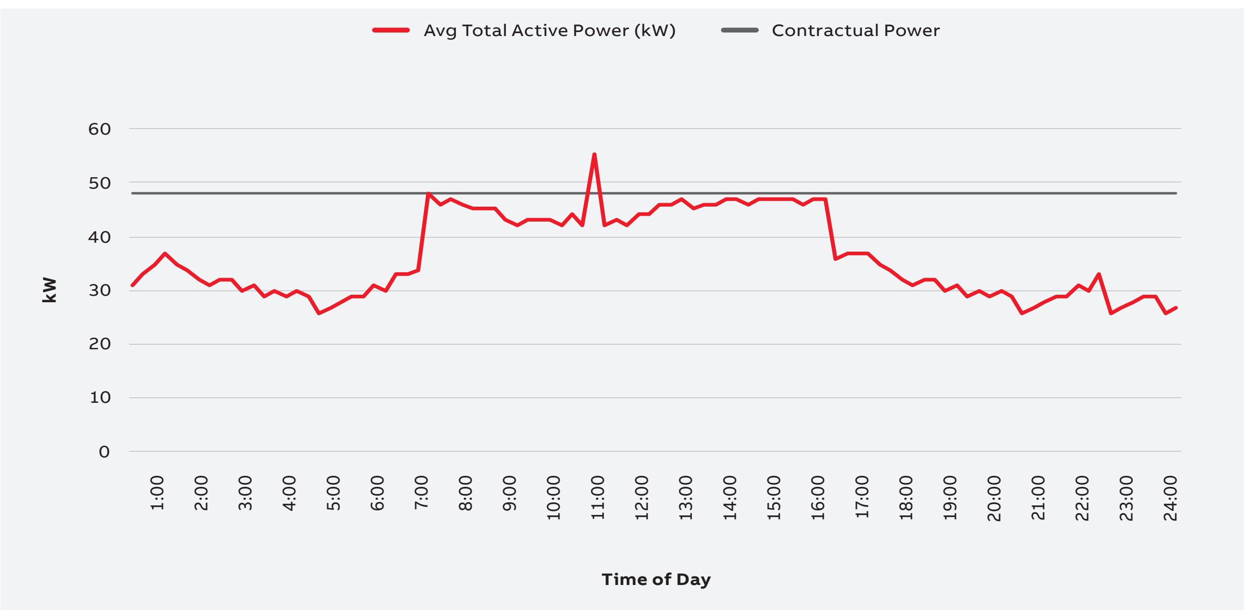

Figure 2: Hypothetical representation of a building's power absorption over a typical day

Indicators (EnPI), mainly used to acquire certifications or as a base for energy audits, provide the highest potential to identify paths and the effects of interventions - but only if they are continuous and structured.

In numbers, let's assume that a 5% energy efficiency improvement - relatively easy to achieve with a metering system installed3 - can reduce electricity consumption by approximately 5%. Let's assume that the organisation's industrial production site (which include a solar rooftop) incurs an average energy cost of EUR 800.000 per year. By measuring and monitoring the electrical distribution system, the organisation can save thousands of Euros, if not hundreds of thousands annually. In our hypothetical example, the cost savings on the energy bill amount to EUR 40.000 per year.

Without access to data, organisations are subject to inefficiencies in diagnosing and fixing problems. For example, if a piece of equipment is not behaving correctly, the plant or energy manager sends a maintenance crew to investigate the issue. If the problem with the equipment is mechanical, it can be fixed. But if the nature of the problem is different (such as voltage imbalances), it could lead to a lot of guesswork and effort and money wasted without results. Data accessibility and reliable information will decrease the time it takes to identify the problem and remediate it.

INTELLIGENT ENERGY OPTIMIZATION

Energy monitoring is not the only solution to maximising energy efficiency. Intelligent energy optimisation also plays an important role. In general terms, energy optimisation means optimising energy usage to maximise benefits for people and the environment and consists of three concurrent strategies: saving energy, managing demand response and using renewable energy sources. Thus, energy optimisation solves multiple challenges that impact not only the electrical distribution system but load management. An advanced energy optimisation solution enables sustainability through active management of site equipment (which helps reduce CO_2 emissions) and decentralises energy generation.

Intelligent energy optimisation can help customers use energy in concert with a dynamic power grid and distributed energy resources while enhancing a shift from fossil fuels to greener energy sources. Therefore, it can support the creation of smart grids (and eventually "smart cities") within commercial and industrial sites and decentralise the responsibility of generating energy and contributing to the market. Several studies4-5 predict that energy optimisation solutions can lead to as much as 25% energy and cost savings - by shifting or shedding loads, for example - dramatically shrinking an organisation's investment payback period. In our hypothetical example, adopting an intelligent energy

Figure 3: ABB AbilityTM Energy Management interface

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optimisation solution could lead to a lower energy bill - approximately EUR 200.000/ year - and potential revenues whenever energy surplus is shared with the grid.

Facility management beyond electricity
As a complex system, a commercial or industrial site will have sources of energy other than electricity, such as fuels, steam, heat, compressed air and other media6, as well as other utilities (water, gas). These sources should also serve the purpose of efficiency.

Key performance indicators (KPIs) for these sources are often included in energy audits (inspection surveys that seek to prioritise the most effective opportunities for energy and other utilities savings).

In a multi-energy/utility building, efficiency can be achieved by coordinating the different sources and utilising storage technologies such as batteries, TES, and supercapacitors, potentially creating independent micro-grids. Therefore, facility optimisation as a whole provides a leading approach for the effective peak-shaving of electricity or heat demand, efficient use of renewable energy, low-cost carbon capture and distributed energy systems.7

Most organisations, however, are still far from implementing a monitoring and optimisation strategy for their facilities. Barriers include the high cost of optimisation systems as well as still-present technological limitations. To be sure, exploiting data from multiple energy sources and utilities could help organisations achieve their most challenging environmental and sustainability targets. The good news is that digitalisation enabled by the IoT is continuing to evolve, making the adoption of reliable and low-cost cloud or hybrid offerings easier than ever.

THE BENEFITS OF POWER MONITORING AND ENERGY MANAGEMENT

As we mentioned, companies with power monitoring and energy management systems can achieve significant cost and maintenance savings by continually assessing their operational data.

In most cases, these savings directly impact the P&L bottom line. That said, there could also be under-evaluated benefits that are less obvious:

ENERGY BILL VERIFICATION

A commercial bill usually provides only bottom- line power usage and penalty charges. Often there is no way for the user to verify the correctness or analyse these values. Installing an energy management system can provide robust but straightforward intelligence. For example, the ability to read kilowatt-hours and active/reactive power and compare that data with tariffs published in the contract will help identify errors or misreadings.

MULTI-UTILITY VALIDATION

A commercial or industrial site generally has different providers for energy, water and other utilities. The bills (i.e. water) are usually based on different timeframes (i.e. monthly, bimonthly, quarterly, etc.) and are often not checked or controlled accurately. Small but continuous leakages often go undetected for long periods, leading to unexpectedly high charges. Data monitoring can support the alerting and early detection of leakages, allowing for timely intervention and cost savings.

TRACK LOAD PROFILES

Tracking the load profiles helps to identify early signs of poor equipment health. Let's assume that, from the time of installation, a typical power load peaks at 6 a.m. and drops off at the end of the day. Tracking the load will immediately help spot a change in that pattern, revealing an underlying potential problem - for example, a malfunctioning compressor or equipment left running overnight. Data comparison can support the energy/ facility manager in assessing the situation and planning for a correction before the problem becomes severe.

MULTI-SITE COMPARISON

Better quality and continuous flow of information will have a significant impact on organisations with a multi-site structure. A more accurate comparison between different facilities that might be similar will allow harmonisation of operations and costs. Let's say there are two equivalent production lines in two different facilities. One production line performs below par, consuming more energy than the other due to poorly functioning equipment. A multi-site comparison of power consumption and power quality helps pinpoint where the problem is, allowing for the appropriate corrective action.

MAXIMISE EQUIPMENT PERFORMANCE

Harmonic distortion caused by nonlinear loads is a common issue that can damage electrical components. In the same way, transients, swells and under/over voltage events can harm equipment. For example, a mere 5% harmonic distortion within transformers can result in a 25% loss of capacity. Similarly, large motor imbalances will cause inefficient performance, potentially leading to a large amount of wasted energy8 and an increased probability of failure. Power-quality management features coupled with general device information can help identify the problem early so that damage and downtime can be minimised, if not eliminated.

ENERGY MANAGEMENT AS SAAS (SOFTWARE-AS-A-SERVICE)

A few years ago, building and facility operators were limited to basic on-premise power monitoring systems, while most advanced energy management systems were based on complex and expensive solutions. Few systems allowed upgrading, and almost all required the on-site intervention of a dedicated team.

Also, few smart devices were available, with connectivity limited to a small amount of data and almost no ability to upgrade once installed. Additionally, especially in brownfield projects, measuring points and smarter devices were selected based on loads dimension rather than usefulness in strategically monitoring the system.

Lately, however, the market has seen a steady increase of smart devices with higher accuracy and more monitored parameters. Operators, supported by new regulations and certifications, are becoming more focused on identifying the correct measuring points to yield the best and most accurate information.

New digital technologies are strongly shifting the market toward affordable hybrid/cloud-based solutions supported by a SaaS model, thus providing flexibility in upgrades, add-ons and pricing.

The market for energy management and power monitoring systems is changing radically. IoT platforms for energy management are quickly emerging for industrial, commercial and residential applications with their defining characteristics. By unlocking the potential of cloud infrastructure, these platforms make possible instantaneous, unlimited and global access to information anytime, anywhere, at an affordable price. More complex analytics can run smoothly with a higher quantity of data processed in a shorter period, dramatically accelerating feedbacks and outputs, resulting in increased efficiency, innovation and value creation.

With a few clicks and minimal investment, operators can migrate from a simple and basic energy management solution that offers dashboards for real-time visibility of energy usage. Alerts for abnormal conditions and detailed reports to a more sophisticated version with features like advanced power analytics, power quality analysis, power forecasting and intelligent alerting. These "smart" capabilities give operators the valuable information they need for their specific application or system.

SEIZING THE FUTURE OF ENERGY MANAGEMENT

Energy's future will embrace new value chains interconnected by digital technologies with the continuous, multi-directional data flow. All stakeholders will add their value to the system, ensuring higher overall efficiency at all levels, from production to the final consumer. Complex or straightforward energy management systems will play a pivotal role in this changing ecosystem, promising to generate massive ROI through improved efficiency, yield and asset availability.

Digital transformation will also include artificial intelligence (AI) and machine learning (ML) technologies. These advanced technologies are being developed to help commercial and industrial buildings predict unexpected behaviours related to energy consumption and power quality, and asset reliability, leading to even greater energy efficiency. The most advanced applications will include industry-specific solutions, which will offer the possibility of adopting future technology. For most organisations, a substantial shift in thinking, along with changes to their existing energy infrastructure, will be required to capitalise on next-generation digital technologies. The time for that change is now. After all, organisations have a social responsibility to become more efficient, greener and more sustainable. As energy demand grows, it is undeniable that integrated energy management is a fundamental component of that future. wn

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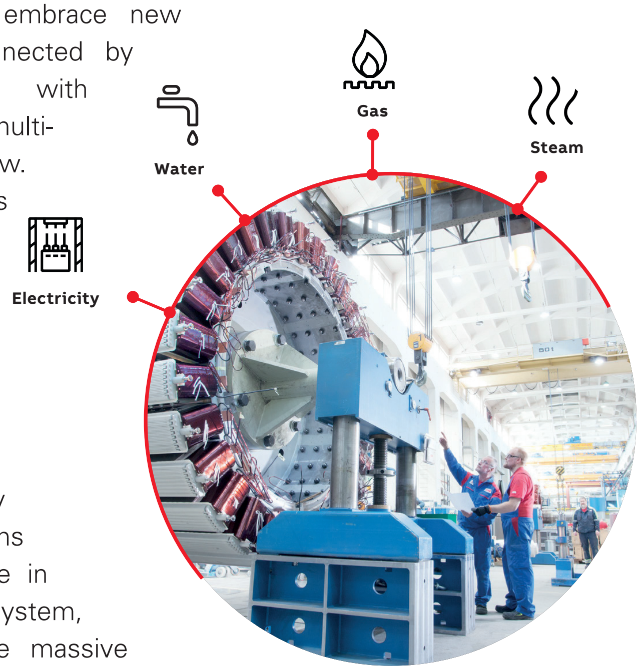


MARKET STATUS

The 93 GW of new installations brings global cumulative wind power capacity up to 743 GW. In the onshore market, 86.9 GW was installed, an increase of 59% compared to 2019. China and the US remained the world's largest markets for new onshore additions. The world's two major economies together increased their market share by 15% to 76%, driven by the Feed-in Tariff (FiT) cut-off in China and the scheduled phase-out of the full-rate Production Tax Credit (PTC) in the US, respectively.

On the regional level, 2020 was also a record year for onshore installations in the Asia Pacific, North America and Latin America. The three regions combined installed a total of 74 GW of new onshore wind capacity last year or 76% more than the previous year. Due to the slow recovery of onshore installations in Germany last year, Europe saw only a 0.6% YoY growth in new onshore wind installations. Developing markets in Africa and the Middle East reported 8.2 GW onshore installations last year, almost the same as in 2019.

2020 A record year for the wind industry

- GLOBAL WIND REPORT 2021

2020 was the best year in history for the global wind industry showing year-over-year (YoY) growth of 53%. Installing more than 93 GW wind power in a challenging year with disruption to both the global supply chain and project construction has demonstrated the incredible resilience of the wind industry.

6.1 GW was commissioned worldwide last year in the offshore market, making 2020 the second-best year ever. China installed half of all new global offshore wind capacity in a record year. Europe recorded steady growth, with the Netherlands taking the lead, followed by Belgium, the UK, Germany and Portugal. The US and South Korea shared the remaining new offshore wind installations in 2020. Total offshore wind capacity has now passed 35 GW, representing 4.8% of total global cumulative wind capacity.

MARKET DYNAMICS

While the first half of 2020 saw auctions being postponed or cancelled due to COVID-19, the sector bounced back with vigour in the second half of the year as key mature and emerging wind markets began to overcome the impacts of the pandemic. According to the Global Wind Energy Council (GWEC) Market Intelligence, nearly 30 GW of new wind power capacity was awarded globally through auctions in the second half of 2020, which is a slight increase compared to the 28 GW awarded during H2 2019. Although only 1 GW offshore wind capacity was awarded through auctions worldwide, more than 7 GW offshore wind auctions/ tenders were launched in 2020. This surge in new capacity to be auctioned is a clear signal that the industry is back on track and that the global pipeline of wind power projects continues to grow.

Through technology innovations and economies of scale, 2020 saw wind power continue to build its competitive advantage throughout the world. Last summer, a consortium of Shell and Eneco won the third zero-subsidy offshore wind tender in the Netherlands. In Latin America, as wind power already had very competitive prices, private auctions or bilateral PPAs have already emerged as an alternative mechanism to government auctions to drive growth. According to BloombergNEF, 6.5 GW wind power was signed through corporate PPAs globally last year, 29% lower than the previous year. Because COVID-19 disruptions worldwide have caused revenues to plummet for many corporates, the level of commitment to sustainable green energy remains impressive.

Last year also witnessed governments of countries such as China, Japan and South Korea making net-zero/carbon neutrality commitments. Similar commitments were also made by major corporates, including oil and gas companies. Completing a systematic and radical energy transition from fossil fuels to renewable energy and low-carbon solutions is imperative to reach the net-zero targets. The current crisis offers a unique window of opportunity to put the world on a sustainable trajectory and meet our international climate goals. Still, we must act now - or miss the opportunity. Although reaching net-zero will require bold actions by many sectors and actors, wind power is one of the cornerstones of green recovery. It plays an essential role in accelerating the global energy transition.

MARKET OUTLOOK

After an unusual 2020, global wind market growth is likely to slow down in the near term primarily due to an expected drop in onshore installations in China and the US following the expiry of incentive schemes. Nevertheless, the market outlook for our forecast period remains positive. GWEC Market Intelligence expects that over 469 GW of new onshore and offshore wind capacity will be added in the next five years - nearly 94 GW of new installations annually until 2025, based on present policies pipelines. We hope and expect that governments will significantly increase their ambitions and targets following COP26, and for that reason, we are upwardly revising our forecasts for the GWR2022.

The CAGR for onshore wind in the next five years is 0.3%, and GWEC expects an annual installation of 79.8 GW. In total, 399 GW is likely to be built in 2021-2025. The CAGR for offshore wind in the next five years is 31.5%. The level of annual installations is likely to quadruple by 2025 from 6.1 GW in 2020, bringing offshore's market share in global new installations from today's 6.5% to 21% by 2025. In total, more than 70 GW offshore is expected to be added worldwide in 2021-2025.

WIND ENERGY'S ROLE ON THE ROAD TO NET ZERO

Like a high-resolution satellite image, 2020 offered a sharpened reality of the state of our planet. The COVID-19 pandemic brought greater recognition to the consequences of human development on the natural world and the cascading knock-on effects an event can wield on our economies, livelihoods and security.

As policymakers chart the way out of the pandemic and emissions show signs of returning to pre-pandemic levels in the world's fastest-growing economies, there is unprecedented agreement that climate change is the true global emergency. The concept of a runaway threat crippling the entire world is now not only credible but relatable. This has prompted the UN to underscore the call for urgent action to reach net-zero greenhouse gas (GHG) emissions by 2050 – a call which has since been echoed by more than 120 countries representing over half of global GDP, alongside thousands of businesses, investors, cities, regions and universities.

It is worth looking back at a long year in which the global wind industry demonstrated its resilience and its role in green recovery. But the events of 2020 also defined the outlines of what lies ahead: the role of wind energy in a carbon-neutral world.

THE PANDEMIC ACCELERATES SHIFTS IN THE GLOBAL ENERGY MATRIX

The pandemic cast a long shadow across the world, posing a challenge to economies and the global wind industry as never before. Its impacts reverberated throughout the wind supply chain, disrupting manufacturing and export flows. From the US to South Africa, projects were hit by delays.

While some impacts were temporary, the pandemic also accelerated energy shifts already in motion. According to the IEA, global energy demand declined by roughly 5% in 2020, including falls of 8% and 7% for oil and coal demand, respectively. Credit agencies are now expecting global oil demand to continue declining steadily over the next decade. In its most conservative outlook, BP forecasted peak oil demand as soon as 2025. Last year, CAPEX committed to offshore wind overtook investment in 2100 Warming projections offshore oil and gas for the first time.

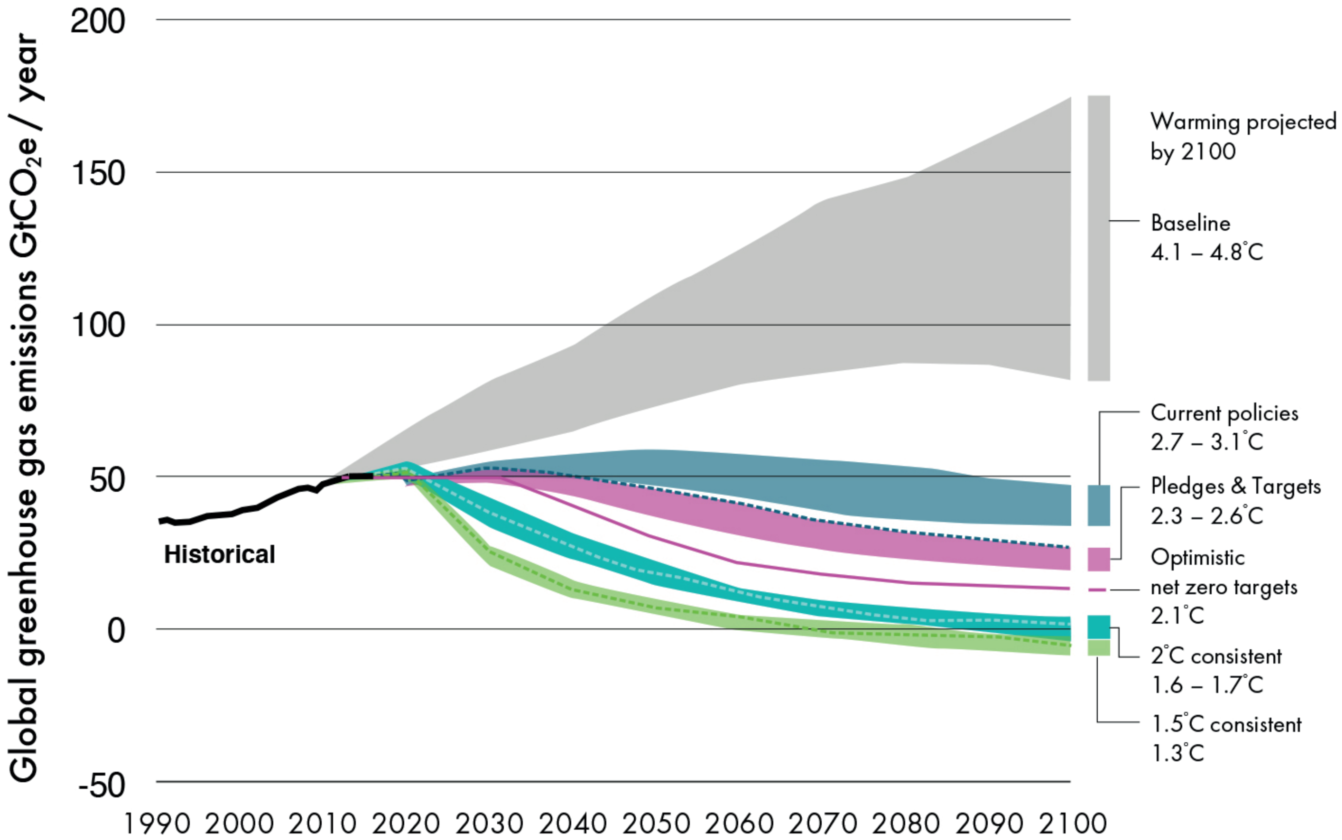
There are calls to phase out coal and the financing of new coal plants from the EU to sizeable Japanese trading houses to the world's most significant investment funds and development finance institutions. Although coal reduction still lags in parts of Eastern Europe, in 2020, renewables generated more electricity in the EU than fossil fuels for the first time, powered by 14.7GW of new wind plants reaching grid connection.

2020 also saw milestone commitments to carbon neutrality, with the EU, Japan, South Korea, Canada and South Africa each pledging to reach net-zero by 2050. Combined with China's net-zero by 2060 target and the US intention to reach net-zero by 2050 under the Biden administration, countries that have adopted or considered net-zero targets now represent two-thirds of the global economy and 63% of global GHG emissions.

These are no longer just market trends, at least in the sense of cyclical movements. It is more apparent than ever that the era of fossil fuels is over, and the global energy transition is here to stay. 2020 presented a once-in-a-generation opportunity to reset human development. The question is whether we can turn the newfound sense of optimism and urgency into accelerated implementation and deliver the transition in time. 2021 must be the time to turn long-horizon net-zero roadmaps into actions via concrete policy interventions, interim target- setting and robust delivery plans. Otherwise, even in the most optimistic scenarios, we will miss our Paris targets.

2100 Warming projections

Emissions and expected warming based on pledges and current policies



Source: Climate Action Tracker, December 2020.

 - continues from page 51

WIND ENERGY'S ROLE IN ACHIEVING NET-ZERO

One year on, from the beginning of the pandemic, the wind industry has demonstrated incredible resilience. In Q2 2020, GWEC Market Intelligence predicted a 20-30% reduction to the end-of-year forecast. But the industry more than bounced back to deliver a record year of growth with 93 GW, spurred mainly by installations in China.

Investment in offshore wind surpassed 2019 levels to reach US$303 billion in 2020, partly due to the sector's longer project development timelines which are more resilient to the pandemic impacts.

While jobs have been lost and projects delayed, the global wind industry defied expectations and is set to continue growing at a steady pace. Before 2025, the industry will exceed 1TW in global cumulative installations of onshore and offshore wind, according to GWEC Market Intelligence.

Cost reduction from larger turbines, innovations in installation/ O&M and reduced investor risk will further drive deployment: Out to 2030, IRENA expects average LCOE of onshore wind to continue declining by 25% from 2018 levels, while offshore wind LCOE will shrink 55% from 2018.

But accelerated growth of wind and renewable energy is required to "bend the curve" and put us on a trajectory that can limit global warming to "well below" 2°C, as set out in the Paris Agreement. Current policies are propelling us towards a 2.9°C pathway by 2100. If all pledges and NDCs as of December 2020 were implemented, we might reach 2.1°C and miss a net-zero by 2050 target.

With a few exceptions, the energy sector, which makes up around three-quarters of global GHG emissions, is characterised by long investment and development timelines – an accelerated pace for change must be set now. Every year we fall short of the dramatic action needed to change our pathway deepens the decarbonisation cuts required in years to come, and locks in the devastating burdens of climate change for future generations.

Fossil fuel-based capacity needs to be phased out concurrent to an increasingly steep expansion of renewables and related infrastructure to have a chance of meeting the Paris targets. For wind, annual deployment must surge to around 180 GW, according to IRENA's Transforming Energy Scenario. Under the IEA's Net-Zero by 2050 scenario, annual run rates for wind would need to be even steeper, reaching 160 GW by 2025 and then 280 GW by 2030 – 3 times the volume built-in 2020.

Over the next ten years, international institutions are calling for profound system transformation to take place. The UN Race for Zero has pegged the tipping point in the clean power sector as reaching a 60% renewable energy share in the global power mix, including 30% from wind and solar power. Total annual global investment in clean power and enabling system infrastructure needs to rise from US$380 billion in 2020 to $1.6 trillion by 2030, according to the IEA.

The backdrop of most energy transition scenarios combines large-scale renewable energy generation, widescale electrification (particularly in the power, industry and short-distance transport sectors) and energy efficiency measures. A mix of innovative technologies, from green hydrogen to digitalisation and storage solutions, will be required to enable high rates of renewables penetration, adequate security and flexibility of the power system and decarbonisation of hard-to-abate sectors. These scenarios require the decarbonisation of molecules, not just electrons.

Can we more than treble the volume of wind energy projects being installed worldwide over the next ten years? Onshore wind is already a mature and mainstream energy source that is cost-competitive with new coal/ gas plants. In many markets, it undercuts the operating costs of fully depreciated conventional generation assets. There is expanding recognition of the economic growth, job creation, water consumption savings and health cost savings attached to wind energy. Meanwhile, initiatives like the UN-linked Ocean Panel and Ocean Renewable Energy Action Coalition have highlighted offshore wind as a vital technology that will provide 10% of the needed carbon mitigation by 2050 for a 1.5°C pathway.

But in practical terms, the scale of build envisioned by 2030 means that actions to set the global wind industry on this path need to be taken now, given the time required for policy commitments to materialise, project development, financing decisions and more. Increasing capacity for wind and renewables will also require urgent forward-planning of infrastructure and grid buildout and investment in storage technologies and demand-side management.

Even a concentrated sprint of action in the run-up to COP26 in November 2021 will not be enough to win the race to net zero. Policymakers must adopt the principle of continuous improvement in line with the "ratchet mechanism" of the Paris Agreement and continue to push for higher ambitions at regular intervals to bend the curve.

Working together to accelerate wind energy deployment
In every significant institutional scenario for energy system transformation, the wind market must rapidly expand over the next decade. The industry must be resoundingly clear that this growth will not happen spontaneously and requires urgent policy interventions worldwide.

A "CLIMATE EMERGENCY" APPROACH TO ACTING NOW

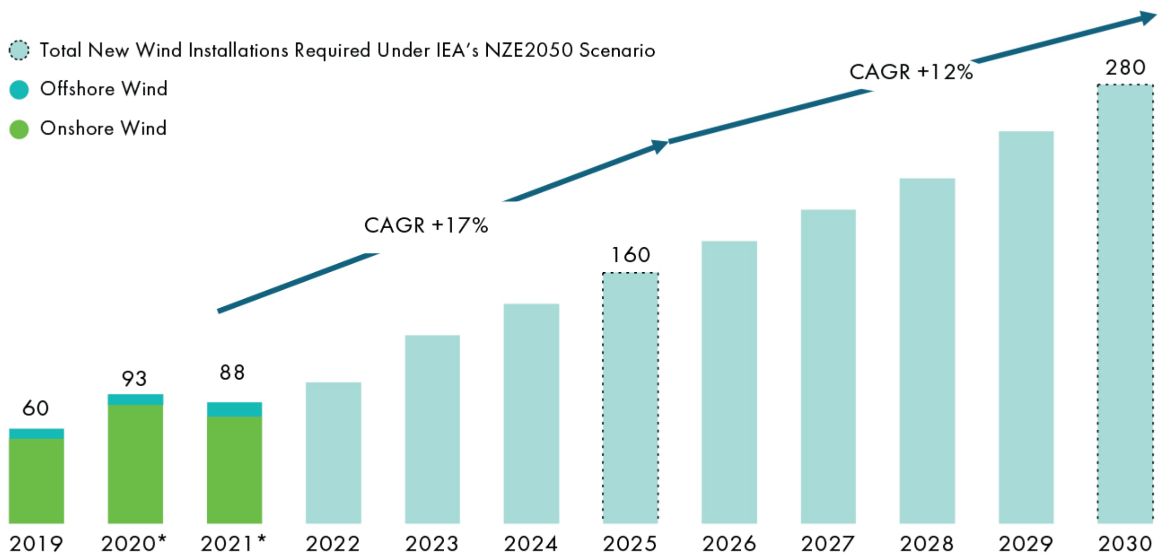
As with wartime-era measures, the experience in 2020 demonstrated the mandate for governments to act in a crisis and free up bandwidth for public institutions. As we freewheel forwards on an "off-track" pathway to 2050, governments should similarly react to convene resources to scale up the deployment of renewable energy radically. Among other measures, this could entail:

- Committing to ambitious capacity targets for wind energy which increase over time;
- Granting "must-run" status, priority dispatch and priority grid connection to wind and renewable projects;
- Categorising wind projects as nationally significant and critical infrastructure, with improvements to streamline permitting and simplify license applications;
- Investing in long-term grid and transmission planning and infrastructure;
- Safeguarding existing and awarded wind projects and avoiding retroactive changes to approved remuneration schemes;
- Enabling open-access regulation for a bilateral market of renewable energy;
- Creating policy frameworks for repowering of older wind plants in mature wind markets;
- Accelerating net-zero commitments, carbon budgets, carbon pricing and science-based approaches among government bodies, and sense-checking reliance on CO_2 removal technologies in net-zero plans; and
- Creating frameworks for a just transition, including ending direct and indirect subsidies for fossil fuel plants, providing fair compensation for early retirement of conventional assets and redirecting subsidies into worker training funds and diversity strategies for workforce development.

Policy and regulation provide the signals to the private sector for action and investment, allowing for economic decision-making. Making benefits and consequences clear to businesses via "pull" signals like targets and "push" signals like taxes will allow a business to reorganise in line with a carbon-neutral pathway.

The last year has demonstrated that investment in the wind industry is plentiful. The pandemic has tipped

Annual wind installations must increase dramatically to reach net zero by 2050
New global wind installations (GW)



Source: GWEC Market Intelligence; IEA World Energy Outlook (2020), volume in 2022-2024 and 2026-2029 are estimates the scales, irreversibly, for private investment in clean energy. In the first half of 2020 alone, while overall investment in power generation slumped, offshore wind financing quadrupled compared to the same period in 2019, reaching US$35 billion.

Retail and institutional investors increasingly view clean energy as a safe harbour. Significant utilities like Engie, Enel Green Power, Iberdrola, TEPCO and KEPCO have been future-proofing their balance sheets by increasing investment in clean energy assets and avoiding the risk of stranded assets.

The challenge will be deploying capital into bankable wind projects at a good rhythm to accelerate annual installations to the near-200 GW level. In 2020, there were more credit rating downgrades for emerging markets and developing countries than in all previous economic crises over the last 40 years. For emerging economies, the pandemic has raised the spectre of higher financing costs due to increased fiscal pressure on the balance sheets of public utilities and grid operators and higher regulatory, currency and counterparty risks.

Greater coordination is needed to de-risk climate and renewable energy finance in emerging economies. Temporary debt suspension by actors like the G20 and IMF will not be enough. Governments should work together with multilateral development banks (MDBs), development finance institutions (DFIs) and the financial sector to create financing mechanisms that build on the solid economics of wind energy, record- low global interest rates and the availability of low-cost funding for renewables and storage capacity.

Such mechanisms could be developed with an "emergency" or "rapid response" approach to quickly support emerging economies and redirect private financial flows to climate change mitigation solutions like wind energy.

FROM HYDROCARBONS TO ELECTRONS

The central logic of the road to net-zero will be to electrify everything we can in line with a cost-optimal clean energy transition. Widescale direct electrification can leverage existing technologies, with wind and renewable energy dispatched to power homes, industry, short-distance transport, and our cities' infrastructure. With more stable generation profiles, offshore wind, hybrid projects and virtual renewable power plants can complement the continuous power demands of the industry and buildings sectors.

Electrification will itself compound the demand for green power. As the market incentives to decarbonise (e.g. carbon caps and border adjustment taxes) and electrify (e.g. electric vehicle subsidies and electrification of industrial processes, such as heat generation for petrochemical cracking) will aggregate the demand for data analytics, cloud-based storage and machine communication.

For the wind industry, the advancement of cyber-physical networks will enable smarter and more efficient grids, greater transparency in how we consume and stronger civic engagement. The expansion of an "Internet of Things" will mean more assets along the value chain will become connected devices to be monitored in real-time and optimised for performance.

Current applications range from intelligent factory cranes to remote monitoring of wind turbines by autonomous devices. A pilot project for predictive analytics has already enabled wind turbines to supply the Danish system operator with balancing reserves at the end of 2020, paving the way for more flexible grid systems with large- scale renewables integration.

COMPLEMENTARY TECHNOLOGIES FOR ENERGY FLEXIBILITY

With higher capacity factors than other renewable energy sources, onshore and offshore wind provides greater energy reliability to emerging markets where power demand is growing, especially if aggregated over large geographical areas. IRENA forecasts global weighted average capacity factors for onshore wind will increase to 32-58% by 2050 and to 43-60% by 2050 for offshore wind. The world's first floating wind farm, the Hywind Scotland project in the North Sea, already achieved 56% capacity factors in its first two years of operation.

Large-scale wind penetration will require balancing and storage technologies to maintain a cost-effective and secure transition. Hybrid renewable tenders with wind, solar and battery elements are now picking up worldwide, from India's Round-the-Clock tenders to Germany's "innovation auctions". But storage technologies will need to be competitive and scalable to disincentivise polluting and inflexible energy systems.

This will be particularly critical for accelerating renewables in markets with weaker grids, which already face challenges in voltage and disruptions from extreme weather events. Cost-effective storage solutions will be needed for grid resilience. Batteries are increasingly affordable for short-duration applications; since 2010, prices have declined by two-thirds for stationary application (such as grid management) and by 90% for lithium-ion batteries in electric vehicles.

System transformation will also require long-duration storage solutions (see: Enabling technology: Power-to-X and green hydrogen). A recent study of California's grid decarbonisation found that it would require up to 55 GW of long-duration storage by 2045 - more than 150 times the state's current storage capacity.

There are higher barriers to electrification for the hard-to-abate sectors, such as steel production, chemicals, aviation, maritime shipping, and other forms of long-haul transport. Investment in energy carrier technology will be required, including in an efficient, versatile and scalable storage solution like green hydrogen.

Green hydrogen is increasingly a jewel in the crown of national climate action policies, after decades of failing to take off due to barriers in production costs, transport, demand and competitiveness in the transport sector. At least 13 countries have a national hydrogen strategy in place, and dozens more are considering one or have supported hydrogen projects.

Back in 2016, the Electricity Generating Authority of Thailand announced its 22 MW Lam Takhong wind project with a 1 MW electrolyser to provide 10 hours of clean energy supply to a local building. There are numerous examples of green hydrogen projects under development, from NorthH2 in Europe to Saudi Arabia's Neom city.

According to IRENA, around 95% of hydrogen production today is based on methane gas and coal. Future deployment of hydrogen must prioritise green hydrogen. Its production is already technically viable and will require investment, learning curves and further deployment to reduce the costs of electrolysers and supply chain logistics. Concurrently, the scaling-up of renewable energy capacity in proximity to hydrogen plants will support hydrogen's pathway to cost-competitiveness.

PUSHING CARBON-INTENSIVE ASSETS OFF THE GRID

Looking ahead to COP26, one of the key set-pieces for the international negotiations will be the agreement of an effective global carbon tax mechanism. This will provide a crucial "push" factor to fossil fuels-dependent markets, going beyond current carbon trading schemes, which allow entities to pay to continue emitting carbon. It will also send a strong signal on the urgency of emissions reductions – while net emissions continue to rise annually, the UN has stated that emissions need to rapidly decline by 7.6% annually from 2020 to 2030 to meet Paris Agreement targets.

Case studies provide evidence for the effectiveness of carbon pricing, from the UK's "carbon price floor" for fossil fuels generators to the reformed Emissions Trading Scheme (ETS) in the EU. China's newly launched national ETS will be an essential step on its road to carbon neutrality and is set to become the world's largest emissions management scheme, with more than 2,200 power generators participating.
There are several challenges around gaining consensus on a global carbon tax, relating to carbon inequities between developing and developed countries, tax at the point of consumption versus production, allocation of revenues and appropriate pricing strategies. According to the IMF, a scheme needs to begin with initially low prices (US$6-20/ton) and then rapidly increase on an annual basis to reach US$40-150/ton by 2050.

At the same time, there is mounting agreement that fossil fuels are immensely under-priced when it comes to the costs of production, air pollution, global warming and environmental impact. A global carbon tax can provide a significant lever to adequately price emissions, incentivise renewables uptake and redirect revenues into green funds for societal benefit.

POTENTIAL PINCH POINTS ON GROWTH IN THE DECADE AHEAD

Looking beyond the urgent policy interventions needed in the next few years, several other challenges are on the horizon.

ADDRESSING STRUCTURAL BARRIERS IN THE GLOBAL SOUTH

The energy transition will adopt a different rhythm and form in every country. But many countries share similar challenges in market design, where investment in wind energy is available, but policy conditions undermine the viability of projects. Wind and solar energy already became the cheapest energy options for two-thirds of the global population by the end of the last decade – for these areas, the issues centres on clearing market barriers to get projects through the development pipeline to grid connection.

For the rest of the world, primarily countries in the Global South, renewable energy uptake faces structural barriers, such as energy access shortfalls and affordability gaps in the power sector.

Worldwide, 770 million people still lack electricity access, and this is set to shrink only moderately to 430 million people by 2030, with a concentration in sub-Saharan Africa and South Asia. The economics of renewable energy, especially for utility-scale wind projects, are more demanding in areas with limited customers on the grid.

While decentralised renewable solutions have been the least-cost response to date, an equitable energy transition will require systemic change. Expanding renewable energy in areas lacking power calls for long-term political economy planning, strong regulation of the power sector, innovative financing models to incentivise private investment in renewables and redirection of fossil fuels subsidies to electricity networks and clean energy assets.

AN EVOLVING GLOBAL SUPPLY CHAIN

As the wind market expands to new markets, the supply chain continues to evolve. The number of wind turbine suppliers has declined from 63 OEMs in 2013 to 33 OEMs in 2019, according to GWEC Market Intelligence. The top six-turbine suppliers now control nearly three-quarters of the global market. More than half of the turbines installed in 2019 were in the Asia-Pacific region, strengthening the existing export hubs of China and India and giving rise to new suppliers as East Asia and South East Asia markets build their offshore wind capacity.

Similar market consolidation is seen in the gearbox segment, where less than half of suppliers operational eight years ago remain active. In blades, the number of independent and SME suppliers has dwindled due to the inability to compete on cost, R&D investment and market coverage. As a result, ten blade producers account for 80% of the total global blade supply today.

The heightened competition for terrain, rare earth and technology ahead raises the risk of price volatility and trade tensions. This can slow down cost reduction and learning curves for the wind industry while inflating project CAPEX. Concurrently, tariffs and protectionism are now heating up around sectors like battery manufacturing – which need to grow to support the energy transition.

WHAT DOES POLITICAL AGREEMENT ON NET-ZERO LOOK LIKE?

A dramatic scale-up of wind energy will require international cooperation on grid infrastructure and cross-border interconnection, sustainable land and ocean management, technical standards, supply chain regulation, environmental protection and more. While the COP process provides a framework for cooperation, much of the multilateral alignment required for the energy transition lies outside the scope of existing mechanisms.

The fuel for this cooperation will be the recognition of common aims and mutual benefits. Take grid: Integrated electricity systems are not only a means for countries with low resource potential or system flexibility to gain access to clean energy. They are also a potential revenue stream for countries with significant resources. The dividends from cross-border power trading can be reinvested for social value creation, such as public health or education. The EU currently has 82 interconnectors across 22 borders, and grid integration is also vital in regions like Central America.25 In other regions where clean energy demand is on the rise, like South East Asia, interconnection is still in the feasibility stage.

Whether the global expansion of renewable energy will result in greater self-sufficiency and trust-building among states or heightened vulnerabilities and competition remains to be seen. The former could unite a global alliance around the ideals of carbon neutrality, while the latter could yield a realpolitik of transactional cooperation, which slows down the transition.

CONCLUSION

As a mainstream energy source in many parts of the world and all major energy transition scenarios, wind energy, are responsible for charting a clear path through the choppy waters ahead. This will require a unified voice on issues of global significance, from carbon pricing to market design, from just transition to a circular economy. This also means a strong representation in the evolving debate on the nature of energy security.

Wind energy will power the road to net zero, but to get there by mid-century requires credible and intensified efforts in the run-up to COP26 and ahead of the next deadline of NDCs in 2025. As a priority in the near term, the wind industry must work in tandem with its collaborators in the energy transition to increase national ambitions for renewables and raise awareness of their cross-cutting benefits for economies and people.

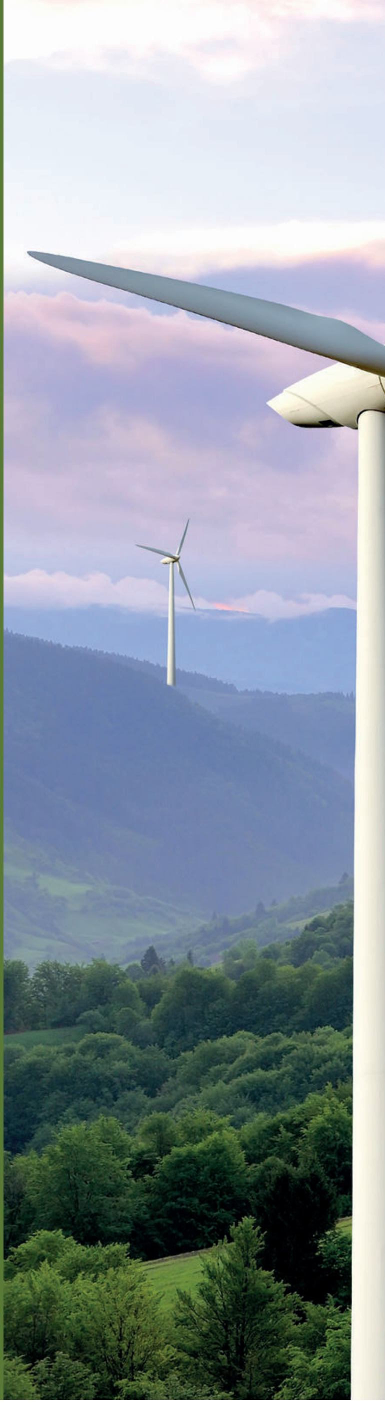
2021 has begun with lofty expectations, marking the UN Decade of Action and the Decade of Ocean Science for Sustainable Development. It also marks the beginning of the decade, determining whether we can reach net zero by 2050. wn

OPINION PIECE

A Surge of Wind Power

Since the start of large scale wind turbine electrical power generation in the early 1990s, there has been a worldwide surge of wind power generation, which by 2019 had risen to 650 GW.

BY DUDLEY BASSON



Wind power is the obvious choice of renewable energy in countries which have good prevailing winds and unreliable availability of solar power or other large scale resources.

Wind power also has the advantage over solar power of frequently being available after dark, reducing the energy storage requirement.

Offshore wind turbines have the additional advantage of better siting for wind power capture and not requiring land area or inconveniencing landowners.

Use the interactive global map to see the vast number of offshore wind farms around the world. Use the cursor to move about the world and the mouse scroll wheel to zoom in and out. The proliferation of offshore wind farms in the North Sea and Baltic Sea is phenomenal. There is also phenomenal offshore development east of Hong Kong. Zoom to make the names of the wind farms appear.

Watch this excellent (must see) video for the erection of a wind turbine and also the manufacture and testing of the gigantic blades and nacelles. (50 mins.)

At present there is no single design of turbine installations to suit all applications. The use of DC generators is usually confined to small local applications for battery charging and

GROWTH OF WORLDWIDE WIND TURBINE CAPACITY		
YEAR	CAPACITY GW	
		INCR.
1996	6,1	
1997	7,6	1,5
1998	10,2	2,6
1999	13,6	3,4
2000	17,4	3,8
2001	23,9	6,5
2002	31,1	7,2
2003	39,4	8,3
2004	47,6	8,2
2005	59,1	11,5
2006	74,0	14,9
2007	93,9	19,9
2008	120,7	26,8
2009	159,1	38,4
2010	198,0	38,9
2011	238,1	40,1
2012	282,9	44,8
2013	318,7	35,8
2014	369,9	51,2
2015	432,7	62,8
2016	487,3	54,6
2017	539,1	51,8
2018	591,0	51,9
2019	650,8	59,8

not for supplying power to the grid.
Alternators of large turbines are of three types:

Synchronous; Asynchronous and Switched reluctance.

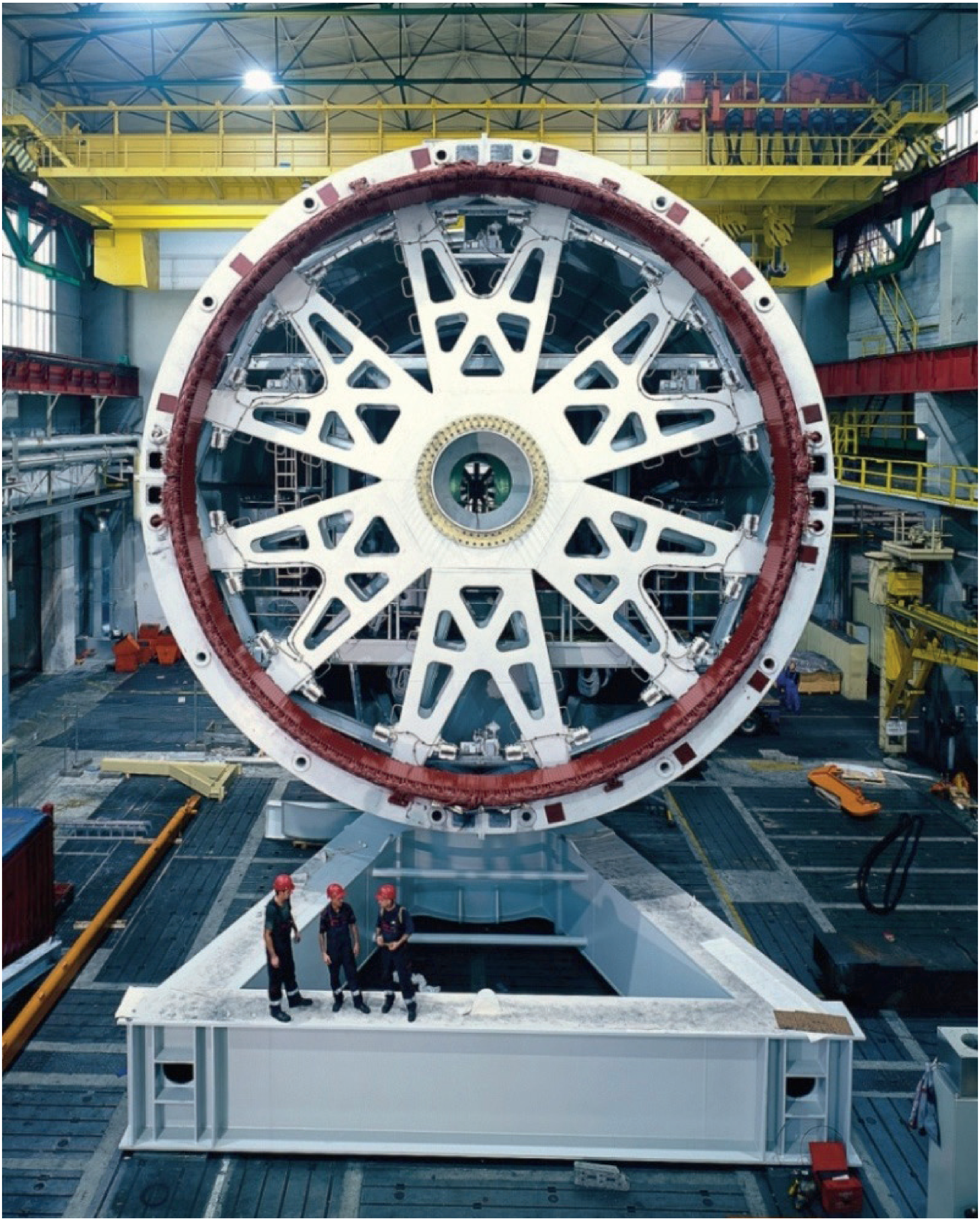
Four further considerations will determine the level of power electronics required:
Fixed or variable speed; Direct or geared drive; Brushed or brushless; Two-level, multi-level or matrix power electronics conversion.

Eliminating a geared drive train and brushed slip-rings is a significant consideration for the reduction of maintenance, especially for offshore turbines. Not using a geared drive train will add considerably to the size of the alternator due to the low speed and require the use of a large number of pole-pairs. This will also require AC-DC-AC conversion to bring the power to grid frequency.

All of these considerations are dealt with here.

This report is dated July 2012 but remains substantially relevant.

Fixed speed wind turbines are commonly fitted with gear trains that drive four pole alternators at 1500 or 1800 rpm to feed the grid at synchronous frequency. The turbines will typically turn at 15 to 20 rpm and may require a gearbox ratio of up to 1:90. For a fixed speed rotor of 20 rpm to directly drive an alternator to give 50 Hz output would require 150 pole-pairs.



A direct drive permanent magnet turbine alternator

Turbine fitted with huge directly driven permanent magnet alternator

If the turbine operates with a variable speed rotor, a lower gear ratio and lower speed alternator may be used, and AC-DC-AC power conversion used to supply the grid at synchronous frequency.

Siemens has made a change in regards to the alternator. In the past, direct-drive alternator rotors with permanent magnets have been located inside the alternator stator. Siemens is now inverting the machine so that the rotor is on the outside.

Henrik Stiesdal, chief technology officer of Siemens Wind Power commented: "On our machine, the rotor is only a thin-walled pipe with permanent magnets. What is outside the air gap is only 20 millimetres of magnet and 50 millimetres of steel pipe."

Considerable mass reduction could be achieved by reconfiguring the magnets as a Halbach array and reducing the back-iron (steel pipe).

There is now a noticeable trend towards large power output, direct drive, permanent magnet turbines.

The most powerful offshore wind turbine available at present is the GE Haliade-X with an output of 14 MW. This direct drive monster has a turbine rotor diameter of 220 m and a total height of 248 m.

VESTAS has announced the proposal of an even larger monster, the V236-15.0 MW and hope to install a prototype by summer of 2022. This variable speed 15 MW offshore beast will have a three stage epicyclic gear train and a rotor diameter of 236 m.

The state-of-the-art modern wind turbines represent civil, mechanical and electrical engineering taken to their limits. Despite their antiquity, the ubiquitous farm lattice tower windmills used for borehole pumping, remain the obvious and most cost effective choice for their particular application.

The modern wind turbines represent highly advanced solutions to complex design considerations and are designed for fully autonomous operation.

The turbine rotor is the most prominent part of the machine which comes to view. The three bladed rotor provides the optimum number of aerofoils for wind energy capture. Adding a fourth aerofoil would not make a significant increase in energy capture and would increase the cost, also requiring a stronger tower and foundation. In high wind survival mode, a four bladed rotor would have higher risk of destructive oscillations.

The spacing of the turbines is important. Wind entering the rotor will impart kinetic energy to the aerofoils and then leave at lower speed. The maximum theoretical capture of wind energy by aerofoils was determined in 1919 by physicist Albert Betz as 59,3% which cannot be attained in practice. The slower air leaving the turbine obviously cannot carry on straight through – most of it must disperse radially where it will mix with air which has not passed through the turbine. Turbine spacing is a complex matter, but a rule of thumb can be given as 7 rotor diameters between turbines.

The aerofoils are similar to aircraft propeller blades with a twist from the hub outwards to provide a constant air angle-of-attack at all distances from the hub. As with aircraft, the aerofoils have pitch control, which with turbines, can regulate the rotor speed and control the power output required. The wind to blade tip speed ratio is normally limited from 6 to 7 in order to limit noise.

The rotor will normally work with wind speeds of from 3 - 4 m/sec to 25 m/sec and will shut down if these limits are exceeded. Wind speeds in excess of about 60 m/sec signal survival mode. The pitch control can also 'feather' the blades to stop energy capture after which the brakes will be applied.

The turbine will of course also have horizontal slewing (yawing) motion to point the rotor towards the wind, and also park the rotor at right angles to the wind in cases of high wind survival mode.

For a fuller treatment of wind turbine design click here.

The various ball and roller bearings used by the turbines are highly specialised and must be designed using computer simulations. They must also be designed for possibly 20 or more years of low maintenance life. The largest bearing is for the slewing motion which must carry the weight of the entire nacelle and rotor as well as resisting huge wind forces. These bearings may also incorporate the gear teeth engaging the slewing motors. The bearings of the rotor shaft must bear the huge weight of the rotor as well as huge axial and radial wind forces. The bearings of the blades providing pitch movement must be able to bear not only the huge weight of the blades but also the leverage of the wind and weight forces on the long blades.

The huge synchronous, permanent magnet, direct drive turbine alternators can contain up to three tons or more of rare earth metal permanent magnets. The mining and production of rare earth metals is currently dominated by China. South Africa has its own high grade rare earth element (REE) mine at Steenkampskraal in the Western Cape with reserves which include 15 600 tons of neodymium. Neodymium is not exactly 'rare'. It is nearly as abundant as copper or nickel but is not found naturally. It is widely distributed and usually mixed with other lanthanide element oxides. Neodymium magnets consist mostly of iron with added neodymium and boron. Sintered neodymium magnets are brittle and can shatter on impact.

There is currently much speculation about possible hazards of human exposure to strong magnetic fields. The general public will normally be exposed to fields in the millitesla range which is regarded as negligible. The earth's magnetic field has a maximum strength of 60 microtesla near the poles. In MRI scans, patients can be exposed to alternating fields of up to 2 T without adverse effects, however medical staff will ensure that they are not exposed to these fields on a regular basis. Short exposure to fields of up to 3 T is not considered harmful. Possibly the greatest danger from strong magnets is injury from magnets snapping together with bone crushing force, and also from pacemakers being disabled. It is vitally important for pacemaker users to keep well away from strong magnets. Extensive testing has shown that electric vehicles pose no magnetic threat to pacemaker users. An object moving across a magnetic field will experience a generated EMF and if the object forms part of a circuit a current will be induced.

For a biological report on human exposure to magnetic fields (14 pages) click here.

In the Siemens turbine nacelle factory, the magnets are stored unmagnetised. They are robotically magnetised and inserted into the turbine alternator thus preventing the factory staff from being regularly exposed to fields of up to 2 T. This also cuts the time from one hour for complex manual insertion to 55 seconds for each magnet. This also eliminates any trapping hazard as the magnets snap into position. The magnets typically have a mass of 18kg each and are capable of exerting a magnetic force of up to 3kN.

If Halbach arrays are to be introduced, this will add to the complexity of assembling the arrays, as the magnets will strongly repel each other, but will however also reduce the mass of the alternator by eliminating back-iron. Halbach arrays can be conveniently used for forming the large number of pole pairs required by the low speed of directly driven alternators. Directly driven alternators will necessarily be of large diameter but will shorten the length of the nacelle by not requiring a gear train.

WIND POWER CAPACITY BY COUNTRY

COUNTRY	MW	PERCENTAGE
China	236 402	36,33
United States	105 466	16,21
Germany	61 357	9,43
India	37 506	5,76
Spain	25 808	3,97
United Kingdom	23 515	3,61
France	16 643	2,56
Brazil	15 542	2,39
Canada	13 413	2,06
Italy	10 512	1,62
Sweden	8 804	1,35
Turkey	8 056	1,24
Mexico	6 215	0,95
Australia	6 199	0,95
Denmark	6 128	0,94
Rest of world	104 684	16,09
World capacity	650 758	100,00

Currently China, the US and Germany hold more than 60% of the world's wind turbine power capacity. The global wind power capacity stands at 650 GW but this represents only 9,0% of the global electrical requirement.

The global electrical power requirement has been projected at:
2020 – 7 228,4 GW
2025 – 8 031,7 GW

Modern wind turbines are known for their reliability and low maintenance requirement, however for some spectacular wind turbine failures watch (10 mins.):

SOLAR POWER

By the end of 2019 the global installed solar power stood at 629 GW of which one third was held by China. The top users of solar power were China (208 GW), the US and India.

Solar power is the obvious choice for countries with abundant sunlight, infrequent cloud cover and low incidence of wind. PV (Photovoltaic) dominates the scene but requires either energy storage or alternative power supply availability for use when sunlight is not available.

CSP (Concentrated solar power) produces heat, not electricity. This will require the use of steam turbines or Stirling engines to generate electricity. A major advantage of CSP is that the heat can readily be stored in molten salt or other storage, for use when sunlight is not available.

In 2018, scientists of Chalmers University of Technology in Sweden developed a "solar thermal fuel," a specialized fluid that can reportedly store energy captured from the sun for up to 18 years.

The solar thermal collector named MOST (Molecular Solar Thermal Energy Storage System) works in a circular manner. A pump cycles the solar thermal fuel through transparent tubes. When sunlight makes contact with the fuel, the bonds between its atoms are rearranged and it transforms into an energy-rich isomer. The sun's energy is then captured between the isomers' strong chemical bonds.

Incredibly, the energy stays trapped there even when the molecule cools down to room temperature. To put the trapped energy to use, the liquid flows through a catalyst (also developed by the research team) creating a reaction that warms the liquid by 63 °C. This returns the molecule to its original form, releasing energy in the form of heat. This system has a higher specific energy than molten salt or lithium-ion batteries. Researchers believe the technology could be in commercial use within 10 years. There is however no suggestion that the system could be used for raising steam to power a turbo-alternator.

HYDROELECTRIC POWER

Globally, hydroelectric power accounts for 16% of the world's power requirement, which is currently nearly double that of wind power. Four countries account for some 50% of the world's hydroelectric power: China, Brazil, Canada and the US.

China's Three Gorges dam has the largest power station on Earth producing some 22,5 GW.

There are globally many pumped storage hydroelectric power schemes in operation, but these are storage and retrieval facilities which cannot be regarded as sources of energy.

WIND FARM	CAPACITY MW	COUNTRY	IMPLEMENTED	ON-OFFSHORE
Sinan Korea	8 200	South Korea	Approved (2030)	Off
Gansu	7 965	China	2012	Onshore
Asian Renewable	7 500	Australia	Proposed	Onshore
East Anglia	7 200	UK	Proposed	Off
Markbygden	4 000	Sweden	Proposed	Onshore
IJmuiden	4 000	Netherlands	2019-2025	Off
Zhang Jiakou	3 000	China	2011-2050	Onshore
Coastal Virginia	2 640	US	Proposed 2026	Off
Korea Offshore	2 500	South Korea	Proposed	Off
Hornsea Project 3	2 400	UK	Proposed 2025	Off
Berwick Bank	2 300	UK	Proposed	Off
Corona	2 200	US – New Mexico	Proposed	Onshore
Urat Zhongqi	2 100	China		Onshore
Hami	2 000	China		Onshore
Formosa III	2 000	Taiwan	Proposed	Off
Moray Firth	1 866	UK	Proposed	Off
Marr Bank	1 850	UK	Proposed	Off
Norfolk Vanguard	1 800	UK	Proposed	Off
Norfolk Boreas	1 800	UK	Proposed	Off
Damao Qi	1 600	China		Onshore
Alta	1 550	US	2010	Onshore
Muppandal	1 500	India		Onshore
Chokecherry	1 500	US - Texas	Proposed	Onshore
United Power	1 487	China		Onshore
Hollandse Kust Zuid	1 400	Netherlands	(2023)	Off
Sofia Offshore	1 400	UK	Proposed 2021	Off
Qiji	1 300	China		Onshore
Mingyang	1 286	China		Onshore
Hornsea 1	1 218	UK	2019	Off
Hornsea 2	1 386	UK	Proposed	Off
Dogger Bank A	1 200	UK	2013	Off
Dogger Bank B	1 200	UK	(2023-6)	Off
Dogger Bank C	1 200	UK	Proposed	Off
Forest Wind	1 200	Australia	Proposed	Onshore
Envision Energy	1 128	China		Onshore
Ocean Wind	1 100	US	Proposed	Off
Jaisalmer	1 064	India	2001	Onshore
XEMC World Power	1 052	China		Onshore
Shanghai Electric	1 014	China		Onshore
Hongshagang	1 000	China		Onshore

Kailu	1 000	China		Onshore
Fosen Vind	1 000	Norway	Proposed	Onshore
Chengde	1 000	China		Onshore
Aubanel	1 000	Mexico	Proposed	Onshore
Hartland	1 000	US – North Dakota	Proposed	Onshore
Silverton	1 000	Australia NSW	Proposed	Onshore
Traverse	1 000	OS - Oklahoma	Proposed	Onshore
Talinay	1 000	Chile - Coquimbo	Proposed	Onshore

Click here to view a huge number of charts relating to power generation over the entire globe. The charts have time slide bars so that development over the years can be seen. Zones can also be selected showing more detail for individual countries.

Let us take a look at the world's largest current and proposed wind farms. The many farms of less than 1 GW capacity are not included. Exact implementation dates are not given here as many wind farms are incrementally implemented over a period of several years, and many are not used at full capacity. In China, many wind farms remain underutilised, due to opposition from the power station and coal mining industries. Romania has a large number of small wind farms totalling nearly 3 GW capacity.

Let us take a look at some noteworthy wind farms:

SINAN KOREA

A south-western town of South Korea, Sinan, is a step closer to building the world's largest offshore wind farm. The $135 billion investment in green and digital technology will go towards an expansion of solar panels and wind turbines to 42,7 GW in 2025, up from 12,7 GW last year. The offshore wind farm, to be implemented by 2030, will have a capacity of 8,2 GW.

GANSU WIND FARM

The Gansu wind farm project is a group of large wind farms in desert areas in the western Gansu province of China. The Gansu wind farm sits along the Gobi Desert where there are extremely high winds. This location is however more than 1600 km from China's high density port cities that would serve as the biggest consumer of this energy. The complex is operating at below 40% utilization of the current 8 GW, but has a planned capacity of 20 GW.

ASIAN RENEWABLE

The Asian Renewable Energy Hub is one of the most exciting energy projects in the world, with the potential to address key energy security and emissions reduction challenges facing Australia's regional neighbours. It will create significant new manufacturing opportunities in Western Australia and will generate cheap clean power for the Pilbara region. Cheap clean energy will enable new and expanded mines, mineral processing, and large scale production of green hydrogen products for domestic and export markets.

This 50-year project will include 26 GW of wind and solar generation, 3 GW of generation for Pilbara energy users and 23 GW of generation for production of green hydrogen and green ammonia. The initial onshore wind farm will have a capacity of 7,5 GW.

EAST ANGLIA ARRAY

The East Anglia Array is a proposed series of offshore wind farms located around 48 km off the east coast of East Anglia, in the North Sea, England. Starting with East Anglia ONE it is being developed in partnership by ScottishPower Renewables and Vattenfall.

All 102 Siemens Gamesa offshore wind turbines – situated 43km off the Suffolk coast – are now fully operational, with the capacity to produce 714 MW. Up to six individual projects could be set up in the area with a maximum capacity of up to 7,2 GW.

MARKBYGDEN WIND FARM

The Markbygden Wind Farm will be a series of interconnected onshore wind farms in northern Sweden. The project is expected to be completed by 2022 and might have a capacity of up to 4 GW, comprising up to 1101 wind turbines.

The first wind farm in phase 1 was commissioned in 2014 comprising 36 turbines, followed by 179 turbines to be fully operational by the end of 2019.

IJMUIDEN VER WIND FARM ZONE

The IJmuiden Ver Wind Farm Zone (IJVWFZ) is located 62 km off the west coast of the Netherlands. There will be 4 wind farm sites designated within the IJmuiden Ver Wind Farm Zone: sites I, II, III, and IV. The Dutch Government will issue 2 tenders for the permits to develop the sites.

The total surface area of the wind farm sites within the zone (including maintenance and safety zones) is approximately 400 km². These wind farm sites will accommodate 4 GW of offshore wind capacity.

Transmission system operator TenneT will construct 2 offshore platforms with grid connections.

ZHANGJIAKOU WIND FARMS

One of the cities hosting China's Winter Olympic Games in 2022 has turned to renewables to reduce future emissions and address growing energy demand.

The municipal authorities for Zhangjiakou City, in co-operation with the China National Renewable Energy Centre (CNREC) and the International Renewable Energy Agency (IRENA), have adopted an ambitious 30-year roadmap to phase out coal-fired power generation and scale up solar and wind power instead.

There are many palaeolithic remains located in Guyuan county, which indicate human activities dating back as far as 1,36 million to 2 million years ago, thus becoming one of the earliest sites of human activities in human history and constituting a challenge against the notion that humanity originated from East Africa.

Zhangjiakou possesses abundant renewable energy resources, including the potential for 30 GW of solar photovoltaic and 40 GW of wind generation. By 2050, the city could increase renewables from less than half to nearly three quarters of its electricity mix.

DOGGER BANK WIND FARMS

Dogger Bank Wind Farms developers have revealed the design for the multi-million pound Operations and Maintenance base, that will serve the wind farms. Aberdeen's North Star Renewables has secured the £270m contract for three state-of-the-art service vessels and will create 130 new full-time UK-based jobs in crewing and shore-based jobs. A new turbine blade manufacturing plant on Teeside will create 750 direct and up to 1500 indirect jobs.

Click here for a list of the world's largest onshore wind farms greater than 250 MW.

Click here for a list of the world's largest offshore wind farms greater than 250 MW.

Click here for a list of largest power stations.

Click here for a list of wind farms in South Africa.

Click here for the story of Senegal's first wind farm, the first in West Africa.

BIRD AND BAT STRIKES

Wind energy has unfortunately its own dark side: thousands of birds and bats are killed annually by wind turbines. Causes of death include collision and barotrauma—internal injuries caused by exposure to rapid pressure changes near the trailing edges of moving blades.

The U.S. Fish and Wildlife Service estimates that between 140 000 and 500 000 bird deaths occur at wind farms each year. The most significant threat is posed to species of large, threatened and high-conservation-value birds such as golden and bald eagles, burrowing owls, red-tailed and Swainson's hawks, peregrine and prairie falcons, American kestrels and white-tailed kites. Since large birds have much lower reproductive rates than small birds (golden eagles, for example, have just one or two chicks in a brood less than once a year), their deaths have a far greater impact on the overall population of the species.

Norwegian scientists have discovered that by painting one of the three turbine blades black, avian deaths are reduced by 72 percent.

Wind turbines have also been found to be one of the leading causes of mass bat mortality - with some studies pinning fatalities at 888,000 bats a year. "Unprecedented numbers of migratory bats are found dead beneath industrial-scale wind turbines during late summer and autumn in both North America and Europe," says Paul Cryan, a research biologist with the U.S. Geological Survey.

"There are no other well-documented threats to populations of migratory tree bats that cause mortality of similar magnitude to that observed at wind turbines."

Bats may not be many people's favourite creatures, but they play an important role in the planet's ecosystems. Not only do the aerial mammals consume hordes of pest insects, they are also instrumental in pollinating flowers and dispersing seeds to regenerate rainforests.

For a more detailed treatment of turbine bird and bat strikes click here.

The World Energy Transitions Outlook preview (Published March 2021) outlines a pathway for the world to achieve the Paris Agreement goals and halt the pace of climate change by transforming the global energy landscape.

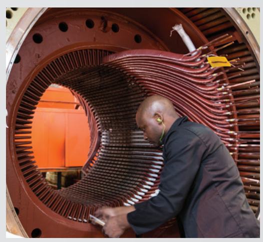
This preview presents options to limit global temperature rise to 1.5°C and bring CO_2 emissions closer to net zero by mid-century, offering high-level insights on technology choices, investment needs and the socio-economic contexts of achieving a sustainable, resilient and inclusive energy future.

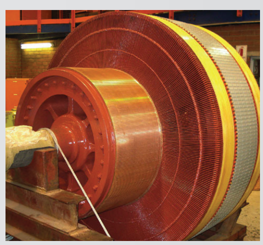
Meeting CO_2 reduction targets by 2050 will require a combination of: technology and innovation to advance the energy transition and improve carbon management; supportive and proactive policies; associated job creation and socio-economic improvements; and international co-operation to guarantee energy availability and access.

AMONG KEY FINDINGS:

- Proven technologies for a net-zero energy system already largely exist today. Renewable power, green hydrogen and modern bioenergy will dominate the world of energy of the future.
- A combination of technologies is needed to keep us on a 1,5°C climate pathway. These include increasingly efficient energy production to ensure economic growth; decarbonised power systems that are dominated by renewables; increased use of electricity in buildings, industry and transport to support decarbonisation; expanded production and use of green hydrogen, synthetic fuels and feedstocks; and targeted use of sustainably sourced biomass.
- In anticipation of the coming energy transition, financial markets and investors are already directing capital away from fossil fuels and towards other energy technologies including renewables.
- Energy transition investment will have to increase by 30% over planned investment to a total of USD 131 trillion between now and 2050, corresponding to USD 4.4 trillion on average every year.
- National social and economic policies will play fundamental roles in delivering the energy transition at the speed required to restrict global warming to 1,5°C.

This preview identifies opportunities to support informed policy and decision making to establish a new global energy system. Following this preview and aligned with the UN High-Level Dialogue process, the International Renewable Energy Agency (IRENA) will release the full report which will provide a comprehensive vision and policy measures for the transition. wn





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19/05/2021	Network Frequency Control
19/05/2021	Rotating Machines Webinar
19/05/2021	5G Webinar Series - Spectrum for 5G
20/05/2021	KZN Centre Webinar - Leveraging Regressions on the Path to Lean Energy
25/05/2021	Fundamentals of Medium Voltage Protectio
25/05/2021	SANS 10142 & OHS Act
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