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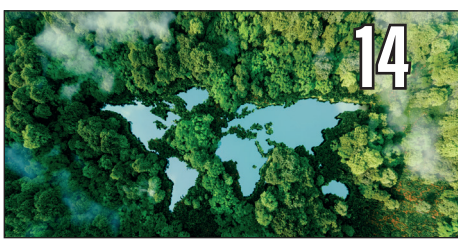

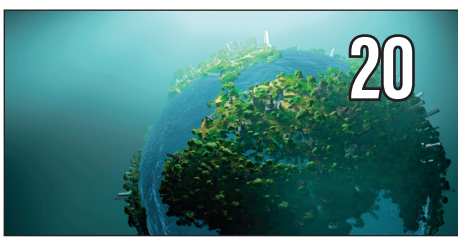

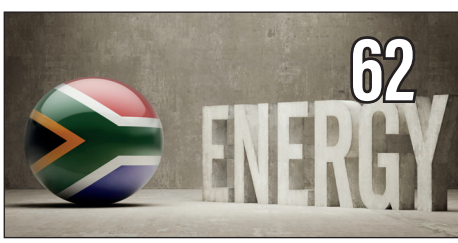

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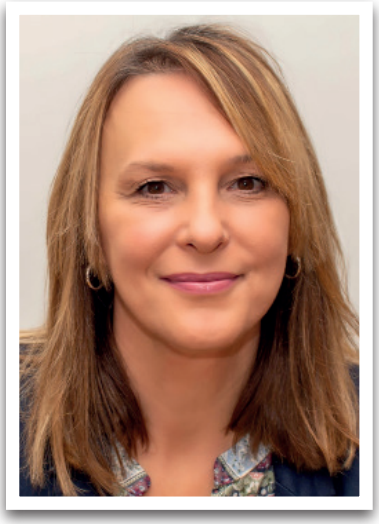

Dear **watt**now reader,

Welcome to the first issue of 2023, featuring water.

Water - a substance composed of the chemical elements hydrogen and oxygen and exists in gaseous, liquid, and solid states.

It is one of the most plentiful and essential compounds. A tasteless and odourless liquid at room temperature, it has the important ability to dissolve many other substances - but its availability is dire.

With the global economic state we find ourselves in and the fact that we are forced to do our best for climate change, water's future is not secure. It is easy to open the tap and pour yourself a glass of water, but one of these days; it might become a distant memory - if WE don't do something about it.

Our first feature article is a report about a new Action for Water Adaptation and Resilience (AWARe) initiative launched by the UN Climate for Change, reflecting the importance of water as both a key climate change problem and a potential solution. Read it on page 14.

The World Bank Group's Water Global Practice brings together financiers, knowledge and implementation in one platform, which generates more firepower for transitional solutions.
Read it on page 20.

Mr Viv Crone, Past President of the SAIEE, wrote a paper on how we might be able to solve the electricity crisis in South Africa. Find it on page 62.

The February issue features Mining, and the deadline is 20 January. Please send your paper/article to:
minx@saiee.org.za.

Wishing all our readers and members a successful 2023.

Herewith the January issue; enjoy the read!

PS: Book now for the SAIEE Annual Awards taking place on the 10th of March 2023. See advert on the next page.

Minx

THE SOUTH AFRICAN INSTITUTE OF ELECTRICAL ENGINEERS INVITES YOU...

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SAIEE

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SAIEE KZN CENTRE DINNER & AWARDS 2022

The SAIEE KZN Committee, via the leadership of the current chairperson Shepherd Nkosi, hosted its 2022 awards and dinner gala at the Coastlands Umhlanga Hotel in November 2022. The exclusive and formal event recognised and celebrated the achievements of academics and the institute's members for their role and contribution towards the advancements in electrical engineering. Industry experts and suppliers had travelled to join in the festivities and celebrate a year of success. Well-known personality Mo Magic dazzled the guests with his live performance and astonishing tricks.

The following awards have been presented:

BEST ENGINEERING STUDENT 2022 AWARD

The award recognised two final-year students, Mr Shivek Reddy and Miss Slindile Catherine Shongwe, who have excelled in their academic careers and, in particular, their final year design project for the year 2022. The award was presented to these top-performing students at UKZN and MUT from the school of electrical, electronic and computer engineering.

Miss Slindile Catherine Shongwe designed a solar-powered advertising board for companies to display their brand at zero utility costs.

Mr Shivek Reddy conducted a comparative study between HPS and LED floodlights to measure the lighting performance at distribution substations.

SIGNIFICANT PROJECT AWARD

The respected award recognised an industry expert who participated in a project that displayed skill & innovation in design, energy saving, legal compliance and budgetary compliance.

This year's winner Mr Neil Kopke a professional technologist from Bosch Projects has led the design for a 20MW Steam Turbine project at Kagera Sugar, a privately owned company operating in Tanzania. This project aimed to increase employment and protect the sugar industry. This project was undertaken to increase production in a country where the regulation prevented sugar import. This project was undertaken to reduce the cost of electricity due to the mill's distance from the main power grid. The project entailed the installation of a 20MW steam turbine coupled to drive a 20MW alternator and associated reticulation of the entire plant.

YOUNG ACHIEVER AWARD

The prestigious award recognised an individual's spirit of achievement, creativity, leadership, innovation, entrepreneurship, and enthusiasm.

This year's winner Mr Umeshan Pillay an electrical engineer from Zutari, has worked on the following projects:

- PepsiCo energy audit at various facilities for purposes of sustainability and ISO 50001
- South African Eskom Investment Support simulation on Battery Energy Storage
- Eastern Cape Intelligent transport systems
- Hulamin Power Black Start Generator project
- In addition, Mr Umeshan Pillay has published a paper in the IEEE journal.

CONCLUSION

Each winner walked away with prizes and tokens sponsored by Aberdare Cables and Electrical Supplies Corporation (ESC). Thank you to all who have contributed to making the event a success. wn

Best Engineering Student 2022 awards: Mr Shivek Reddy (middle)

Best Engineering Student 2022 awards: Miss Slindile Catherine Shongwe (middle)

Significant Project Award:
Mr Neil Kopke (middle)

Young Achievers Award:
Umeshan Pillay (middle)

Shepherd Nkosi
KZN Centre Chairman




















Solar Training and Internships for SA youth

Solar training alone is not enough. Installers need help opening doors in the industry. GREEN Solar Academy has partnered with KP Cares to realise professional solar training paired with an on-the-job experience for technically inclined youngsters across South Africa.

When KP Cares set out to find a training provider to train youth in the fundamentals of PV solar and connect them to the solar industry at large, GREEN Solar Academy was their first choice, backed by the awareness of GREEN's commendable track record in providing solar training on the African continent.

The overall objective of the training Programme is to skill up participants and expose them to first job experience so that they can find sustainable employment in the PV industry, preferably in their own region.

KP Cares is a non-profit and for-public-benefit organisation with a vision to break the cycle of poverty and inequality in South Africa. They do this by focusing on the sustainable development goals of alleviating poverty (SDG 1), good health and well-being (SDG 3), quality education and development (SDG 4) and affordable and clean energy (SDG 7).

They are piloting the training in three provinces in the first year, which commenced in July 2022, with Bothaville, Free State, as their first site. From this region, 28 young people were selected for a solar training programme paired with an internship programme facilitated by GREEN.

Their ages ranged from 20 to 32. Some recently matriculated, while others already had work experience, some having completed their tertiary education in fields ranging from veterinary science to electrical, mechanical and civil engineering. Nine women (28%) are among the 28 learners.

Kgabiso Sephai-Motaung, MD of KP Cares, says, "At KP Cares, we believe in a just energy transition. For it to be just, sustainable socio-economic benefits need to accrue to communities starting with addressing the skills gap. Based on this vision, we embarked on this Programme to bridge the skills gap and galvanise localised industry interest in the green economy targeting grassroots communities."

GREEN suggested a blended learning approach that included online learning, classroom teaching and on-site practical instruction to ensure that there was a method of instruction to match every need.

In late October, the trainees started their introduction to solar energy with GREEN's eLearning course called Principles of PV Systems. This was followed by the 3-day Solar 101 classroom training conducted in Bothaville.

The students then travelled to Wynberg, Johannesburg – some of them travelling outside their hometown for the very first time - to attend a 2-day practical PV mounter course where they worked in teams to affix mounting structures, mount modules and connect cabling on the three training roofs at the GREEN Solar Academy. Equipment used in training includes cutting-edge components supplied by several of GREEN's Technology Partners: K2 Systems, Renusol and IBC Solar mounting structure systems, Jinko,

The dream team - KP Cares directors, GREEN Trainer McDonald Sekoa and the students.

RenewSys and Krannich Solar's Axitec PV modules.

"It was a truly exciting experience to be engaging and sharing information with millennials, guiding them through the process of theory learning and a practical application thereof," says McDonald Sekoa, one of the GREEN Solar Academy trainers who worked with the students.

The next stage of the training involves work visits to actual sites where commercial-scale solar PV systems are being installed on behalf of KP Cares. Under the supervision of GREEN trainers, the candidates will have the opportunity to observe the installation done by the contractor. GREEN will also facilitate visits to live solar plants to introduce the students to typical operation and maintenance tasks.

Once the work skills Programme is complete, possible employment options will include PV mounter for installation companies for commercial and utility-scale PV installations, or O&M technician, with the trainees capable of carrying out tasks such as installation of PV modules, assisting with the wiring and installation of BOS, cleaning PV modules, performing technical checks and maintenance tasks on PV systems. GREEN will then reach out to the companies in its networks in the areas targeted by KP Cares to assist with placing interns. And finally, the trainees will be added to the GREEN Alumni Network, where they will have access to other installers and professional exchange to help them develop their careers further and even become entrepreneurs in the field of solar energy.

Antje Klauss-Vorreiter, MD of GREEN Solar Academy, is "excited that we found a partner with the experience and resources to offer training for the Youth". GREEN and KP Cares joined forces to train young unemployed South Africans to be solar PV installers and place them in internship programmes. wn

How MV Motors can deliver Reliability and better total cost

Many critical industrial and other applications can benefit from Medium Voltage (MV) Electric motors, due to their reliability and low total cost of ownership.

According to Floris Erasmus, sales specialist HV motors at Zest WEG, the benefits of MV electric motors includes their being purpose-designed and well protected. This makes them very reliable, and thus well suited for critical applications where the risk of failure-related disruption must be mitigated.

"Any motor application – from pumps and fans to crushers and conveyors – can present a critical risk if a significant portion of the whole operation relies upon it," says Erasmus. "In these cases, it is often worth considering the MV motor option in new projects or in circumstances where motors are being replaced."

While the category of Low Voltage (LV) electric motors tends to end at about 1,000 V, MV motors range from 1,000 V up to as high as 33 kV. In the South African market, the upper end of the MV range is usually 11 kV, he says.

"MV motors are generally not off-the-shelf, and are rather specially designed for their application," he says. The construction is also different to an LV motor. The 'wire' used in the windings, for instance, is more like a rectangular bar. Normally covered with mica tape, they make up form-wound coils.

"The coils are individually wrapped with thicker insulation to accommodate the higher voltage," he says. "There is only one turn in a slot, so there is no potential difference between turns; this means that there is less chance of an inter-turn failure or short circuit between coils."

An important difference in the winding of an MV motor is that it is conducted using vacuum pressure impregnation (VPI) and the use of an epoxy resin. Applying this resin in a vacuum allows all air and moisture to be removed. The absence of air allows the resin to flow more effectively into the spaces between the steel core and the copper winding. The incidence of air pockets in the slot of the stator is where many winding failures in motors begin.

"If resin is not effectively distributed, this can undermine the mechanical strength of the winding," he says. "The epoxy resin used in MV motors is very strong compared to varnish."

He highlights that the removal of moisture during the VPI process reduces the possibility of short circuits caused by water particles trapped inside the motor windings.

WEG W51 motors fitted with forced cooling units for VSD applications.

"Another benefit of MV motors is their low starting and operating current," explains Erasmus. "The kilowatt rating of a motor – the power it consumes – is a function of the voltage; by raising the voltage, the amperage drawn in reduced."

The starting current of a motor tends to be about six times higher than the operating current, he points out. By reducing the operating current, an MV motor thereby helps to reduce the strain that high starting currents can place on the electrical system in a mine, plant or factory.

The MV option also has a distinct advantage when it comes to the use of variable speed drives (VSDs). The transformers that are part of the MV motor installation ensure that no extra filters or add-ons are required to achieve near-perfect sine waves. He notes that MV VSDs are also better at disrupting harmonics in the electrical system.

Protection systems on MV motors are an important aspect of ensuring their longevity. Erasmus explains that they are normally electrically protected with a smart relay which is password-protected. This makes it difficult to by-pass the overload systems that protect the motor, and prevents the motor from being started under fault conditions. While this protection might slightly increase installation costs, it helps reduce total cost of ownership.

"In terms of our own MV offering, WEG has recently launched its W51 range – which includes MV motors," he says. "This new range offers improved efficiencies and higher output to weight ratios, and the motors are suitable for VSD."

Availability is from a 315 to 450 frame, which with four-pole motors translates to a range of 132 kW to 1,400 kW. The standard range reaches 6,6 kV but motors up to 11 kV can also be requested.

"The range includes motors for hazardous areas, where there may be gasses which are susceptible to ignition," says Erasmus. wn

Floris Erasmus,
Sales Specialist HV Motors at Zest WEG.

Keeping water services on stream

With a reliable electricity supply under threat because of Eskom's woes, it is imperative that a consistent source of high-quality water – the nation's lifeblood – is secured. The Vuthela iLembe LED Support Programme assists the KwaDukuza Local Municipality in reviewing water services delivered to consumers in areas under the Siza Water Concession.

Vuthela is providing professional services to assist the iLembe District Municipality in reviewing the Siza Water contract and identifying where revisions may be required.

Efficient water services are essential to maintain and expand the economic activity by initiating new developments. This will ultimately include more people in the economic activities of districts, creating greater inclusivity for many who would otherwise remain outside the mainstream economy.
Therefore, secure water services are central to the iLembe District Municipality's development plans and future growth trajectory.

The 30-year concession to provide water and sewer services began in 1999 when Siza Water signed a contract with the Borough of Dolphin Coast, now known as the KwaDukuza Local Municipality.

The contract required Siza Water to deliver water and sanitation services in Ballito, Zimbali, Shaka's Rock, Sheffield Beach, Tinley Manor and Salt Rock along the coast and in the inland areas of Shayamoya, Nkobongo, Shakaskraal and Etete.

In the two decades since its inception, many legislative changes have been implemented in South Africa; local development plans have evolved, and the numbers and profiles of municipal customers have changed significantly.

With the Siza Water concession scheduled to end in 2029, the Vuthela iLembe LED Support Programme is supporting the iLembe District Municipality to ensure that the contract continues to be viable over the remaining seven years.

The original contract for the Siza Water concession was based on the Framework for Restructuring of Municipal Services, the general guiding policy in 1999. It was concluded well before any legislative frameworks for water services delivery, municipal services, and Public-Private Partnerships came into effect. This makes it necessary to review the contract's alignment with the current legislative framework and revise it where necessary.

The Vuthela Programme is currently conducting an extensive review of the performance of the contract, legal and financial issues, and the changing customer base.

The analysis of the contract performance will identify the amendments needed to ensure it is aligned with the iLembe District Municipality Regional Water and Sanitation Master Plan (2016) and the Water Services Development Plan (2021).

The review team is working closely with analysts within the iLembe District Municipality's technical department to understand the infrastructure asset base within the concession area. The infrastructure analysis includes assessments of present and future water demand, sales, non-revenue water (which refers to water that is supplied but not paid for), the average daily demand over the year, average daily sales over the year, consumption patterns in the various supply zones, the water infrastructure required and the storage capacity required for the short and long term.

The current concession contract and its various supplementary agreements are also being analysed for their compliance with B-BBEE legislation and the procurement regulatory framework.

National water benchmarking norms and standards for the provision of water services are being taken into account in this analysis.

The concessionaire's audited annual financial statements and quarterly financial reports, income reports, contribution reports, tariff reports and statements are being assessed, along with Siza Water's contribution to SMME and youth development.

The legal review includes analysing the concession's performance and supplementary agreements to ensure that the contract is legally compliant with the current legislative and regulatory framework.
The review is also testing compliance with the contract's model for the equitable distribution of the financial proceeds between the iLembe District Municipality and the concessionaire and assessing the implications of the iLembe District Municipality's current mandate to provide universal water and sanitation and appropriate levels of service.

Procurement and equity aspects of the contract are being assessed against the requirements of the Constitution of the Republic of South Africa, 1996; the Broad-Based Black Economic Empowerment Act, No. 53 of 2003; the Preferential Procurement Policy Framework Act, No. 5 of 2000; the Public Finance Management Act, No. 1 of 1999; the Local Government: Municipal Finance Management Act, No. 56 of 2003; and the Municipal Fiscal Powers and Functions Act, No. 12 of 2007.

This assessment will inform the drafting of amendments to ensure the contract is in line with current legislation and policies.

The contract's performance and service level aspects are being reviewed by testing compliance with the Constitution of the Republic of South Africa; the Local Government: Municipal Structures Act, No. 117 of 1998; and the Local Government: Municipal Systems Act, No. 32 of 2000.
The review is also considering how the Siza Water contract fits in with the National Water Services Benchmarking Initiatives that the South African Local Government Association (SALGA) has agreed to; the National Water Act, No. 36 of 1998; Water Services Act, No. 108 of 1997; and the National Environmental Management Act, No. 107 of 1998.

The professional team conducting the review will draft a Supplementary Agreement to address all compliance issues and proposed remedies.

The financial review of the Siza Water Concession is underway to ensure that projections of the financial and profit-sharing models are accurate, complete and robust. Experts are analysing the impacts of the Covid-19 pandemic on financial projections, investigating the financial performance of the concession, reviewing the current tariff structure and analysing the estimated rate of return for each year until the contract expires.

Shifting trends in the demand and supply of water and sewer services for residential, commercial and industrial consumers in the past 23 years since the concession's inception are also being analysed.

A customer base expert assesses the socio-economic environment, income and affordability variables for the areas within the concession area to indicate the spatial distribution, income levels and affordability of customers supplied by Siza Water. The experts will use this information to forecast how growth areas and future development will impact the demand and supply of water and sanitation services.

This forecast of future demand will guide the provision of additional capacity that may be required, ensuring that consumers in the KwaDukuza Local Municipality continue to receive water and sanitation services until the end of the Siza Water concession in 2029.

The Vuthela Programme continues to provide expert professional services that assist the KwaDukuza Local Municipality and Siza Water to supply water and provide sanitation services to communities in this rapidly growing region of KwaZulu-Natal. wn

Action for Water Adaptation and Resilience initiative launched

A new Action for Water Adaptation and Resilience (AWARe) initiative has been launched at the UN Climate Change negotiations, reflecting the importance of water as both a key climate change problem and a potential solution. It underlines the commitment of Egypt as COP27 President to making water a top priority.

The AWARe initiative, which the COP27 Presidency drafted with the support of the World Meteorological Organisation (WMO), was launched on Water Day on 14 November.

It is a collective effort, with input from many stakeholders and UN agencies.

"This is the first time we have water as part of the informal agenda of the COP," said Hani Sewilam, Minister of Water Resources and Irrigation, Egypt, adding that he turned to WMO to enable synergies in the governance structure and to ensure that the initiative gains momentum from one COP to the next.

"The Global Water Crisis is currently affecting billions of people worldwide and is projected to be further aggravated by increasing demand, changing water availability and increasing impacts of floods and droughts, which calls for greater international cooperation," said Dr Sewilam.

AWARe has three principal aims:

- Decrease water losses worldwide and improve water supply
- Promote mutually agreed, cooperative water adaptation action
- Promote cooperation and interlinkages between water and climate action to achieve the 2030 agenda, particularly Sustainable Goal Six on water and sanitation.

"WMO supports AWARe as an initiative complimentary to the Early Warning for All and the Water and Climate Coalition. AWARe can be a practical vehicle to implement Early Warnings for All and the Water, and Climate Leaders Call to improve water data and information for a climate-ready world," said WMO Deputy Secretary-General Dr Elena Manaenkova.

In a statement published at COP27, Water and Climate leaders urged negotiators to "get serious about water." Water-related hazards are an important part of the new initiative to achieve Early Warnings For All in the next five years. Between 2001 and 2018, UN-Water reported that 74% of all-natural disasters were water-related. Currently, 3.6 billion people face inadequate access to water at least a month per year, which is expected to increase to more than 5 billion by 2050.

The Executive Action Plan for the Early Warnings for All initiative calls for initial new targeted investments between 2023 and 2027 of US$ 3.1 billion – a sum which would be dwarfed by the benefits. It would cover disaster risk knowledge, observations, forecasting, preparedness and response, and communication of early warnings.

EARLY WARNINGS FOR ALL

Early Warning Systems are a proven, effective, and feasible climate adaptation measure that saves lives and provides a tenfold return on investment. The WMO State of the Global Climate 2021 report shows that extreme weather events (floods, drought, heatwaves, storms, etc.) led to hundreds of billions of dollars of economic losses and wreaked a heavy toll on human lives and well-being. The IPCC's Sixth Assessment Report on Impacts, Adaptation, and Vulnerability recognized early warning systems and disaster risk management activities as key cross-cutting adaptation options that enhance the benefits of other adaptation measures when combined.

And yet, major gaps in early warning systems remain, especially in developing countries. Furthermore, there is a global incapacity to translate early warnings into early action. The UN Secretary-General Antonio Guterres has tasked WMO with spearheading action to ensure every person on Earth is protected by early warning systems within five years. COP27 in Egypt will move the focus from promises and pledges to action on the ground.

The practicality and implementability of early warning systems make them an ideal focus area for COP27. The UN Water Conference, the Mid-term Review of the Sendai Framework, the 2023 SDG Summit, the UN Future Summit and COP28 all present additional key opportunities to advance the implementation of risk-informed early warnings and early action to enable future preparedness.

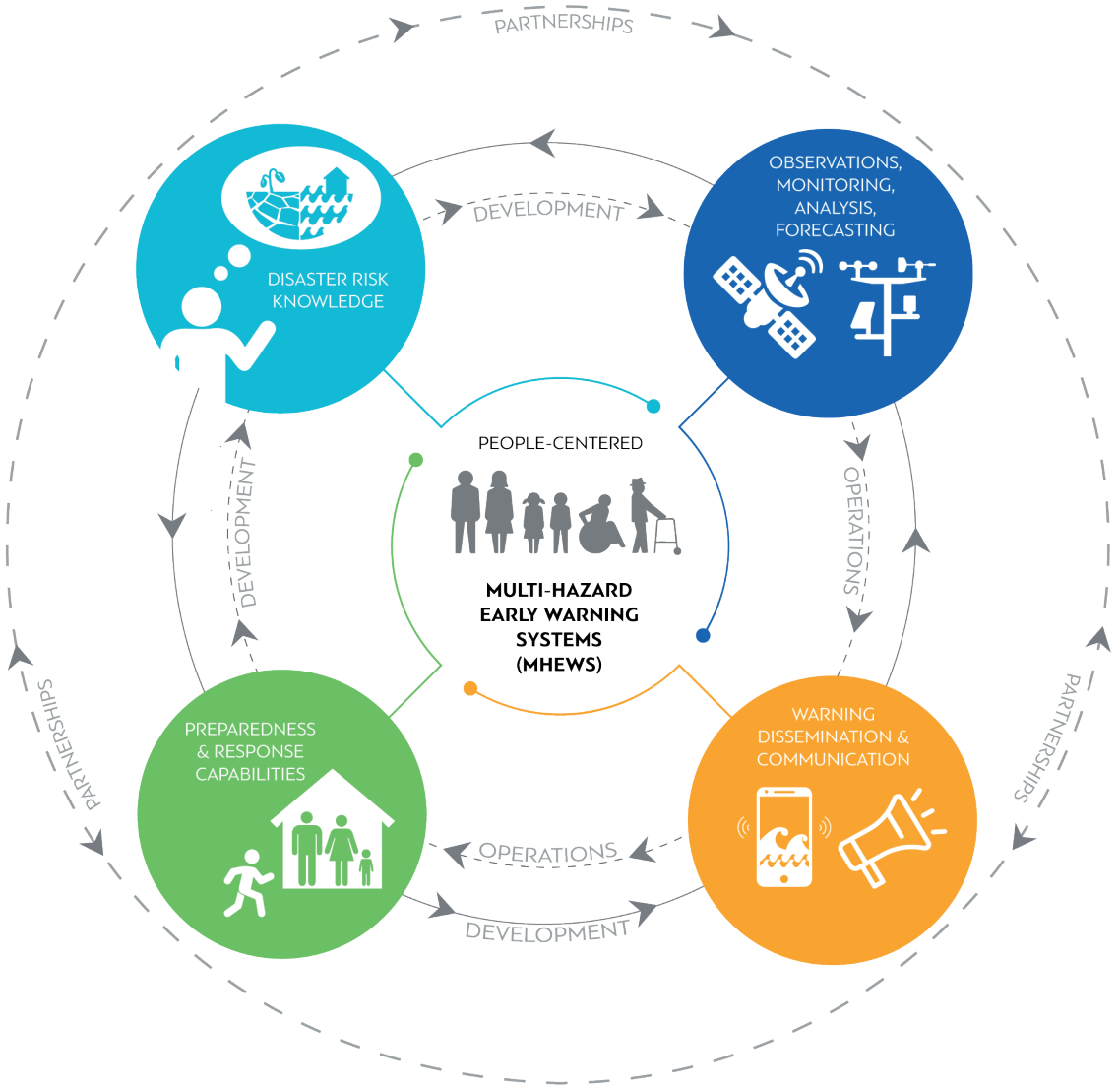

Figure 1. Graphical presentation of a Multi-Hazard Early Warning System (MHEWS)

Disaster risk knowledge

Systematically collect data and undertake risk assessments

- Are the hazards and the vulnerabilities well known by the communities?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?

Detection, observations, monitoring, analysis and forecasting of hazards

Develop hazard monitoring and early warning services

- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?

Preparedness and response capabilities

Build national and community response capabilities

- Are response plans up to date and tested?
- Are local capacities and knowledge made use of?
- Are people preapred and ready to react to warnings?

Warning dissemination and communication

Communicate risk information and early warnings

- Do warnings reach all of those at risk?
- Are the risks and warnings understood?
- Is the warning information clear and usable?

The four components of an early warning system.

MULTI-HAZARD EARLY WARNING SYSTEMS (MHEWS)

A Multi-Hazard Early Warning System (MHEWS) is an integrated system which allows people to know that hazardous weather or climate events are on their way and informs how governments, communities and individuals can act to minimize impacts. End-to-end MHEWS include risk knowledge, observation, communication, and response,, as shown in Figure 1.

MHEWS should be people-centred to empower those threatened by hazards to act in sufficient time and an appropriate manner, and they build on partnerships within and across relevant sectors.

THE STATE OF MHEWS GLOBALLY

An enhanced data collection campaign conducted since March 2022 shows that significant MHEWS gaps remain globally; only half of WMO Members report having an MHEWS in place. Even fewer countries have MHEWS based on national legislation and regulatory frameworks for emergency response, which are essential to ensure their effectiveness. Significant gaps remain in vital underpinning observations, especially in Africa, Small Island Developing States (SIDS) and Least Developed Countries (LDCs). Many African countries report not having Standard Alerting Procedures to support MHEWS communication and dissemination. An updated high-level analysis of this data will be shared with key partners shortly. See Figures 2, 3, and 4.

To ensure robust monitoring for achieving the five-year goal, a composite Early Warning Index will be developed with Members and key partners in the months ahead. This index will better demonstrate changes in the global status of early warnings and action as we advance and highlight areas where urgent action is required.

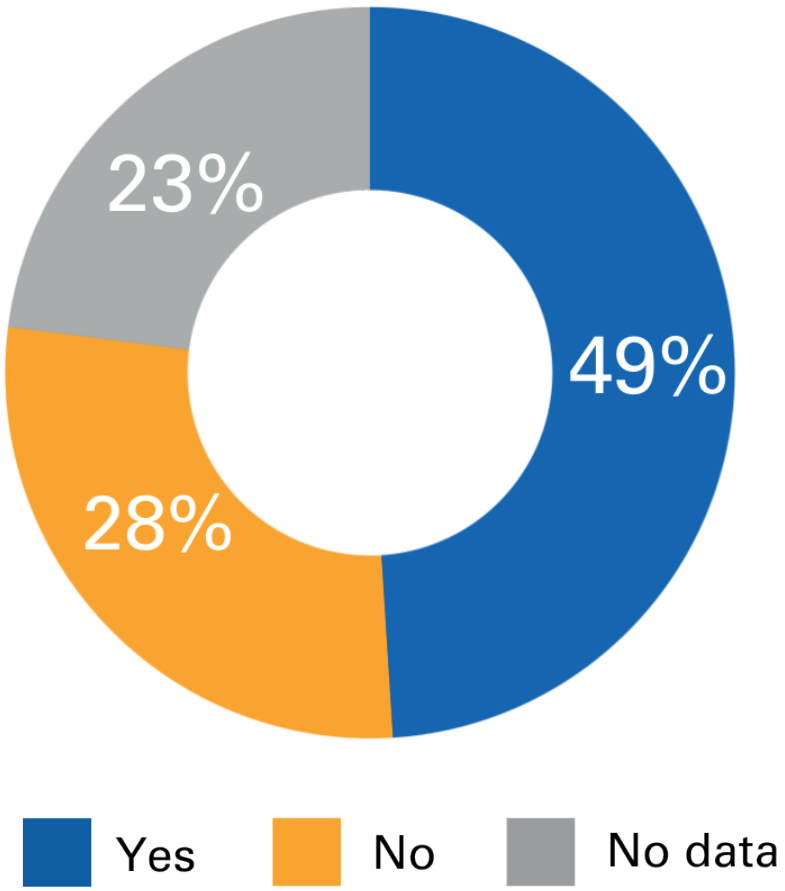

Figure 2. Percentage of WMO Members reporting to have MHEWS (Source: WMO Performance Monitoring System, July 2022)

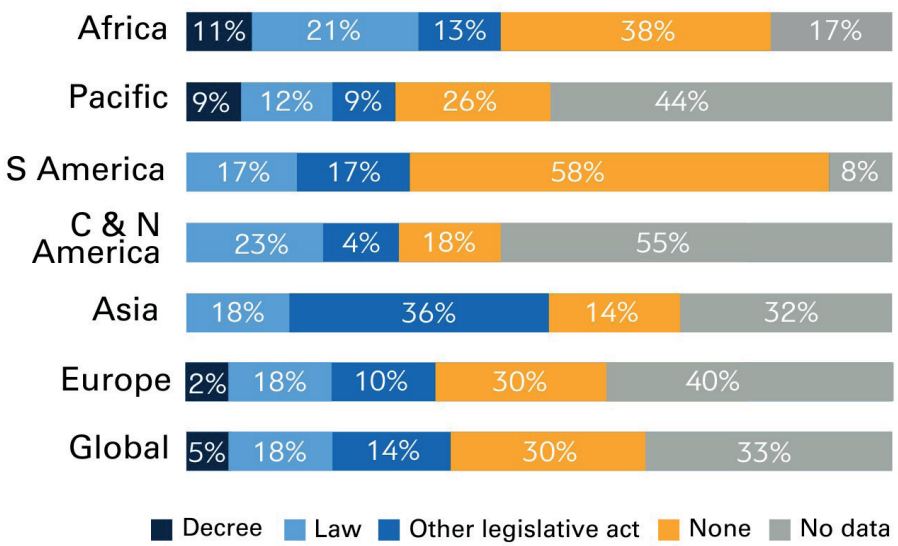

Figure 3. Percentage of WMO Members reporting to have legislation on MHEWS (Source: WMO Performance Monitoring System, July 2022)

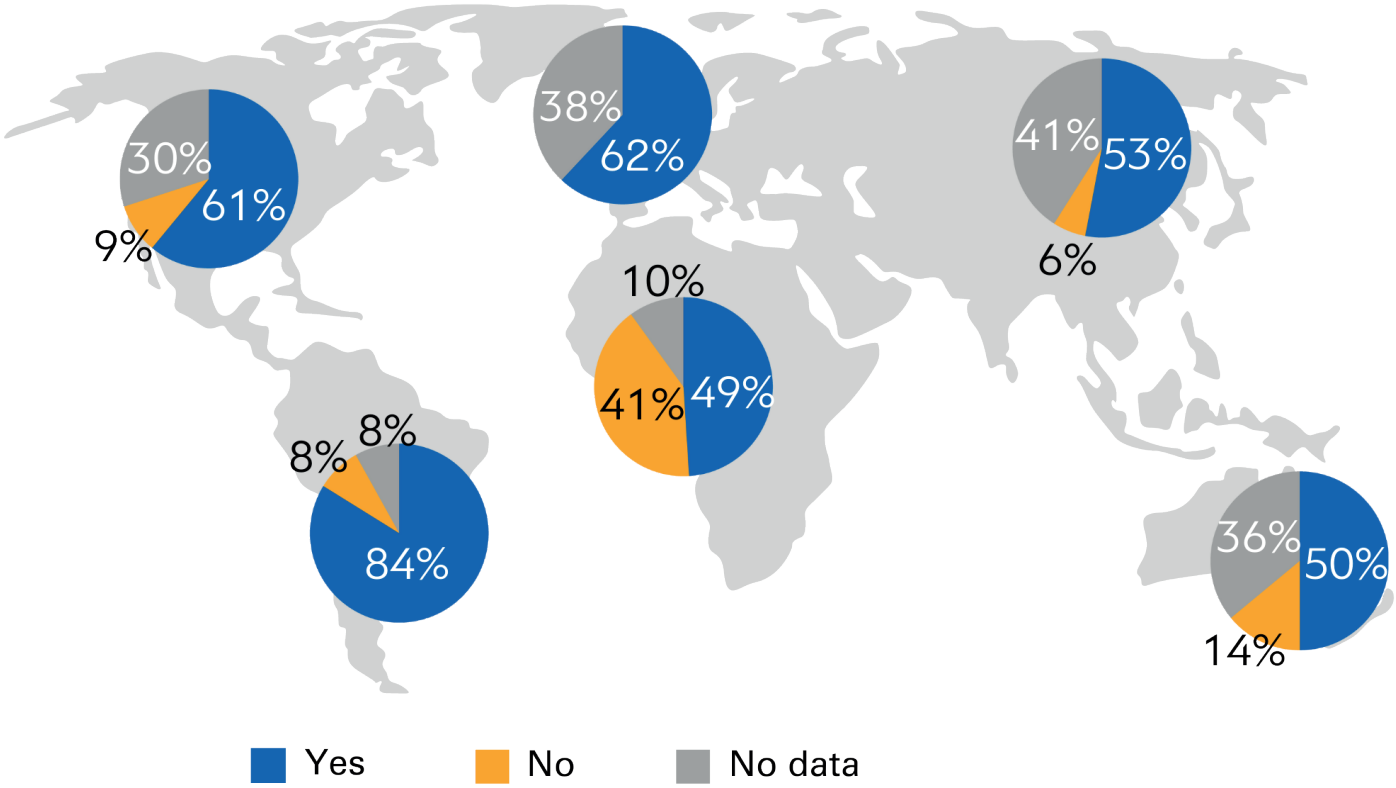

Figure 4. Percentage of countries reporting to have Standard Alerting Protocols (SAPs) (Source: WMO Performance Monitoring System, July 2022)

LINKING EARLY WARNINGS TO EARLY ACTION

Early warning systems can only save lives and protect livelihoods if they incorporate clear roles, responsibilities and coordination mechanisms for action. The overall success of an early warning system ultimately depends on its ability to translate warnings, particularly impact-based forecasts, into prevention and mitigation measures for all affected people, including hard-to-reach communities. Ensuring every person on Earth is protected by early warnings requires greater collaboration across all potential data providers (from satellite imagery down to local data crowdsourcing), sector experts, media and other two-way communication services, decision-makers and end users. WMO is working with the United Nations Office for Disaster Risk Reduction (UNDRR) and a specially formed' Early Warnings for All' Advisory Group from across the Risk-Informed Early Action Partnership (REAP) to ensure the perspectives of all stakeholders across the full value chain of early warning are included in the design of the Action Plan.

Building on the recently adopted WMO Executive Council Resolution (EC-75 4(2)/1) on the Early Warnings for All initiative, the plan will reflect WMO Members' commitment to collective action on 1) Earth System observations and monitoring, 2) Predictive and warning capabilities and 3) Coordinated communication for anticipatory action, in addition to other related work such as the WMO Global Multi-Hazard Alert System (GMAS) Framework, the WMO Coordination Mechanism (WCM) for Humanitarian Support, and the Global Water Information System (GWIS) as called for in the Water and Climate Leaders Action Plan. Effective implementation of the architecture will require inputs from a wide range of actors, including Academia, National Disaster Agencies, NGOs, the Private Sector, Climate Finance Institutions, and the UN System, as well as the important role of National Hydrological and Meteorological Services and WMO Technical Commissions. Key components, overall targets, and the final scope of the architecture will be discussed with partners at a two-day workshop in Cairo in early September 2022.

INITIATIVE ARCHITECTURE TO DELIVER ON THE FIVE-YEAR GOAL

WMO is developing with key partners transformation plans for each of the four components of the early warning value chain (see Figure 1), demonstrating the

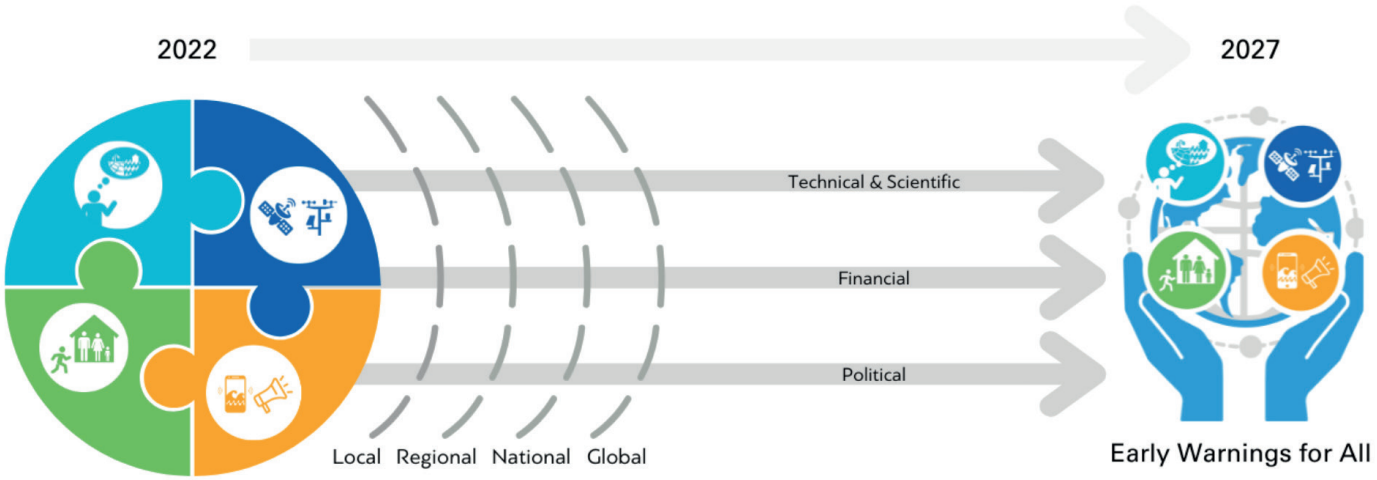

Figure 5: Five year goal plan

steps required to deliver on the five-year goal across the global, regional, national, and local levels. These transformation plans will be developed according to the architecture shown in Figure 5. The development of the plan is based on globally agreed guidance on MHEWS. It will address the technical/scientific, financial, and political tracks required for the hydro-meteorological, disaster risk and early action communities to work together to ensure every person on Earth is protected by early warnings within five years.

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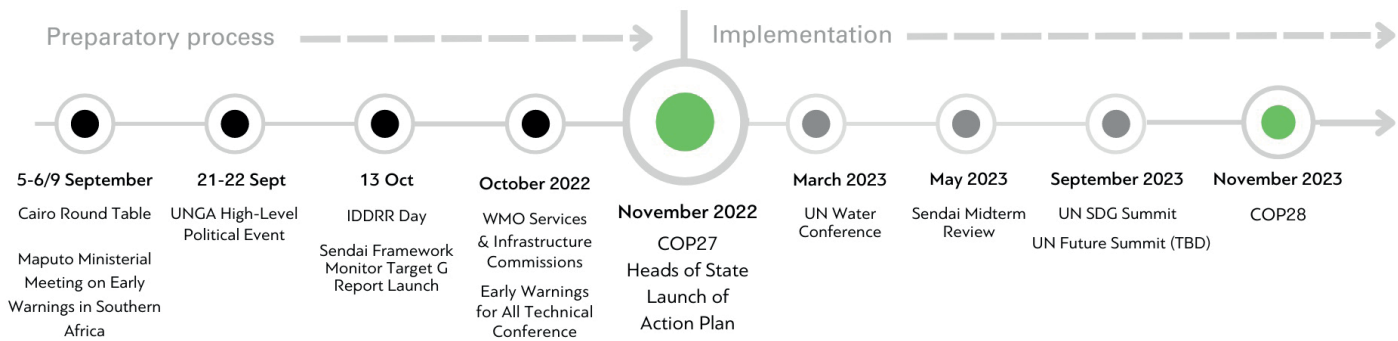
FINANCING SOLUTIONS

A range of new and pre-existing innovative financing solutions are required to implement the plan to protect every person on Earth. These include a scaling up of the Climate Risk Early Warning Systems (CREWS) Initiative, the Systematic Observations Financing Facility (SOFF), and accelerated investment programmes of climate funds, such as the Green Climate Fund (GCF) and the Adaptation Fund, and key Multilateral Development Banks (MDBs), as well as other innovative new financial instruments across all stakeholders of the early warning value chain.

MILESTONES TO COP27 AND BEYOND

Below are some of the key milestones leading up to COP27 and beyond. wn



WATER GLOBAL PRACTICE

Launched in 2014, the World Bank Group's Water Global Practice brings together financing, knowledge, and implementation in one platform. By combining the Bank's global knowledge with country investments, this model generates more firepower for transformational solutions to help countries grow sustainably.

The Global Water Security and Sanitation Partnership (GWSP) continues to advance global knowledge and build the government capacity needed to support the sustainable delivery of water services. The fiscal year from July 2021 to June 2022 (FY22) presented unprecedented and complex challenges. The COVID-19 pandemic progressed from a crisis to an ongoing development issue. Meanwhile, new challenges in inflation and rising interest rates emerged, contributing to an emerging debt crisis and threatening global stability, further jeopardised by the war in Europe. Underlying these economic concerns, the impacts of climate change continued to grow and deepen.

Investing in water and sanitation remains essential for eradicating poverty, addressing the negative impacts of climate change, and building more inclusive and equitable societies. Water is inextricably linked to the global economy and the changing environment. However, progress toward Sustainable Development Goal 6 and the other water targets of the SDGs is insufficient.

GWSP's focus on analytics, timely data and information, and effective capacity development is even more crucial in this context. GWSP complements and influences World Bank Group financial instruments and promotes global dialogue and advocacy with key partners.

As the Partnership completes its fifth year, it supports client governments by generating innovative global knowledge and providing country-level support.

As well as describing the activities of the past fiscal year, this year's annual report describes how GWSP has evolved since its inception and outlines some of the key lessons learned. GWSP results and impacts are presented through its three business lines—water resources management, water in agriculture, and water supply and sanitation—highlighting GWSP's five key themes: inclusion, resilience, finance, institutions, and sustainability. The report also includes a special chapter highlighting

how GWSP's support contributes to improvements in global biodiversity, climate change, water sector Public Expenditure Reviews, inclusion, and countries affected by fragility, conflict, and violence (FCV).

SPECIAL FOCUS

Fragility, conflict, and violence disrupt development and pose a significant challenge to eradicating poverty.

Work by the Water Global Practice (Water GP) in FCV-affected countries has grown significantly since GWSP's inception, and the Partnership now supports active engagement in 33 countries. In many cases, work in countries affected by FCV has started with small but critical analytical work and expanded to influential and impactful operations. Based on the success of these initial projects, GWSP support has expanded into sanitation, water resources management, and irrigation.

The Partnership plays a critical role in providing the knowledge and tools to help countries understand climate change drivers and impacts on the water sector and increasing their ability to monitor, manage, and prepare for variable water flows. Over the past five years, climate change considerations have become embedded throughout the GWSP portfolio, as reflected in the rising number of projects with climate co-benefits. In FY22, GWSP continued to play an important role in supporting the integration of climate considerations into client countries' policies and investments, supporting the World Bank's Climate Change Action Plan, and a variety of other tools, including climate and disaster risk screening, climate co-benefits assessments, greenhouse gas accounting analyses, the use of a carbon shadow price in economic analysis, and integration of climate change indicators into projects' results frameworks.

Public Expenditure Reviews (PERs) assess how public funds are spent, how well they are spent, and what funding and financing gaps exist. GWSP supported the development of a robust methodology and comprehensive approach to implementing PERs in the water sector, covering water supply and sanitation, irrigation, and water resources management.

The water PERs revealed that in many developing countries, policy priorities and public fund allocations do not align, and only an average of 72 per cent of allocated funds are spent due to low execution capacity. The PERs have already informed government policy. For instance, the PER undertaken in the Dominican Republic helped build the government's commitment to reforms for the entire water sector. As a result, in 2021, the government released a Water Pact, laying out the desired reforms in the water sector from 2021 to 2036.

Since its inception, GWSP has supported social inclusion in water. An emerging lesson is that achieving real change is possible but is a slow and often nonlinear process involving the challenging work of changing institutions, shifting social norms, and identifying opportunities to align incentives better to promote inclusion. GWSP's support for social inclusion initially started with a focus on gender. Still, the program has broadened to develop guidelines and tools that clients can use to reach other marginalised groups, such as persons with disabilities, and effectively engage citizens. For example, with GWSP support, substantive advances have been realised in increasing capacity and impact efforts to address the gender gap in water sector employment. GWSP's support has advanced the development of water-specific guidance and tools for clients on disability inclusion. In FY22, almost half of all countries with World Bank water operations included actions on disability.

GWSP supports opportunities to increase further the benefits of integrating biodiversity into water sector investments. Using nature-based solutions has significant potential to increase biodiversity while also adding to resilience, making it an effective way to achieve multiple objectives. In Colombia, a GWSP-supported water diagnostic recommended policies to increase storage capacity by restoring ecosystems such as wetlands and estuaries and reward efforts by industry and large-scale water users to restore the natural integrity of waterways and support biodiversity. GWSP is increasingly applying a biodiversity lens to transboundary work, identifying priority actions to support freshwater biodiversity conservation and address the root causes of biodiversity loss in the context of international waters. For instance, with GWSP assistance, technical advice was provided in Cambodia and the Lao People's Democratic Republic on managing transboundary aquatic habitats to restore biodiversity and help boost declining indigenous fish stocks.

GWSP ACTIVITIES IN WATER RESOURCES MANAGEMENT

Since 2017, GWSP has supported activities to address three central water resource management needs.
These include:

- Accurate data—and building the capacity to analyse it— to support decision-makers in developing and implementing effective policies and practices
- Cross-sectoral collaboration to holistically address the many threats to water security
- Water management tools that are adaptable and transferable.

Groundwater is the principal source of water for drinking, irrigation, and industry in many countries. It is vital in sustaining many aquatic and terrestrial ecosystems, but it is under increasing pressure due to overexploitation, pollution, and climate change. In FY22, GWSP supported analytical work highlighting key causes of groundwater contamination and identified strategies for preventing, managing, and responding to threats. In the Horn of Africa, GWSP research and support influenced the design of a transboundary project to foster cooperation with Ethiopia, Kenya, and Somalia to tap into the region's largely underutilised groundwater resources.

GWSP's support in Senegal has evolved from a focus on sanitation to engaging in national water security and led the government to request support in assessing current water resources management measures and identifying barriers to achieving water security. In Argentina, Colombia, and Peru, water security diagnostics included recommendations for enhancing water security through improved sector performance and strengthening the water sector architecture.

GWSP ACTIVITIES SUPPORTING WATER IN AGRICULTURE

Over the past five years, GWSP support for water in agriculture has evolved to address resilience, water security, and environmental sustainability. It has also raised awareness of irrigation's role in decarbonisation and service to farmers, including supporting farmer-led irrigation development. GWSP support has also contributed to the use of disruptive technologies such as remote sensing and water accounting to improve irrigation performance and guide investment decisions.

GWSP supported a web-based water analytics tool and the development of a digital water accounting app that uses remote sensing and ground data analysis to allow users to target the schemes most in need of support to increase efficiency and improve service delivery. For example, the information generated in Georgia has been highly influential in planning and decision-making for sustainable water irrigation and storage management.

GWSP has continued to support farmer-led irrigation development, and in FY22, supported a diagnostic in Zimbabwe, which identified constraints farmers face in irrigation, and proposed policy recommendations to increase irrigation efficiency based on feedback from farmer representatives, government agencies, and private sector actors. The Zimbabwean Ministry of Agriculture now considers farmer-led irrigation to be the most direct and cost-efficient way of accelerating irrigation to contribute to Zimbabwe's food security, climate resilience, and economic growth.

GWSP WATER SUPPLY AND SANITATION ACTIVITIES

Water and sanitation security are fundamental to green, resilient, and inclusive development. GWSP helps tackle the most pressing issues to jumpstart utility reform and obtain quick wins and a five-year plan to sustain performance. The UoF Program is growing rapidly and has reached over 70 utilities in more than 25 countries.

In Nigeria, GWSP is supporting the implementation of a series of state-level reforms to strengthen the enabling environment and support performance build water and sanitation security by supporting a shift toward establishing the policies, institutions, and regulations needed to tackle the enormous challenges facing the water sector.

GWSP provides knowledge and technical expertise to support utility performance improvement efforts worldwide, helping to build utilities' capacity and letting them benefit from innovation and technology to "leapfrog" to higher maturity levels. Through the Utility of the Future (UoF) Program, participating utilities are assisted in completing a utility assessment, a 100-day action plan that improvement across key elements critical for service quality and sustainability. Technical assistance is also being provided to help the government implement the "Clean Nigeria: Use the Toilet" campaign, designed to achieve an open defecation–free Nigeria by 2025. In Benin, a new rural water supply model has been established with GWSP support based on professionalised service delivery, private sector innovation, and private finance. GWSP has supported developing and awarding contracts with private water supply system operators, introducing strong incentives for the operators to deliver on expanding access and improving service quality and sustainability. GWSP support in the South Pacific is expanding to address the challenges of climate change and the growing fragility of water resources.

REPORTING ON RESULTS

The GWSP Results Framework tracks how the Partnership helps client countries improve and deliver water services by working to enhance the impact of the World Bank's water portfolio and achieve measurable results on the ground.

GWSP activities influence project design, strengthen dialogue and enhance capacity, thereby contributing to outcomes toward sustainable, resilient, and inclusive water management and delivery—and, ultimately, to the overall objective of achieving a water-secure world for all by sustaining water resources, delivering services, and building resilience.

In FY22, GWSP informed $13 billion in newly reported lending projects and $41.9 billion in all lending projects (including previously reported projects). Among the newly influenced lending projects, 13 were linked to 8 countries with fragile and conflict-affected situations (Democratic Republic of Congo, Mali, Mozambique, Niger, Nigeria, Solomon Islands, South Sudan, and Timor-Leste), with commitments of more than $2.4 billion.

In FY22, nearly half of the lending projects influenced by GWSP sat outside the Water GP, illustrating that GWSP has a wide audience and mandate across the World Bank. For example, GWSP informed approximately $1.3 billion in the Urban, Disaster Risk Management, Resilience and Land GP's FY22 lending portfolio and more than $1.1 billion in that of the Energy and Extractives GP.

In FY22, GWSP supported the following achievements in terms of the design of Water GP projects.

- INCLUSION - In FY22, 100 per cent of projects were gender tagged, meaning they demonstrated a results chain by linking gender gaps identified in the design phase analysis to specific actions tracked in the Results Framework during implementation. In addition, 88 per cent of new projects approved in FY22 (compared to 85 per cent in FY21) have other social inclusion aspects, such as activities that target the poor, vulnerable, or underserved communities or areas. Almost half (46 per cent) of the projects in FY22 include actions on disability.
- RESILIENCE - One hundred per cent of new projects incorporate resilience in the design of water-related activities. Given that the total water lending portfolio almost doubled in FY22, the total financing with climate co-benefits was higher than in FY21 ($2.2 billion in FY22 compared to $1.4 billion in FY21).
- FINANCING - There was an increase in the percentage of projects that supported reforms/actions improving financial viability (from 69 per cent in FY21 to 89 per cent in FY22) and projects with an explicit focus on leveraging private finance (from 8 per cent to 22 per cent).
- INSTITUTIONS - All the new Water GP lending operations in FY22 focused on strengthening institutional capacity through establishing new institutions or enabling existing ones to deliver services sustainably.
- SUSTAINABILITY - In FY22, all 24 Water GP lending operations promoted sustainable and efficient water use. Furthermore, the indicator for rural water supply and sanitation that measures the functionality of water points increased from 80 per cent in FY21 to 100 per cent in FY22.

WATER RESOURCES MANAGEMENT

The importance of sustainable water resources management cannot be underestimated. By 2050, it is predicted that 1.8 billion people will be living in regions or countries with absolute water scarcity. Such scarcity can drive groundwater depletion, resource degradation, tensions (as countries, individuals, businesses, and sectors compete for water use), and social vulnerability and fragility.

Water scarcity, of any degree, also sharpens the complex trade-offs within the water-food-energy nexus. Achieving equitable and sustainable water resources management is challenging given the shifting dynamics of the water sector, encompassing climate change, conflict, and environmental degradation. But while the forecast may be dire, the collective knowledge base is growing in depth and applicability.

Three things are clear:

1. Aaccurate data—and the ability to analyze it—is crucial for decision-makers to develop and implement effective policies and practices
2. the underlying cause of many threats to water security are not specific to the water sector, making cross-sectoral knowledge sharing and cooperation key
3. A new context and new challenges require new, updated responses.

By 2050, it is predicted that 1.8 billion people will be living in regions or countries with absolute water scarcity.

No two circumstances are exactly alike. Thus, water management tools should take the best of global knowledge and experiences and make them adaptable and transferable to on-the-ground realities.

The world is facing a global decline in water storage. Built storage capacity is decreasing as existing water storage infrastructure ages. Likewise, groundwater, which is the principal source of water for drinking, irrigation, and industry in many countries, and vital in sustaining many aquatic and terrestrial ecosystems, is under increasing pressure due to overexploitation, pollution, and climate change. In FY22 GWSP supported analytical work that highlighted key causes of groundwater contamination and identified strategies for preventing, managing, and responding to threats. This was documented in **"Seeing the Invisible: A Strategic Report on Groundwater Quality."** The **"Practical Manual on Groundwater Quality Monitoring"** that accompanies the report signals a shift in approach to supporting water resources management. Moving beyond knowledge and data generation, the Water GP is being supported by GWSP to increasingly focus on action, generating practical guidance designed to assist budget planners, project managers, and water resource managers. The move into supporting implementation is reflected in the development of handbooks, supported by GWSP, that present new knowledge and concrete advice to improve borehole drilling.

Looking into an uncertain future for the world's water storage supplies, one certainty is the need for collaboration and dialogue across sectors and borders. Water resources management is of concern well beyond domestic water supply, with impacts on issues ranging from how humans relate to one another and their environment, to building climate resilience, addressing food security, and mitigating conflict. In the Horn of Africa, GWSP research and support influenced the design of a recently approved $385 million transboundary project to foster cooperation with Ethiopia, Kenya, Somalia, and the Intergovernmental Authority on Development, to tap into the region's largely underutilized groundwater resources. This project will help these countries cope with, understand, and adapt to drought and other climate stressors impacting their vulnerable borderlands. Likewise, in Cambodia, GWSP support to the Mekong Integrated Water Resources Management project has fostered transboundary dialogue between the Lao People's Democratic Republic and Cambodia on the effective management of water resources and fisheries. Along with the Energy GP, GWSP is supporting work in water storage, given its central role in climate change mitigation and adaptation. A report, to be released in late 2022, documents ways countries and partners can respond to the increasing global water storage gap.

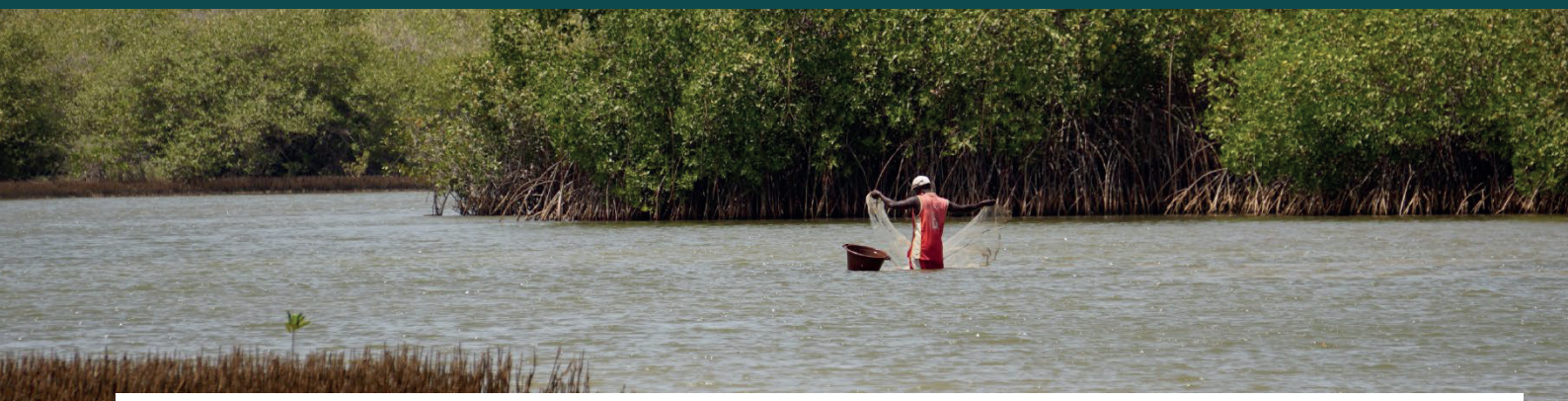
SENEGAL: INCREASING WATER SECURITY

CHALLENGE

Senegal is struggling to meet the water and sanitation needs of its growing and urbanizing population, with water use set to rise an estimated 30 to 60 percent by 2035. Most industrial uses and 85 percent of potable water depend on groundwater that is under increasing threat of overuse and pollution. Water-related extreme events and pollution cost Senegal over 10 percent of its GDP.

The Dakar-Mbour-Thiès region is home to over one-third of Senegal's population and generates half of the country's GDP. Deteriorating water resources and an inadequate institutional framework pose serious threats to the region's economy. To achieve and sustain its development goals under the Plan for an Emerging Senegal, the country must urgently prioritize water security.

Only a quarter of rural dwellers use safely managed sanitation. The government plans sanitation investments in rural small towns, including sewerage networks, wastewater treatment plants, and sludge disposal facilities. However, this infrastructure will increase the operating costs of the National Sanitation Agency (ONAS), which is already struggling to cover costs of existing wastewater treatment services and facilities.

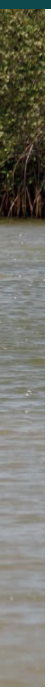


APPROACH

GWSP's support in Senegal has evolved from a focus on sanitation to engaging in national water security.

In FY22, GWSP supported the completion of a sanitation assessment in six large rural centers where the government plans to build sanitation networks, sewerage plants, and sewage sludge disposal facilities. GWSP support was instrumental in helping ONAS identify better management strategies and test new sanitation service models. The assessment found that oversight and management would be improved if the regulatory framework was adjusted to enable ONAS to operate throughout the entire sanitation chain. Recovery of sanitation fees from water bills is low, and a recommendation was made to revise tariff structures to balance current losses and ensure cost recovery. The assessment recommended stronger leasing agreements and coordination between ONAS and the service operators to improve technical performance and transparency, allowing ONAS to minimize its facility operation responsibilities and focus on infrastructure development and financing, while the operators focus on operations.

The successful partnerships and dialogue built through the work on rural sanitation led the Government of Senegal to request GWSP support in assessing water security challenges across the sector. The resulting study, **"Challenges and Recommendations for Water Security in Senegal at National Level and in the Dakar-Mbour-Thiès Triangle,"** is the first of its kind to assess water resources management at the national level in Senegal. In the process of identifying barriers to achieving water security, it takes a close look the Dakar-Mbour-Thiès region, where achieving water security will be most critical to development. Demand for water in the region already exceeds current resources, making the need to diversify supply critical. Presented at the World Water Forum in Dakar in March 2022, the study identified seven areas of priority action, including the need to reduce pollution in water reservoirs, promote the use of treated wastewater for agriculture, and increase access to sanitation services.

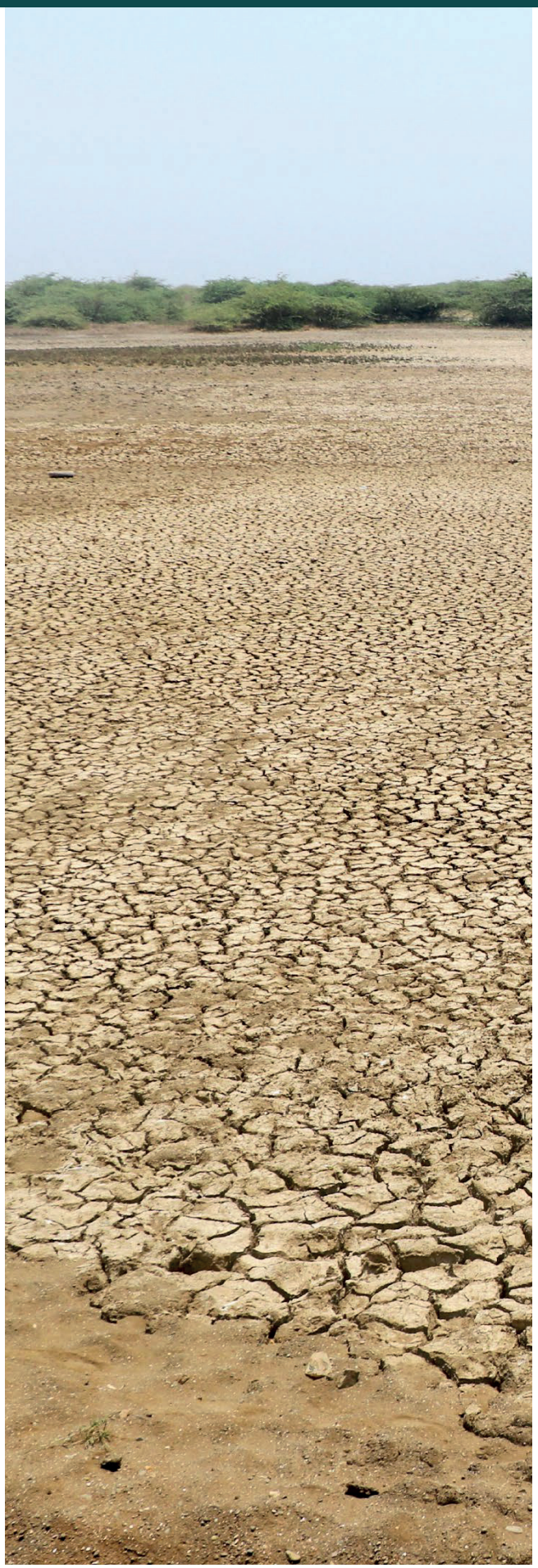


Ensuring sustainability of water resources and water-related services in Senegal's Dakar-Thiès-Mbour triangle requires a collaborative mechanism that brings together experts representing a range of institutions working across sectors affected by and linked to water security—including water, sanitation, drainage, water resources, agriculture, energy, industry, and urban development—as well as the ministries of economy and finance.To strengthen the integrated approach, a steering committee bringing together all the sectoral ministries was established, which is a first step toward the creation of a national platform that is focused on addressing water security challenges.

ADDITIONALITY

The Government of Senegal is starting to make some of the structural changes recommended in both sanitation service delivery and overall water resources management. The Ministry of Water and Sanitation has revised Senegal's national water law in line with the recommendations of the water security study, and the new law is set to be approved.

The government has requested ongoing World Bank support to the sector, and in particular new investment targeting water security in the Greater Dakar area. A new $250 million Integrated Water Security and Sanitation project is under preparation, targeting (1) water security and resilience, (2) urban/rural sanitation within the circular economy, (3) irrigation, and (4) strengthening and reform of the framework for public-private partnerships.



FEATURE - continues from page 29

ARGENTINA, COLOMBIA, AND PERU: WATER SECURITY

CHALLENGE

Latin America is one of the most water-rich regions in the world, home to important international rivers and aquifers, including two of the five largest river basins and two of the ten longest rivers in the world. Despite the fact that many countries in the region have an abundance of water, the resources of many are under high levels of stress, with potential effects on productive sectors, particularly agriculture.

Unsustainable use of water resources, growing water demands, pollution, declining water storage, urbanization, and climate change have undermined water security. These factors contribute to large gaps in water services and reduce resilience, putting the region's socioeconomic progress at risk.

Governance gaps in managing water-related risks are mainly due to unclear budgetary mechanisms, scarce information, low technical capacities and community awareness, and a lack of prioritization of water at the political level. Overall, a paradigm shift is needed in managing water resources for current and future generations across the region.

APPROACH

GWSP has supported an initiative to identify the key challenges to Latin America's water security, and has supported Argentina, Colombia, and Peru in highlighting the centrality of water security to their national development. Detailed, comprehensive Water Security Diagnostics of the three countries have been prepared, using the Water Security Diagnostics Framework developed with GWSP support. The framework is used to assess what is needed to facilitate social, economic, and environmental development, and link this to water sector performance and deficiencies in the sector's institutional architecture. The Water Security Diagnostics consider management of water resources, delivery of water services, and mitigation of water-related risk with an aim to determine where countries should invest to close water security gaps.

In Argentina, the Water Security Diagnostic found that water security deficits inflict an annual economic cost of about 2.2 percent of GDP, of which 0.8 percent is due to floods and droughts. Much of the loss from droughts due to climate variability in Argentina occurs in the agriculture sector, where about 0.6 percent of GDP is lost. The largest cost driver—accounting for more than half the yearly total—is the lack of secure, piped water supply services for about 17 percent of the population and the lack of sewerage for about 48 percent. The diagnostic documented clear inequalities in water supply and sanitation access, and also found that floods are a poverty trap for lower-income Argentines, especially in urban areas. The poor often find it hard to fully recover before the next disaster, and experience a loss in well-being (measured in terms of consumption power) more than three times greater than those in the highest income quintile. One reason for Argentina's particular vulnerability to drought is its increasing reliance on rainfed agriculture, which is highly exposed to climate variability. Coastal erosion, driven both by urban development and by sea level rise, poses large risks to the tourist economy.

In Colombia, the Water Security Diagnostic found that a mismatch between freshwater availability and demand makes the country highly vulnerable to water shortage risks in the future. Water security deficits, including floods and droughts, cost Colombia between 2.2 and 2.7 percent of GDP on average. Groundwater resources in the country are inadequately measured and administered, even though groundwater could become a strategic reserve during extended periods of drought. Furthermore, many water bodies are contaminated by untreated industrial and domestic wastewater, affecting public health, increasing the costs of treating water for drinking purposes, and reducing the potential use for other sectors such as agriculture. The industrial sector is the largest contributor of net organic load that is discharged to water bodies. Colombia's water sector is governed by numerous agencies, many laws, and several funding sources, fragmenting the design, implementation, and monitoring of policies and investments. The diagnostic predicted that water shocks will cause serious drags on the Colombian economy if investments and public expenditure stimulus in water do not ramp up.

In Peru, growth is dependent on water, yet the country faces the greatest climate variability in the Latin America and Caribbean region and significant rainfall spatial distribution. The Water Security Diagnostic found that almost half of the country is highly vulnerable to natural disasters associated with the El Niño phenomenon and long-term climate change. Water insecurity costs Peru between 1.1 and 4.0 percent of GDP, of which 0.65 percent is attributed to floods. In Peru, unlike the other two countries, these estimates include the impact of water insecurity on production in three export-oriented industries: agriculture, mining, and manufacturing. Water shocks linked to extreme rainfall and droughts are expected to increase given the continuous deterioration of watersheds, increased precipitation variability, and the acceleration of glacial retraction in the Andes. Peru provides only half of its population with safely managed water, and even less with safely managed sanitation. The people of the Amazon rainforest shoulder the biggest share of the burden associated with poor water supply and sanitation services. Most of the agricultural land along Peru's Pacific coast is irrigated to sustain commercial agriculture, but in the Andes Mountains and high-altitude Amazon, where 50 percent of the rural population lives in poverty, only about 20 percent of the cultivated land is under irrigation. This leaves agricultural production exposed to shifts in rainfall patterns linked to climate variability and climate change. Although Peru has a comprehensive water management legal framework, it has not reaped the benefits of the framework, given low levels of implementation.

The Water Security Diagnostics consider management of water resources, delivery of water services, and mitigation of water-related risk with an aim to determine where countries should invest to close water security gaps.

The initiative resulted in a regional report titled "Water Matters: Resilient, Inclusive and Green Growth through Water Security in Latin America," published in March 2022. This draws on the three national Water Security Diagnostics, as well as other relevant analytical work conducted by the Water GP and the Sustainable Development Unit in Latin America. Because the report does not single out individual countries, it can examine difficult issues faced across the region, such as transparency, corruption, and indigenous people's rights.

ADDITIONALITY

The Water Security Diagnostics gained considerable traction, both in the three countries and regionally. They identified problems, recommended evidence-based solutions, and opened technical and policy dialogues with the respective governments.

The process of developing the diagnostics was highly participatory, which has helped build trust. As a result, other stakeholders have also begun to engage and adopt the messages in the diagnostics. For instance, in Colombia the Bank is working with ANDESCO (Asociación Nacional de Empresas de Servicios Públicos y Comunicaciones), a water utility federation, to host a multidonor roundtable. The regional report, meanwhile, opened engagement with regional partners, including the Organization of American States.

Policy changes have already been achieved as a direct result of the diagnostics. For instance, in Peru, the government made policy changes that integrate an approach to planning based on water security and risk, and consider climate change. In Argentina, the National Plan for Infrastructure Works refers in numerous places to priorities identified in that country's Water Security Diagnostic, and the Ministry of Public Works has requested the World Bank to help prepare projects on flood risk management and improve wastewater treatment.

The Water Security Diagnostics in Argentina, Colombia, and Peru have been used by the teams preparing Country Climate and Development Reports in the three countries, and have prompted dialogue in other countries.

BOX 3.1

BANGLADESH:
Bringing the Water, Finance and Transport Sectors Together to Build Climate Resilience in the Jamuna River Basin

Rapid industrial growth and an expanding population are increasing demand for freshwater in Bangladesh and pushing the sustainable management of water resources to the forefront of the country's economic and social development agendas. Over 93 percent of Bangladesh's total renewable water resources are transboundary, making regional cooperation an essential part of water management.

Bangladesh relies on "normal" monsoon floods to recharge groundwater, supply irrigation, deposit fertile sediments, and balance the larger wetlands ecosystem. However, a projected 440 percent rise in industrial growth by 2050 (largely in the garment and textile industry), alongside increasing climate change impacts and a predicted 200 percent growth in household water demand, would put unprecedented pressure on its available water resources. This would be exacerbated by increasing geogenic and industrial pollution in groundwater, which almost exclusively sustains the country's water demands.

Since 2019, GWSP has been supporting a platform to help stakeholders establish a dialogue and increase donor coordination around water sector priorities. The Bangladesh Water Platform provides a dynamic country-specific space for stakeholders to solve substantial water issues by facilitating the collection and sharing of information and knowledge. It thus serves to streamline integrated and coordinated approaches among government actors and sectors. The resulting dialogue helped to develop stakeholder input and consensus for the Bangladesh Delta Plan 2100, which identifies cross-sectoral action needed to improve productivity, address climate change threats, and minimize disaster risks in the delta.

Through the water platform, the World Bank initiated several diagnostic and economic studies to support the plan and inform the design of several intersectoral projects. These include the planned World Bank–financed Jamuna River Economic Corridor Development project, which will focus on increasing climate resilience and financial sustainability. Over the past two years, GWSP support has helped the government prepare for the implementation of this new project, including the development of a hydroeconomic model that found for every dollar invested in the project, $10 would be generated. This rate of return has made the project the top priority in the Bangladesh Delta Plan 2100.

The Jamuna Project is the first of its kind to integrate all the issues of flood and erosion risk

management: mitigation, preparedness, and recovery. GWSP support has been critical in bringing the water, finance, and transport sectors together to consider this work from a multisectoral perspective. Support has focused on building skills and knowledge for new technologies in the areas of predisaster preparedness, community financial protection, and the use of innovative structures and nature-based solutions for flood and erosion mitigation, including dynamic navigation (which allows a river to move naturally during monsoon floods and integrates modern navigation aids with smart dredging to guide vessels along the best navigation routes during the dry season).

GWSP investment, supplemented by grants from the Korea Green Growth Trust Fund and the Finance, Competitiveness and Innovation GP, has been instrumental in increasing the government's capacity to implement Phase One of this challenging cross-sectoral project. Specific examples of GWSP support include:

- Supporting the river engineering knowledge institute Deltares to work with the Ministry of Water on designing cost-effective, locally adapted flood mitigation structures.
- Increasing the government's capacity to develop and use actuarial analysis and flood-forecasting models to inform ongoing project design and flood-insurance decisions.
- Providing knowledge and technical assistance to complement conventional flood mitigation and dredging investments. This included helping to introduce up-to-date dynamic navigation techniques and supporting a River Information System within the Ministry of Shipping.

CAMBODIA: INCREASING GOVERNMENT CAPACITY TO MANAGE WATER RESOURCES

CHALLENGE

Cambodia's economy and livelihoods are highly dependent on natural resources, and water in particular. Although there is great potential for sustainable agriculture and fisheries development to grow the economy, support rural livelihoods, and reduce social and environmental vulnerabilities, the majority of the country's rural population is engaged in small-scale, low-profit agricultural practices.

Cambodia is highly prone to flood and drought events, with around 80 percent of the land area within the Mekong and Tonlé Sap river basins. Its current irrigation and water storage infrastructure is inadequate for securing livelihoods. Minimal country information and data are available to guide investment, making it difficult to identify priorities and design sustainable water management policies.

Historically, there has been minimal collaboration and dialogue among the many multilateral, international, and local organizations working to tackle these issues. This has led to a duplication of projects in some areas, and knowledge and resource gaps in others.

APPROACH

GWSP support played a key role in expanding funding, resources, and collaboration in the country's water sector. In FY19, with GWSP support, Cambodia established the Development Partner Coordination Group for the Water Resource Sector to bring together donors. Adopting the knowledge and lessons shared from a similar model implemented in Nepal with GWSP support, this water platform is designed as a space for donors to discuss areas of concern and gaps in Cambodia's water sector. Current members include several international development organizations, and the platform acts as a communication channel to facilitate dialogue with the government.

The platform has been successful in increasing communication, highlighting potential collaborations on water sector projects, and preventing duplication of knowledge development and investments on the ground. Additionally, because many of the donors are also involved in projects along the water-food-energy nexus, there is enhanced opportunity for knowledge sharing and coordination across sectors. The water, environment, and agriculture GPs have worked collaboratively on the Bank's engagement.

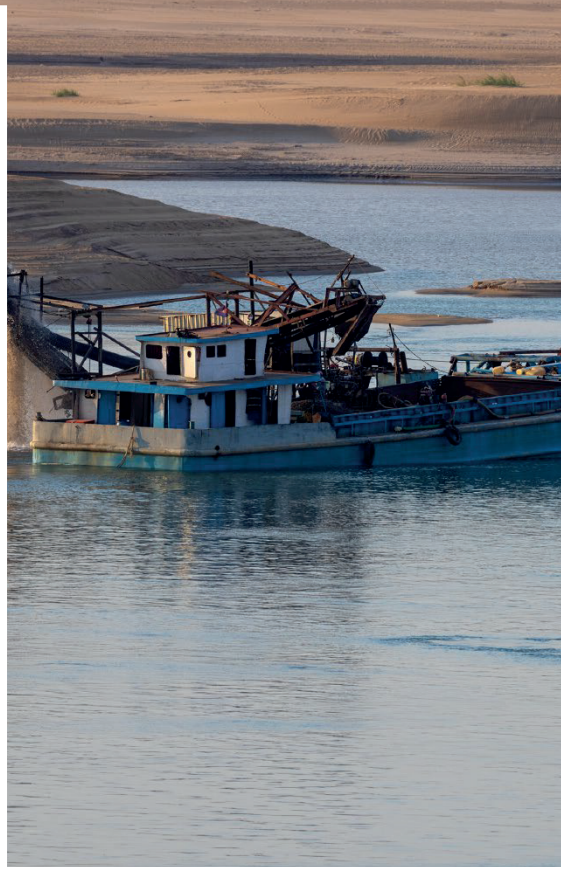
In response to widespread flooding throughout the Mekong River Basin in October 2020, the GWSP-supported Water Expertise Facility provided a grant to enable a rapid assessment of probable causes of flooding during the monsoon season and recommend ways to enhance flood resistance in the water and agricultural sectors. This included bringing together policy makers from relevant ministries to discuss water resource issues in the Mekong and Tonlé Sap basins and urge the government to take further action on flood management. Moreover, tools designed with GWSP support, such as river basin profiling and water resource management modeling, have influenced how the government is working on issues such as water security for agriculture and flood preparedness.

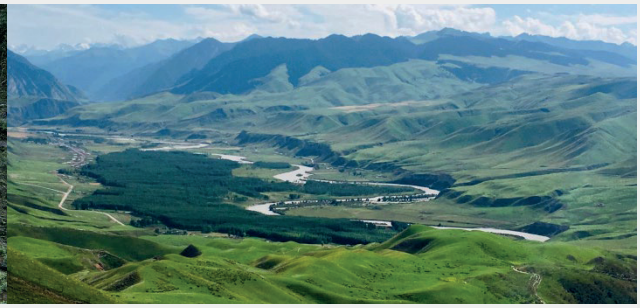
GWSP-supported knowledge products, such as the report "High and Dry: Climate Change, Water and the Economy," have been instrumental in filling knowledge gaps and generating government interest in moving toward a more integrated water management model. In early 2021, GWSP supported Cambodia's first Water Dialogue event. Bringing together senior government officials, key stakeholders, members of the donor community, and World Bank specialists, the event led to greater collaboration and dialogue with the Cambodian government.

ADDITIONALITY

GWSP support has been instrumental in scaling up World Bank investment in Cambodia's water sector, including the planned World Bank–financed Cambodia Water Security Improvement project.

This project has adopted knowledge obtained through GWSP support to apply integrated approaches to address water security challenges, involving mutisectoral interventions. The country is now better able to predict and manage the impact of natural disasters on the agriculture sector, and the government is equipped to invest in water security and increase agricultural water productivity. The government is integrating models and hydromet data into a new national information and data center established by the Ministry of Water Resources and Meteorology.





BOX 3.2 SUPPORTING SUSTAINABLE WATER MANAGEMENT IN CHINA

GWSP is helping to build institutional capacity for sustainable water management in China. Through analytical work, technical assistance, and tools, GWSP is supporting government efforts to ensure protection and restoration of the Yangtze River Basin, informing improvements in the policy framework for valuing water, and exploring the contribution of China's water sector to global public goods.

GWSP is supporting a large-scale, ambitious effort to strengthen water resources management, safeguard water for the environment, and reduce water pollution. The $400 million World Bank–financed Yangtze River Protection and Ecological Restoration Program complements the approximately $6 billion the government is investing to support its national strategy for the Yangtze River Basin. The program directly addresses some of the main drivers of biodiversity loss and prioritizes safeguarding water for the environment. Related analysis will yield important lessons for the sustainable management of river basins elsewhere in China and around the world.

GWSP has helped to identify opportunities for improving water policy through the identification, evaluation, and realization of the many and diverse ways water is valued in China. The 2022 GWSP-supported report **"Clear Waters and Lush Mountains: The Value of Water in the Construction of China's Ecological Civilization"** outlines a policy framework that builds on a number of background analyses. Among these is the use of innovative financing mechanisms for "eco-compensation"—fiscal transfers for environmental and natural resources management—and their application in the Yangtze River Basin.

GWSP support has also been key to assessing the contribution of the water sector in China to global public goods. This work has explored the role of knowledge transfer, learning from China's development of its water sector over the past 40 years, the country's unique freshwater biodiversity, and China's approach to the management of transboundary water resources and contribution to the world's virtual water trade.

Over the past five years, GWSP support to water in agriculture has evolved to address resilience, water security, and environmental sustainability.

WATER IN AGRICULTURE

Water is central to nourishing the world. Reliance on rain-fed agriculture alone is insufficient to meet the challenges posed by climate change, and irrigated agriculture is essential for food security.

Sustainable irrigation and drainage services, along with regenerative agricultural practices, are key, and essential to climate change adaptation and mitigation. Sustainability requires more than engineering and infrastructure investment to break the all-too-common cycle of build-neglect-rehabilitate.

The agriculture sector has shifted focus from generating calories to producing food that is both more nutritious and sustainably grown. There is a need for improved governance, inclusion, and innovation to strengthen and improve the delivery of irrigation and drainage services to farmers.

Over the past five years, GWSP support to water in agriculture has evolved to address resilience, water security, and environmental sustainability. It has also involved raising awareness of the role of irrigation in decarbonization. GWSP support of farmer-led irrigation development and the use of disruptive technologies—such as remote sensing for water accounting—has served to improve irrigation performance and guide investment decisions.

GWSP has supported the development and introduction of a toolkit to assist in improving the management of irrigation service delivery ("The Irrigation Operator of the Future" toolkit), based on another GWSP-supported initiative, the Utility of the Future. The toolkit proposes technical, financial, and governance improvement pathways, and includes indicators to track progress in improving irrigation service delivery. Operators and irrigation service providers are supported to participate in a series of workshops that facilitate the collection of information on the current performance of irrigation and drainage systems, the identification of challenges, and the development of a 100-day action plan and a five-year investment plan. As the initiative moves into a pilot stage, feedback from irrigation operators and service providers is being used to help ensure relevance and improve engagement (see box 3.4).

Given the urgency of producing more food with less water, and in light of the challenges posed by climate change, it is critical to develop tools to help clients make effective, evidence-based irrigation and agriculture investment decisions. Data scarcity should not be an obstacle to optimal water management and governance. GWSP has supported the development of tools to benchmark and assess irrigation performance. In addition, GWSP has supported the development of methods to measure and monitor water resources and to promote efficient water use through water accounting. This work is critical to the sustainable allocation and overall management of water resources.

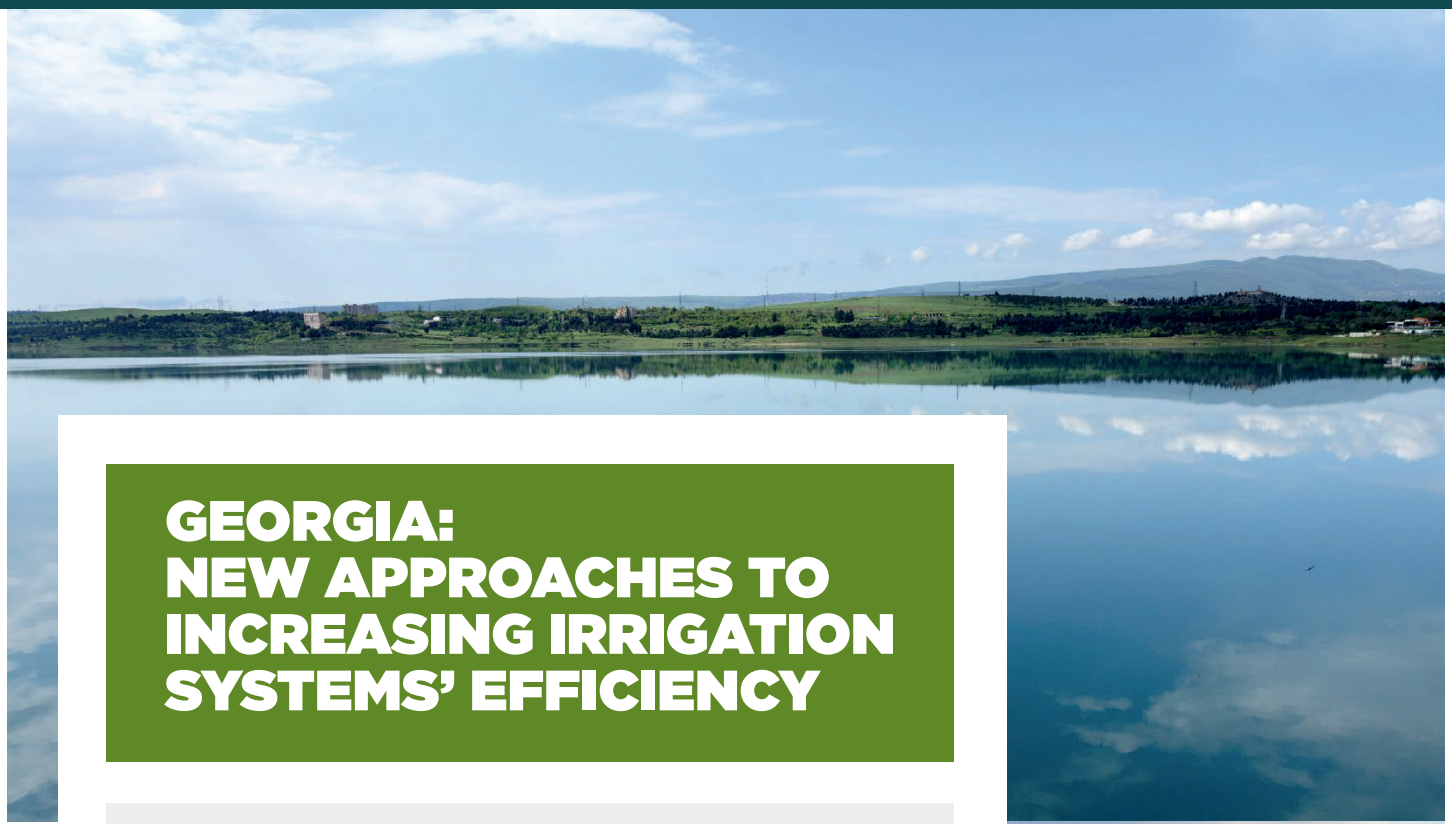
With GWSP support, the Water GP's Water in Agriculture team has developed several scalable, innovative tools and approaches. For instance, the Global Water Accounting Tool is a web-based interactive platform that has provided automated water accounting reports for large-scale applications, such as the $340 million Sindh Water and Agriculture Transformation project in Pakistan. Also with GWSP support, the team has assisted the West Bengal Irrigation and Waterways Department to apply remote sensing and GIS applications to improve oversight of water delivery and utilization, and the benchmarking of irrigation canal performance.

To increase cross-sectoral work and collaboration, the Water in Agriculture team is taking an increasingly holistic approach that builds on cross-sectoral relationships both in and outside the World Bank. For example, the International Network of Service Providers for Irrigation Excellence, INSPIRE, launched in 2021, is a technical working body with a worldwide reach that brings together over 300 experts in the field to share knowledge and lessons relevant to the effective delivery of water services. INSPIRE is co-led by the World Bank's Agriculture and Food GP and the Water GP and supported by GWSP, along with several other development agencies.

Farmer-led irrigation development (FLID) is a dynamic approach to helping farmers develop irrigated agriculture, and GWSP has helped garner public sector support for it. In FY22, FLID moved from concept to operationalization at scale. GWSP supported work with governments in 13 countries, and more than $430 million in World Bank lending is now earmarked for FLID. This will leverage farmers' own investments, and expand access to irrigation for 185,000 farmers over 85,000 ha of agricultural land (see box 3.3). While GWSP support to date has focused on Africa, where the need for resilient irrigation is the greatest, in the coming years it will expand to other regions.

GWSP support has also helped raise awareness of concrete ways to decarbonize irrigation, focusing on reducing methane, the most potent greenhouse gas, and nitrous oxide emissions. GWSP funding has been used to connect and support teams working on interventions that promote low-carbon rice cultivation, including the use of the alternate wet-and-dry irrigation technique, which produces less methane emissions than the traditional flooding of rice paddies. GWSP support will continue to further global knowledge of such challenges as the measurement and validation of emissions reduction at scale and climate financing options, including access to carbon markets.

With GWSP support, the Water in Agriculture team is helping client governments ensure that investments are physically and financially resilient, delivering both economic and environmental benefits.



GEORGIA: NEW APPROACHES TO INCREASING IRRIGATION SYSTEMS' EFFICIENCY

CHALLENGE

In Georgia, the agriculture sector provides over 19 percent of employment nationwide, and generates 28 percent of total exports. The sector has been critical in establishing Georgia as an important source of regional food security and spurring its transition from a lower- to upper-middle-income country. However, reliable water access remains a constraint to expansion and profitability, and as a result a significant share of the population is still employed in low-productivity agricultural activities.

While irrigation schemes are plentiful in Georgia, many are in need of rejuvenation, modernization, and investment. A lack of reliable agro-hydrological data hinders evidence-based decision-making to support investments to ensure efficient and reliable irrigation service delivery. Remote sensing-based methods for the assessment of irrigation performance and water use are increasingly being used as innovative tools to fill such data gaps. These tools generate information on volumes and quality of water flows, as well as current and future trends in supply and demand, which, when systematically organized and presented, inform water accounting processes. Such methods offer an opportunity to help Georgia modernize agricultural water management and work toward water security.

FEATURE - continues from page 43

APPROACH

GWSP supported the use of the Global Water Accounting Tool in Georgia to help stakeholders gain access to public-domain remote-sensing-based information. This information includes decision-making parameters such as water availability, use, and productivity; the agricultural water deficit; and the water balance—depending on location and the challenges faced. The tool has informed the development of a digital water accounting app that uses remote sensing and ground data analysis to generate maps that show irrigation performance across various schemes. Using this information, it is possible to target the schemes most in need of support to increase efficiency and improve service delivery. This app was piloted across 20 irrigation schemes in the Alazani Basin in eastern Georgia.

The pilot successfully demonstrated the potential of using satellite data, and also increased the government's familiarity with water accounting. In FY22, GWSP supported extensive hands-on training to guide the tool's integration into mainstream decision-making and planning for irrigation.

ADDITIONALITY

The information generated has been highly influential in the government of Georgia's planning and decision-making for sustainable water irrigation and water storage management. The data complement ongoing environmental flow assessments using remote-based sensing and combining economic, climatic, and hydrological factors to guide more robust choices for irrigation investments.

Other donors and partners, including the French Development Agency, are using the shared data in their projects. The approach has also spurred cross-border dialogue and learning with neighboring countries, improving regional water management. For instance, the water assessment app was showcased in Armenia, which prompted the government to develop a similar tool to guide irrigation and water storage decisions. It is now being piloted in one river basin, with plans to expand to other areas. In Ukraine, the water analytics tool is laying the groundwork for post-war recovery decision-making. Adaptation of the tool for use in Ukraine has led to the development of additional aspects, such as the role of energy use in irrigation and climate impacts, highlighting the tool's adaptive potential.

GWSP will continue to provide support that is complementary to the World Bank's $150 million Georgia Resilient Agriculture Irrigation and Land (GRAIL) project. Under this project, a roadmap will be developed to establish a Hydro-Agro Informatics Program and Center to institutionalize the use of remote sensing and data analytics and harmonize the collection of data on water and agriculture.

BOX 3.3

ZIMBABWE: Taking Farmer-Led Irrigation to Scale

In recent years, Zimbabwe has experienced one of the highest food price inflation rates in the world, and up to 5 million people are at risk of famine. Irrigation plays a significant role in Zimbabwe's agricultural productivity, addressing food insecurity and securing economic growth. The Government of Zimbabwe is implementing an Irrigation Master Plan that aims to expand irrigation from the current 220,000 hectares to 350,000 hectares in 2025.

However, irrigation systems are not functioning on more than a fifth of the land they cover, and the country is struggling to cover operation and maintenance costs. Under the Irrigation Master Plan, government agencies would develop, operate, and maintain irrigation infrastructure. However, so far, many of the public investments in irrigation have proven to be unsustainable.

Under these circumstances, farmer-led irrigation development (FLID), whereby farmers take the lead in the establishment, improvement, and expansion of irrigated agriculture, offers a sustainable alternative to public sector investment in irrigation infrastructure and management.

GWSP supported a national FLID diagnostic in FY22, generating interest from the Ministry of Lands, Agriculture, Fisheries, Water, Climate and Rural Development. With the support of GWSP, online consultations, stakeholder surveys, and a workshop have been carried out to identify the constraints farmers face in irrigation and propose policy recommendations. Based on the feedback from farmer representatives, government agencies, and private sector actors, key regulatory and policy solutions have been identified. Farmers' access to water and local water management is being enhanced through such approaches as local coordination, the granting of water permits, monitoring of compliance, and application of adaptive allocation (that is, responsive to supply and demand).

To design targeted financing mechanisms, four categories of farmers have been identified, from smallholder farmers not using any irrigation technology to farmers using sophisticated, high-tech systems and connecting digitally with agricultural advisory services. Solutions have been identified to respond to their unique technical and financial constraints. Key policy recommendations have been developed related to building a digital platform of farmers and other stakeholders to enable market linkages.

The Ministry of Agriculture now considers FLID to be the most direct and cost-efficient way of accelerating irrigation to contribute to food security, climate resilience, and economic growth in Zimbabwe. Following the activities supported by GWSP in FY22, the ministry is planning to sustain government action on FLID and go to scale.

BOX 3.4

PILOTING THE "IRRIGATION OPERATOR OF THE FUTURE" TOOLKIT in Albania, Tajikistan, Georgia, and Tanzania

In FY22, GWSP supported the piloting of the Irrigation Operator of the Future toolkit in Albania and Tajikistan, and the use of elements of the toolkit in irrigation sector assessments in Georgia and Tanzania.

In Albania, the toolkit was applied at the field level in selected irrigation schemes. It helped inform the decentralization of the management, operation, and maintenance of irrigation and drainage schemes from the national level to local municipalities. The pilot identified key opportunities for improvement, including the development of greater capacity among technical staff, options for financial sustainability, possible modernization investments to replace open channels with more efficient pressurized pipelines, and reform of the irrigation tariff. These opportunities are now being developed into a strategic action plan.

In Tajikistan, the government's priority is high-level institutional reform in the context of seriously degraded and dysfunctional infrastructure. Irrigation systems are mostly pumped, and energy costs are often unaffordable for farmers. The toolkit was used to identify needs in terms of strategy development, irrigation transmission efficiency, and greater on-farm water productivity.

In Georgia and Tanzania, irrigation investment planning diagnostic work was already underway and elements of the toolkit were used to complement existing analyses and identify opportunities. The assessment identified weaknesses to the prioritization of irrigation investments, water-user contracts, tariff setting, and communication with farmers. In Tanzania, the tool identified critical functional and management gaps, and a lack of legal clarity on irrigation fee structures and on the functions of local water user associations. These findings led to recommendations for a more comprehensive national investment strategy, tariff reform, and a drive for improved customer communications and relationship development.

The pilots revealed ways the toolkit can be strengthened and improved. In FY23 full pilots of multiple types of schemes on a range of continents will be undertaken, with the aim of developing a more sophisticated and user-friendly toolkit.

WATER SUPPLY AND SANITATION

Building water and sanitation security is fundamental to green, resilient, and inclusive development. But this security is threatened. There are significant gaps in water supply and sanitation services, and progress toward achieving SDG 6 is too slow. In 2020, 2.0 billion people lacked access to safely managed drinking water and 3.6 billion people lacked access to safely managed sanitation.

It is estimated that progress needs to at least quadruple to reach the water supply and sanitation targets of the SDGs. At the same time, the impacts of climate change are becoming more intense, with prolonged dry and wet spells taking a disproportionate toll on communities lacking access to safe and affordable water and sanitation services. Climate change increasingly jeopardizes the reliable availability of water and is compelling many sector stakeholders to change their way of developing and delivering services. Population growth and escalating urbanization further impede progress. Ensuring water and sanitation security is a growing challenge in many World Bank client countries, as they strive to decentralize service provision and close existing service gaps.

GWSP helps build water and sanitation security by supporting a shift toward establishing the policies, institutions, and regulation needed to tackle the enormous challenges facing the water sector. GWSP support facilitates the development of innovative and scalable solutions to key challenges, such as the need to rapidly increasing

access to safe water and sanitation, ensure maintenance of existing infrastructure, and improve the quality of services.

For example, the GWSP-supported Citywide Inclusive Water Supply initiative examines the traditional focus on piped water connections and explores how off-grid, off-utility services offered by supplementary providers could be reimagined as solutions. Circular economy approaches, which minimize waste, maximize water use efficiency, and recover, reuse, and restore water resources, offer another example. They can substantially contribute to building water security by increasing the menu of water resource options and helping cities transition from a traditionally linear approach—in which freshwater is extracted, used, treated, and disposed of—to a sustainable, resilient, and circular one.

Utilities and other water service providers are at the very heart of efforts to build water and sanitation security. But these institutions are increasingly challenged by public health crises, urbanization, and climate change. Despite concerted efforts, many utilities continue to struggle with operational and financial performance, which translates into losses in distribution systems and high rates of nonrevenue water (that is lost en route to users, or otherwise not paid for). Such operating and investment inefficiencies drive up costs and strain revenues, undermining utilities' financial performance and ability to expand coverage. Utilities risk slipping into vicious cycles of no revenue, low staff pay, and poor service delivery. Moreover, water and sanitation utilities that run on a loss or government subsidies have little to no capacity to absorb shocks, or to serve growing peri-urban areas.

With GWSP support, the Water GP works to break these vicious cycles. GWSP helps build utilities' capacity and lets them benefit from innovation and technology to "leapfrog" to higher levels of maturity. This allows them to deliver high-quality services in an efficient manner while embracing innovation, inclusiveness, market and customer orientation, and resilience.

In every country of the world, rates of access to water supply and sanitation services are lower in rural areas than in urban ones. Yet investments in rural areas are often compromised by low-quality construction and poor maintenance. As a result, water and sanitation infrastructure falls into disrepair, often only a few years after installation. These challenges must be addressed to achieve universal access and ensure water and sanitation security for rural populations. This demands technical support and capacity building at both the user and institutional levels; a separation of policy, ownership, operations, and regulation; and a progression toward professionalized management.

The interconnectedness of water and sanitation with other development priorities, such as health, environmental, social, and economic goals, is putting pressure on historically siloed approaches to water supply and sanitation services. At the same time new technologies and innovations offer unprecedented opportunities to transform the water and sanitation sector and step out of existing siloes. GWSP is supporting concerted efforts to address these growing pressures and achieve water supply and sanitation security for all.

NIGERIA: SUPPORTING WATER AND SANITATION SECTOR REFORM

CHALLENGE

Nigeria is Africa's largest country, with a population of more than 200 million people, 40 percent of whom live in poverty. Fragility, conflict, and insecurity afflict many parts of the country. Insufficient capacity constrains the public sector, and on many human development indicators, Nigeria ranks among the lowest in the world, with human development outcomes particularly low among girls and young women.

Nigeria has already been substantially impacted by climate risks, including major flooding due to harsher torrential rains and severe drought from extended dry spells. Resilient WASH infrastructure and service provision will be critical for communities to develop greater climate resilience, and to thus mitigate the conflicts between different users of land and water resources that are being exacerbated by climate change.

In 2021 approximately 70 million Nigerians had no access to basic drinking water services and 114 million were without basic sanitation facilities. Access to piped water declined from 36 percent in 1990 to 11 percent in 2021. An estimated 19 percent of Nigerians practiced open defecation in 2020, and fecal sludge is commonly released untreated into the environment. Urban water utilities largely fail to meet the needs of their already small customer base, forcing a majority to

rely on expensive and often unsafe alternatives, such as private water vendors and shallow private wells. In 2016, water quality testing at a national scale revealed that over three-quarters of the population used contaminated water sources, and that nearly half used sources that were at very high risk of fecal contamination.

The poor performance of the sector was highlighted in the GWSP-supported WASH Poverty Diagnostic in 2017. In 2018, Nigeria's WASH sector was declared to be in a state of emergency by President Muhammadu Buhari. The government subsequently launched the National Action Plan, a 13-year strategy for the revitalization of Nigeria's WASH sector, aimed at ensuring universal access to sustainable and safely managed WASH services by 2030.

APPROACH

GWSP has provided significant assistance to support the government's commitment to reform and build government capacity. This complements the World Bank's $700 million Nigeria Sustainable Urban and Rural Water Supply, Sanitation and Hygiene Program-for-Results (SURWASH).

GWSP is supporting the preparation of Policy, Institutional, and Regulatory (PIR) Plans and Performance Improvement Action Plans (PIAPs) for each of the seven participating states. These plans must be developed and implemented to receive disbursement under the Program-for-Results project. The PIR plans support the implementation of a series of state-level reforms to strengthen the enabling environment, while the PIAPs support performance improvement across key elements critical for service quality and sustainability at the level of the implementing agency. GWSP has supported the dissemination of preparatory tools through workshops and additional hands-on support to the participating states.

Technical assistance is also being provided to help the government implement the "Clean Nigeria: Use the Toilet" campaign, designed to achieve an open defecation-free Nigeria by 2025 and launched by the Federal Ministry of Water Resources in 2019. Support was provided through GWSP to the ministry, the federal program implementation unit, the Clean Nigeria Campaign Secretariat, and the states to develop strategic documents for the implementation of the campaign, including a Program Operations Manual, and guidance notes for the preparation of policy, institutional, and regulatory plans and Performance Improvement Action Plans.

Technical assistance was also provided to develop working methodologies and establish operational procedures as well as a monitoring, evaluation, and reporting system used by the Clean Nigeria Campaign Secretariat. At the state level, technical assistance is being provided to develop sanitation action plans that align with the principles of citywide or area-wide inclusive sanitation. GWSP supported extensive training, including assistance to the National Water Resources Institute to design and conduct a short course on rethinking rural sanitation.

The GWSP-supported Utility of the Future (UoF) initiative has allowed seven urban water utilities to assess their current performance, envision their future, and begin the process of defining processes and plans to reach goals that were set as part of their PIAPs. With GWSP assistance, the utilities are implementing 100-day action plans to improve their financial viability. Through sector diagnostics and the PIR plans and PIAPs, sector institutions in the program states are being supported to build their resilience and address risk. Additionally, the GWSP-supported Equal Aqua platform helped six Nigerian utilities create more inclusive and diverse workplaces by promoting gender diversity and disability inclusion.

ADDITIONALITY

The declaration of a WASH state of emergency in Nigeria, driven by evidence, opened the door for an ambitious and bold set of reforms. GWSP analytical work made it possible to implement SURWASH as an innovative program for results, supporting investments across urban and rural areas. Government commitment and capacity have been built, drawing on several interconnected GWSP-supported initiatives, such as UoF and Citywide Inclusive Sanitation.

GWSP support has ensured that sanitation maintains a high profile in the reforms and is recognized as a neglected issue and an urgent priority.

GLOBAL: BUILDING THE CAPACITY OF WATER SERVICE PROVIDERS AT SCALE

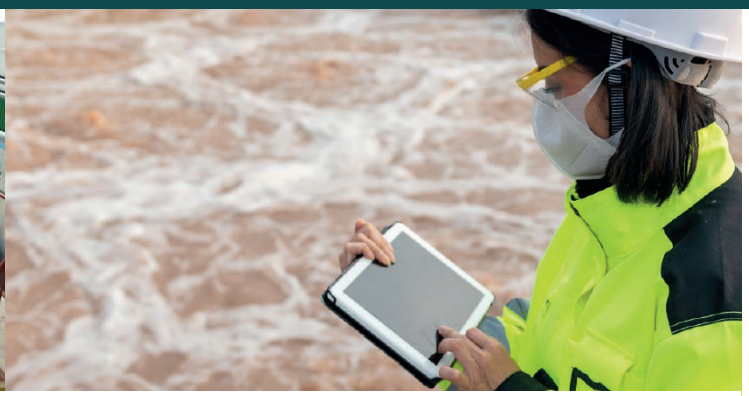
CHALLENGE

Global challenges—including climate change, water scarcity, population growth, migrations, rapid urbanization, and recovery from the COVID-19 pandemic—threaten the provision of high-quality and sustainable services, jeopardizing the possibility of providing "water and sanitation for all." Well-performing water and sanitation utilities are key to providing quality services, but they require a new, strategic management approach to create efficient and sustainable strategic business models, ensure continuity of operations, develop strategic capabilities, and encourage continuous improvement.

APPROACH

GWSP provides knowledge and technical expertise to support utility performance improvement efforts worldwide. The goal is to create future-focused utilities that operate in an efficient, resilient, innovative, and sustainable manner, and deliver reliable, safe, inclusive, transparent, and responsive water and sanitation services.

Through the UoF Program, participating utilities get assistance in the completion of a three-step process. The process comprises a utility assessment, a 100-day action plan that tackles the most pressing issues to jumpstart utility reform and obtain quick wins, and a five-year plan to sustain performance.



With GWSP support, through a partnership with Aguas de Portugal, on-demand utility-to-utility technical assistance is provided. GWSP also supports the digital transformation of water and sanitation utilities. The challenge is to scale up to reach as many countries and service providers as possible, and to address specific capacity issues that service providers face in responding to the sector's growing challenges.

In Zambia, Peru, Nigeria, Kosovo, Albania, and Poland, a series of week-long, on-site immersion workshops were held. These "ignition weeks" take utilities from initiation and assessment to the preparation of an agreed short-term action plan. This training will support the rolling out of the UoF initiative to at least 30 more utilities in these six countries, where the assistance provided through GWSP is linked to World Bank projects that invest in strengthening the utilities. In Peru, for instance, the UoF framework has been applied in the six utilities participating in the $200 million World Bank–financed Modernization of Water Supply and Sanitation Services project. They have prepared 100-day plans and five-year plans, under which technical assistance needs have been identified that are being addressed through the project.

All UoF resources are publicly available in eight languages, further supporting roll-out and scale-up. In addition, in response to demand from utilities, a gender lens was incorporated into the UoF Program, in collaboration with the Equal Aqua platform, resulting in gender-focused diagnostics. The UoF Program also includes the "UoF Global Youth Challenge," through which over 200 young professionals have proposed innovative ideas for water utility management. The UoF Program is growing rapidly, and to date has reached over 70 utilities in more than 25 countries. It continues to be scaled up; for instance, in the Philippines, 12 utilities and the departments of the interior and local government have been trained to implement the UoF Program at the national level over the next three years.

GWSP support has allowed the Water GP to focus on specific issues related to improving utilities' operational performance and efficiency, and helping them futureproof their operations. One of these issues is digitization. This simply refers to converting analog data into digital files, but in the context of utility management, it changes the way that utility workers interact with instruments, making measurement of key performance parameters easier and more accurate, enabling remote and more efficient operation. Digitization goes beyond technology and includes human resources, processes, and corporate culture. It requires clear governance, a strong vision, and the application of well-chosen performance indicators to deliver the expected benefits. "Digital transformation" represents a foundational change in how an organization delivers value to its customers and users, and facilitates more proactive, data-driven, informed, and connected utilities and customers.

Utilities have been supported to establish digital roadmaps, which are three-to-five-year action plans to deploy digital solutions. Because digital solutions change over short periods of time, a digital roadmap is short in nature, and identifies the most important bottlenecks. The roadmap is thus highly relevant to key areas where digital solutions can improve quality, reliability, and overall performance optimization. Water utilities can leverage a set of digitally enabled capabilities to address sector-specific challenges such as deteriorating infrastructure, water scarcity, drought potential, an aging workforce, and energy efficiency.

In Morocco, the national water operator, ONEE Branche Eau, wanted to prioritize the continuity of service provision. With GWSP support, ONEE developed a digital observatory that allows staff to adjust operations according to weather, demands from clients, and other real-time parameters. GWSP also assisted ONEE in assessing its digital maturity level and creating a digital roadmap. Priority projects were identified, and using tools and methodologies developed with GWSP assistance, gradual adoption of digital technologies was supported.

In Cusco, Peru, GWSP supported SEDACUSCO, the water supply and sanitation utility, in applying a "digital lens" to its operations. A digital maturity assessment was conducted, and a series of priority steps toward digital transformation identified. Assistance is being provided as needed in the preparation of a strategic investment plan that responds to the results of the digital lens methodology. There are plans to replicate this approach in five other utilities in Peru that are part of the Modernization of Water Supply and Sanitation Services project.

ADDITIONALITY

In Nigeria, Albania, Zambia, and Peru implementation of utility strengthening has influenced the quality of World Bank operations. For instance, in Peru, the World Bank–financed Water Sector Modernization project has UoF 100-day plans at its core, and the diagnostics have contributed to plans for a more ambitious next stage of sector transformation.

The digitization work done in Morocco has established a basis for advice on this topic to be provided to other utilities around the world. It has helped shape a new toolkit, based on a methodology that first assesses the digital maturity of the utility and then builds a relevant roadmap. GWSP is now supporting initial work with utilities in Tunisia, Peru, India, and Kenya at various stages of digital transformation.

In Morocco, GWSP's support has laid the groundwork for more digitization activities under the $210 million Water Security and Resilience project, and in Peru it has contributed to a strategic investment plan that encompasses digitization.

FEATURE - continues from page 55

BENIN: ESTABLISHING PROFESSIONALIZED MANAGEMENT OF RURAL WATER SUPPLY SYSTEMS

CHALLENGE

It is estimated that in 2020 only 26 percent of the population of Benin used piped water. The government has made ambitious plans to address this, and the Government Action Program, adopted in 2016, sets targets for achieving universal access to water supply in both urban and rural areas well before the end of the SDG era.

In May 2017, the National Strategy for Rural Water Supply 2017–2030 was adopted, and a National Master Plan for the Development of the Rural Water Supply Sector was prepared to operationalize this strategy. Under this plan, the government will invest more than $270 million in rural drinking water, complementing close to $500 million being invested by the World Bank and donors.

The government set up a dedicated executing agency for rural water supply and requested assistance from the World Bank to adopt a new approach. With GWSP support, a new model has been established based on professionalized service delivery, private sector innovation, and private finance. The rural areas of Benin have been divided into three areas, each to be served by a private operator. While the government will pay for initial capital costs, the operators will self-finance, through their remuneration, water system renewal,

rehabilitation, and operation and maintenance. The focus is on achieving higher levels of service, and the government aims to phase out handpumps and standposts and provide everyone with fully metered household connections. These plans are ambitious, time is short, and the government wants to make rapid progress.

APPROACH

Beginning in 2019, GWSP supported the process of developing and awarding contracts with private water supply system operators. With GWSP's assistance, the tender documents were prepared over a very short time period: a call for tenders was launched less than a year after the start of the process.

The COVID-19 pandemic temporarily put the process on hold, but in April 2022, the three affermage contracts were signed with joint venture operators, after a bidding process that attracted both international and regional bidders. The contracts introduce strong incentives for the operators to deliver on expanding access and improving service quality and sustainability, as well as reducing nonrevenue water and improving bill collection. Together, the three contracts will directly support the provision of safe and affordable drinking water to more than three million people.

GWSP's assistance built on foundational work supported by another trust fund, the Public Private Infrastructure Advisory Facility, to establish the enabling environment for public-private partnerships. An asset holding company will be established to manage the operators and oversee the contracts.

GWSP support also included an evaluation of human resources needs and the development of training resources for the water operators. Training will be based at the newly expanded Water Training Centre, where 660 people will be trained to help fill the large number of new jobs predicted to be created by the rural water supply initiative. GWSP's assistance also made possible a gender gap assessment to define the specific support needed for women's empowerment in the rural water sector, both in terms of employment and responsibility for decision-making. The initiative will lead to job opportunities for women in a sector where they historically have not been present at the technical, management, and entrepreneurial levels. A new monitoring indicator—"number of women benefiting from training as rural water supply professionals"—has been incorporated into the results framework, with a target of 15 percent.

ADDITIONALITY

Focused technical assistance to the rural water sector, made possible through GWSP support, has led to concrete and tangible results in Benin. The initial milestones of the reform program included recruitment of regional operators, development of a tariff policy, and training of rural water professionals, all of which have been met. The public-private partnership law in Benin is being implemented for the first time through the World Bank–financed Rural Water Supply Universal Access Program-for-Results, known as AQUA-VIE, leading the way for other sectors in the country.

The rural water supply executing agency has already demonstrated greater capacity and has signed Framework Partnership Agreements with every rural municipality. It has published six semi-annual reports, publicly available on a government website, contributing to transparency and accountability in the sector. The reports detail both the assets and the performance of service providers based on key performance indicators.

Tariff reform has resulted in tariff regulation by the government to ensure the financial viability of the regional operators and contribute to the development of rural water supply systems. Where tariff proceeds are not sufficient, the government has committed to allocating funding to cover the costs of service expansion and rehabilitation through an asset management contract that will be signed with the rural water supply executing agency.

Work supported by GWSP influenced two World Bank operations. The $220.0 million AQUA-VIE project, approved in 2018, finances the construction and rehabilitation of rural piped water supply systems for 1.6 million people. The Đ62.0 million Small Town Water Supply and Urban Septage Management project (PEPRAU) is focused on improving access to water in selected small towns and safe fecal sludge disposal in the capital city, Cotonou.

As a result of the satisfactory ratings since the approval of AQUA-VIE in 2018, $250 million in additional financing was approved by the World Bank in June 2022. This will support the provision of drinking water services to 1.3 million additional people in rural areas, with specific focus on making water infrastructure accessible for persons with disabilities, and will include new reforms to transform the executing agency for rural water supply into an asset holding company.

Renewed capacity in the rural water supply sector has made possible plans to expand efforts to include water resources management, for instance measurement of the impact of rural water supply systems on groundwater, especially in hydro-geologically difficult areas.

Interest in the model used in Benin has been expressed by other countries. For instance, the government of the Democratic Republic of Congo is considering a water supply project supported by the World Bank and has begun discussions with its counterparts in Benin.

PACIFIC ISLANDS: BUILDING THE RESILIENCE OF THE WATER SUPPLY AND SANITATION SECTOR

CHALLENGE

In the small island developing states of the Pacific region, livelihoods are deeply linked to the natural environment. Levels of unplanned urbanization are high, and sanitation and water infrastructure is rudimentary. These countries are uniquely vulnerable to resource scarcity and suffer the impacts of extreme weather disproportionately. Climate change is degrading and depleting water resources. Rising sea levels threaten coastlines and cause salinization of groundwater, making some areas uninhabitable. Extreme weather events are putting scarce freshwater resources under stress.

In small atoll countries, centralized water systems are scarce, and most people still rely on unsafe water sources such as rainwater and unprotected wells. Anthropogenic land-based activities and wastewater pollution have further jeopardized water quality. Local capacity to adapt is limited: there are few water professionals, a lack of data to inform policy reform and responses, and little accountability. Water governance is often complicated by traditional social and political structures. The Pacific region is therefore trailing far behind when it comes to SDG 6.

APPROACH

While the program supported by GWSP in the Pacific islands is relatively new, GWSP supported activities initiated in Papua New Guinea in 2017 have since provided the analytical foundation to influence government policy and improve World Bank project design. To date, the focus of GWSP support has been helping governments to achieve universal water supply and sanitation access, which requires an in-depth understanding of the historical barriers to universal access and the key challenges to effective policy and good governance. GWSP support is now expanding to address the challenges of climate change and the growing fragility of water resources.

Papua New Guinea is one of the poorest countries in the region. It has low levels of access to water supply and sanitation services, which have only decreased over the past two decades. In 2015, the country adopted its first national WASH policy, drafted with support from the Water and Sanitation Program. GWSP has since supported operationalization of this policy; the preparation of prospective legislation to establish the first national WASH authority to oversee the planning, financing, and regulation of sector development; and the design of a mechanism for WASH service delivery in rural areas. The government's capacity to understand and assess the risks associated with water resource selection, including climate change impacts and anthropic pressure, has been enhanced, optimizing investments. These outcomes have informed the implementation of a $70 million World Bank–financed project with the primary goal of increasing access to water supply services in five towns.

The Solomon Islands are rapidly urbanizing and the population of the capital, Honiara, is expected to triple in just 30 years. Under the 30-year strategy of the national water utility, Solomon Water, direction will be sought from the Solomon Islands' government on options to provide services in informal settlements, which are estimated to house over 30 percent of Honiara's population. The results have built institutional knowledge and know-how on citywide water and sanitation planning and evidence-based decision-making. Moreover, results have informed investments in a program focused on WASH services in settlements under the Urban Water Supply and Sanitation Sector project, co-financed by the World Bank, the Asian Development Bank, and the European Union (totaling $82.3 million, of which the World Bank component is $15.0 million). With GWSP support, the national utility has prepared a strategy to expand service delivery, and decreased the volume of unaccounted for water from more than 7 million cubic meters per year to just over 4 million.

Kiribati is a group of atolls scattered in the central Pacific, and is one of the smallest, most remote, and most geographically dispersed countries in the world. GWSP has provided critical assistance in exploring water security and sanitation service options for the capital city, South Tarawa, which has uniquely fragile water resources. A 2018 GWSP-funded study on building urban water resilience in small island countries focused on South Tarawa and provided a detailed account of water and climate challenges. This study provided critical recommendations for water conservation and source diversification, strengthening of sector capacity, and water catchment management.

This informed the South Tarawa Water Supply project, co-financed by the World Bank, the Asian Development Bank, and the Green Climate Fund and Global Environment Facility (totaling $58.12 million, of which the

World Bank component is $15.0 million). Subsequent GWSP support in 2021 allowed timely inputs from a roundtable of experts on the updating of the South Tarawa sanitation roadmap, which guides investments and reforms in the sanitation sector for the next 20 years. These sanitation investments include the World Bank's $19.5 million South Tarawa Sanitation project, which builds on the concept of citywide inclusive sanitation.

At a regional level, GWSP support has allowed the World Bank to work with the Pacific Water and Wastewater Association (PWWA) to establish utility benchmarking. Using data from the GWSP-supported International Benchmarking Network for Water and Sanitation Utilities, PWWA published a report in 2020 analyzing 10 years' worth of benchmarking data from 31 utilities in the Pacific region, including an analysis of the impact of the COVID-19 pandemic. GWSP support will allow the World Bank to assist PWWA member utilities to conduct more detailed analysis of climate change risk and develop plans with select utilities to address these risks across their business operations.

As institutional capacity is low in most South Pacific countries, there is a pressing need for donors to coordinate in order to limit the load on governments. The Asian Development Bank is active in the region and helps coordinate grants from bilateral donors. The Pacific Regional Infrastructure Facility is a key platform for donors to coordinate and inform technical assistance. GWSP contributions to staff time allow World Bank staff to co-chair the facility's water and sanitation working group with the Asian Development Bank.

ADDITIONALITY

GWSP engagement and support have accelerated the dialogue on the challenges and opportunities in the water sector in the South Pacific region, leading the way for World Bank efforts as a whole. Funding provided through GWSP has strengthened the Bank's ability to deliver quality analytical work and water sector lending to Pacific island governments. Over the past five years, GWSP support in the region has evolved from a few small initiatives to an entire program, including $120 million of lending.

Impacts of GWSP support have included the first steps to develop legislation to establish the National Water Sanitation and Hygiene Authority in Papua New Guinea, and a definition of the path by which the government of the Solomon Islands can implement water and sanitation services in informal settlements as targeted in the Greater Honiara Urban Development Strategy and Action Plan.

GWSP has helped position the Water GP to address the lack of systematic and coherent climate policies and practices in the water sector across the Pacific region.

Download Complete Annual Report here.

Solving the Electricity Crisis:

SOUTH AFRICA MUST FOLLOW ITS OWN PATH

By Viv Crone | Pr Eng, FSAAE, FSAIEE

THE ELECTRICITY CRISIS

For the past 14 years, South Africa has been experiencing a growing electricity system crisis. This has manifested itself as increasing periods of load shedding, huge Eskom debt and above inflation increases in the price of electricity.

Many 'solutions' have been proposed, with the main emphasis on replacing existing fossil-fuelled facilities with 'renewables.' The main argument for embracing this solution is the view that renewable generated energy costs less than fossil-fuelled energy, has far lower levels of carbon emissions and is the path chosen by many developed countries.

However, South Africa as a country is unique in several ways. Although it is the most developed African country and has an established industrial capacity, it has one of the highest unemployment rates in the world with almost half the adult population living in poverty [1].

Instead of an economic growth rate of at least 5% required to alleviate poverty, the current rate is negative, driven by several factors, of which continual load shedding is the most significant.

For 2022 up to the end of October, it is estimated that almost 7 500 GWh of electricity or ~3.5% of the total electricity demand was unserved. This has resulted in a reduction of GDP by ~1.4% so far this year based on an Eskom commissioned survey [2].

The Energy Availability Factor (EAF) of Eskom's coal fleet has been steadily deteriorating over recent years to currently below 60%.

Without a proper electricity system, the South African economy has no hope of being able to grow sufficiently to reduce and alleviate the poverty suffered by its people.

THE GOAL

Considering other current and important aspects of climate change, poverty alleviation, a just energy transition, etc., it is critical to agree on what the ultimate required goal should be for the country of South Africa.

A Just Energy transition should benefit the people of South Africa as a whole and not only the workers and communities involved in the energy industries.

So, our goal should be to ensure that we have an effective electricity supply system, which is a critical key enabler for a country to develop and prosper. To be effective, the electricity supply must be reliable, affordable, minimise environmental damage and be accessible to all citizens.

In addition, a move away from the use coal as a primary fuel is dictated, but this should not further disadvantage the country.

THE CURRENT ELECTRICITY NETWORK

The current electricity network covers the country and supplies the majority (>80%) of electricity from an Eskom coal-fired fleet of power stations in the northern part of South Africa, with contributions from nuclear (~5%) and IPP renewables (~6%).

Figure 1 [3] shows a typical weekly electricity demand profile and how the supply of electricity is built up.

The figure shows the Eskom daily variation of electricity demand over a typical winter week and how this demand is met using the different resources and technologies available.

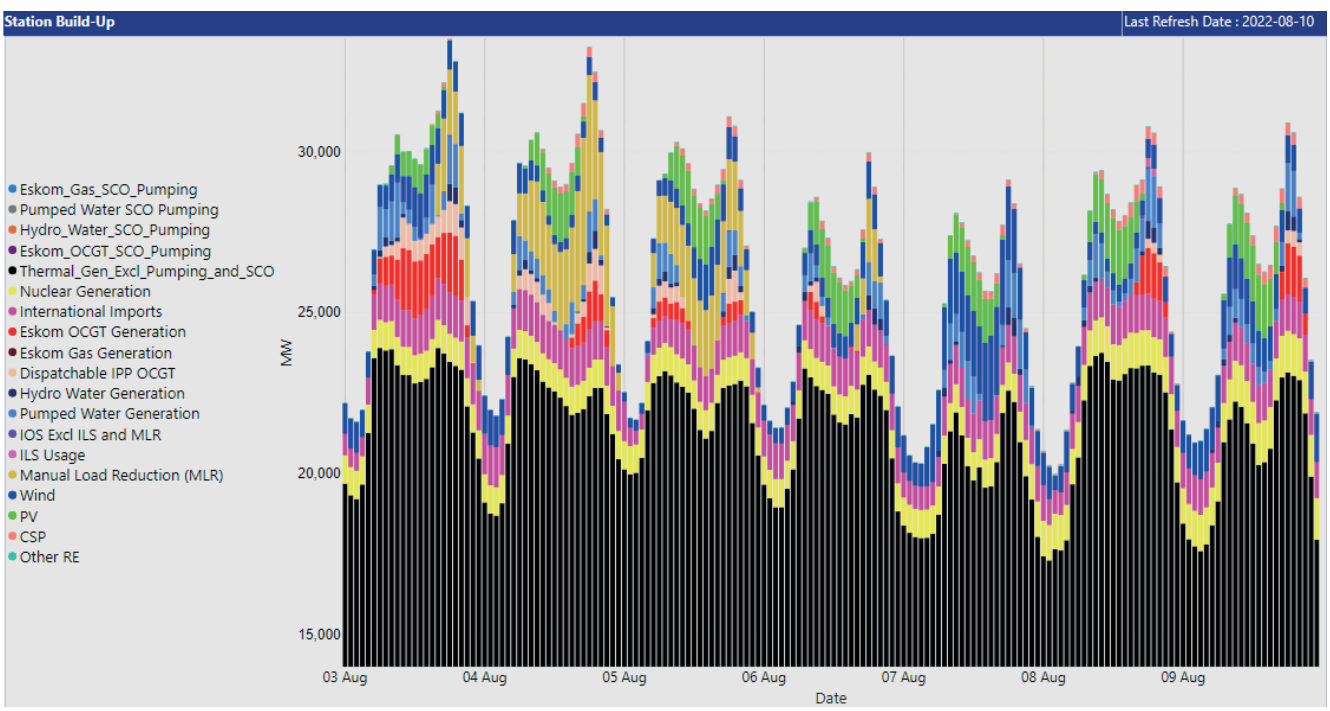


Figure 1: Eskom Generation Build-up (source: Eskom Data Portal)

Description	Energy Source	% of Total Energy Cost	% of Total Energy	Cost per kWh
Baseload	Coal	64.6%	84.3%	R0.40
Baseload	Nuclear	1.0%	5.3%	R0.10
Peaking	ESKOM Open-cycle Gas Turbines (Diesel)	4.0%	0.7%	R3.12
Peaking	IPP OCGTs (Diesel)	3.4%	0.4%	R4.11
Renewable	IPP	23.0%	5.9%	R2.03
Imported Energy		4.0%	3.4%	R0.60

Table 1: Eskom Relative Costs of Generation Resources

It will be noted that there is a daily baseload level of between 18 GW and 21 GW that changes slowly depending on the day of the week and weather.

On top of this baseload level, there are peaks over the waking hours that indicate a morning peak as people become more active and industry starts up to a large evening peak as people go home, prepare food, and heat their homes.

The build-up of generating capacity to meet the current demand is done by bringing resources that are available, in increasing cost order onto line as the demand increases and releasing them as the demand wanes.

Table 1 shows the relative 2021 costs of Eskom generating resources [3].

The total current installed capacity from all generating resources in South Africa is approximately 54 GW, however on any given day up to 20 GW of baseload supply may be out of service.

This coupled with the intermittency of the variable renewable energy, pumped storage resource status and availability of diesel for the gas turbine peaking

Type	Capacity [MW]
Coal	39 346
OCGT	3 414
Wind	3 433
Hydro	3 324
Nuclear	1 860
Solar PV	2 212
Solar CSP	500
Biomass	51
Total	54 140

Figure 2 Total Installed Capacity [MW] (Source: [4])

resources determines the available electricity generating resources on an ongoing basis.

ELECTRICITY SYSTEM REQUIREMENTS

As the Nuclear Energy Agency has stated "The continuous availability and affordability of energy and, in particular, electricity is an indispensable condition for modern societies." [5]

To be able to supply the required electrical energy and power demand of a country, the makeup of generation plant available must first have the capacity to generate the ongoing amount of energy required plus be able to deliver it at the required power level when required.

This is achieved by having a mix of generation technologies that first have the required energy capacity (i.e., kWh or Joules) and then using different technologies to deliver it and meet the power demand (i.e., kW).

The fact that in the Eskom electricity system, the electricity costs vary by a factor of over forty times from the lowest cost (nuclear) to the highest cost (3rd party gas turbines) is indicative of the realities of the technology mix and complexity of the system.

The increasing penetration of variable generation technologies, such as wind and solar PV, significantly changes the overall operational requirements of the electricity system.

From a system that has a large, generally inflexible baseload component, future requirements will include increased flexibility, additional capacity to make up for intermittency of renewables and reduced carbon emissions.

To be practical, affordable and have acceptable risk, this change must take place with careful system planning over a period of tens of years as existing generation facilities that are decommissioned are replaced and additional capacity added to meet the country growth requirements.

This change must be achieved with the lowest risks possible, using well-established and proven technologies and methodologies.

High-risk, leading-edge solutions that risk the future failure of South Africa must not be considered.

ELECTRICITY SUPPLY SYSTEM COMPLEXITY

A country-wide electricity supply system is an extremely complex system and is made up of several technologies that ultimately form a 'chain' of electricity supply to the end-user.

Focusing on the generation part, a critical characteristic of an electricity supply system is that it must meet the changing demand on a second-by-second basis. This is achieved by the instantaneous conversion of stored energy in many forms into electricity, as it is required, using different generation technologies.

Electricity generation sources fall into 2 main categories. Those whose energy outputs are 'dispatchable' and those that are intermittent or variable. A dispatchable energy source is one whose output can be increased or decreased depending on the current demand. These sources include thermal and nuclear power stations and open and combined cycle gas turbines, energy storage systems and hydro power.

The rate of increasing or decreasing output, or ramp-rate, is an important parameter in the overall control of an electricity network. Existing baseload thermal and nuclear power stations have ramp-rates of around 25% to 30% per hour.

More rapid changes in demand are met by 'mid-merit' and 'peaking' generation facilities. These, although costing more to run, have much higher ramp-rates. Some gas turbines can ramp from zero to full output in less than 5 minutes!

Energy storage technologies such as pumped storage hydro and batteries can react very quickly to demand changes but have a limited endurance.

Renewable energy sources such as solar PV and wind are variable and not dispatchable. One must use the weather-dependent energy generated if or when it is available. The remaining or residual load must be covered by dispatchable

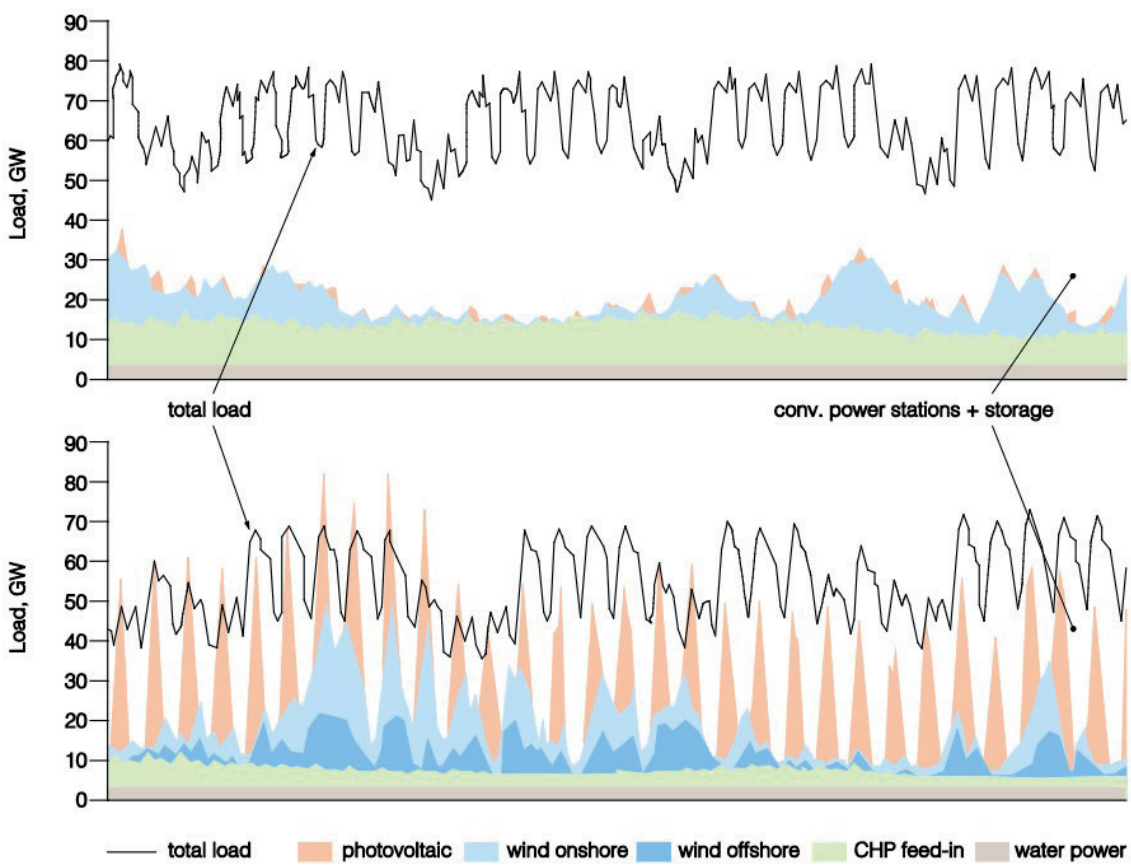


Figure 3: Effect of Renewable Generation Penetration (Source IEA)

generation technologies in the electrical system.

The above components of the electricity system have typical lifetimes of 15 to 50 or 60 years depending on the technology. Thus, technology decisions made have long term consequences and cannot be rapidly changed or replaced.

Figure 3 from an IEA report [6] shows the system requirement effects of increasing renewable penetration into an electricity system.

The input from renewables is shown as various coloured traces. The white space between the total load and the renewable outputs is that which is filled with dispatchable generation technologies.

In the top diagram, with a low penetration of variable renewable generation the gap between the demand and the power supplied is met or filled by dispatching the required power as required and following the load. This load-following requirement is relatively slow and can be met by normal existing coal-fired or nuclear 'baseload' power stations.

In the bottom part of the diagram, variable renewable power is a much larger part of the generation resources and the gap between the renewable power and the total power demand is generally smaller but much more variable.

To fill in the spaces between the renewable energy power and the demanded power now requires power to be supplied from dispatchable sources that can follow the more rapidly changing demand.

The South African existing coal-fired fleet was not designed to operate in this new mode and will have to be replaced over time by more flexible dispatchable technology.

This change can only be economically and feasibly achieved over the medium to long term.

SOME CHARACTERISTICS OF VARIOUS ESTABLISHED GENERATION SOURCES

Electricity can be generated using many different sources. Each of these technologies has specific characteristics, which make them more or less desirable for a particular country.

Table 2 below shows some characteristics of various established electricity generation technologies. Other sources that are not yet in utility usage such as small modular nuclear reactors and 'green' hydrogen are not considered here as there are still too many uncertainties in their final utility.

A sensible 'mix' of these technologies is necessary to create an effective electricity system such that energy security, flexibility, affordability, and environmental criteria are optimised.

SOME DISPATCHABLE TECHNOLOGIES

There are two dispatchable technologies with reduced emission (compared to coal) that are currently discussed as part of South Africa's future energy structure. These are the use of natural gas and 'green' hydrogen.

NATURAL GAS

There have been recent sizeable gas field discoveries off the South African west and southern coast with an estimated life of up to 30 years. These include the Brulpadda and Luiperd finds off the coast of Mossel Bay and the Ibhubesi gas field north-west of Saldanha Bay.

Established Technologies	Lead time [Years]	Life-cycle Emissions of CO2 (IPCC) [g/kWh]	Flexibility	Capacity Factor	Capital Cost (low) [$/kW]	Capital Cost (high) [$/kW]	LCOE [$/MWh]	Dispatchable	Lifetime [years]	Efficiency
Coal Fired Thermal	4	820	Low	85%	$ 4 074	$ 6 625	$ 82.00	Yes	40	30% to 47%
Nuclear	6	12	Low	90%	$ 7 030	$ 7 547	$ 88.00	No	40	55%
Onshore Wind	3	11	n/a	41%	$ 1 718	$ 1 718	$ 40.00	No	20	35%
Offshore Wind	4	12	n/a	44%	$ 6 041	$ 6 041	$ 136.00	No	20	35%
Solar PV	2	48	n/a	29%	$ 1 327	$ 1 748	$ 36.00	No	25	12% to 20%
Hydro	4	24	High	54%	$ 3 083	$ 3 083	$ 64.00	Yes	100	90%
Battery Storage	1	33	High	10%	$ 1 316	$ 1 357	$ 129.00	Yes	10	77% to 98%
OGCT	2	-	High	10%	$ 785	$ 1 294	$ 118.00	Yes	-	38%
CCGT (Natural gas)	3	490	Med	87%	$ 1 062	$ 2 845	$ 40.00	Yes	30	58%
Biomass	4	230	Med	83%	$ 4 525	$ 4 525	$ 90.00	Yes	20	up to 45%
Pumped Storage	4	24	High	-	$ 2 600	$ 2 901	$ -	Yes	40	65% to 70%
CSP with Storage	2	-	High	65%	$ 5 896	$ 6 500	$ 180.00	Yes	30	0%
Geothermal	4	38	High	90%	$ 3 076	$ 3 076	$ 39.00	Yes	30	15%
Internal Combustion Engines (ICE)	1	-	High	85%	$ 2 018	$ 2 018	$ -	Yes	25	35% to 42%

Table 2 Some Electricity Generation Technology Characteristics

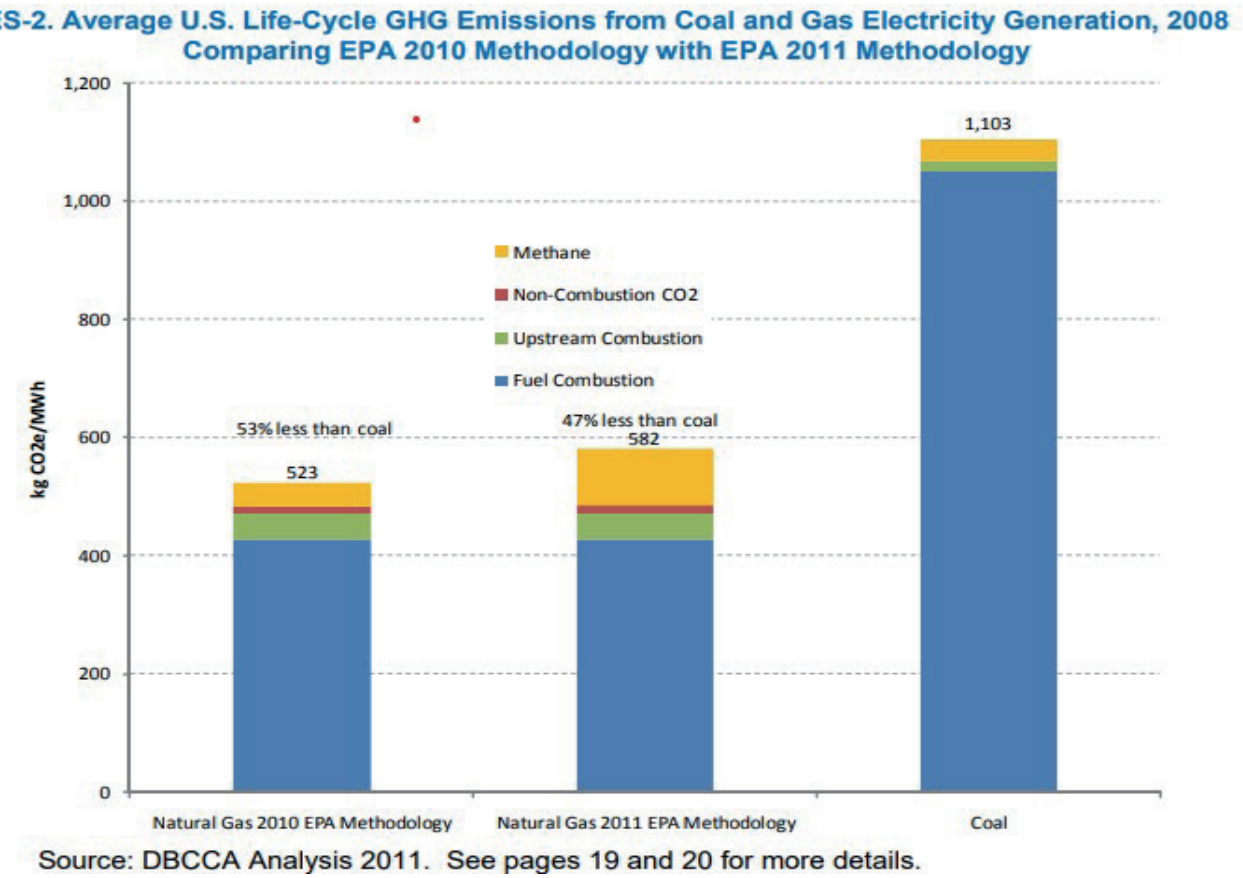


Figure 4: Average Life-cycle GHG Emissions for Coal and Gas Electricity Generation (Source DBCCA [7])

In addition to these, discoveries off Mozambique have an economic lifetime of up to 45 years.

Using natural gas to generate electricity produces about 50% less emissions than coal over the lifetime of the generating plant. [7]

Using this resource in conjunction with the well-established Open-Cycle and Combined-Cycle Gas Turbine technology will provide a viable transition fuel away from coal, increasing flexibility and substantially reducing emissions and air pollution.

'GREEN' HYDROGEN

There has been much recent publicity about using hydrogen produced from excess renewable electricity as a source of fuel with either much reduced or no carbon emissions.

The hydrogen could be converted back to electricity on demand using fuel cells or turbines.

A major challenge is the round-trip efficiency of this hydrogen cycle, which is currently between 18% and 46% [8], which makes it uneconomical at present. The 'hydrogen-economy' may provide part of the electricity grid of the future, but it is still developing and not ready as a part of a low-risk electricity system solution.

AN ELECTRICITY SUPPLY SYSTEM IS AND WILL BE A COMPROMISE

The ideal electricity supply system would be able to immediately meet the changing electricity demand, occupy no useful space, have very high efficiency, very low costs, and produce no pollutants or environmental damage. However, Engineers that are responsible for the design and successful implementation of an electricity system must find an acceptable compromise between the laws of physics, which are immutable and practical constraints imposed by finances, environmental damage, and the welfare of society.

This means that any solution to the current electricity crisis will be a compromise, and decisions such as to how much environmental damage will be tolerated, how money will be available to implement and operate the system and what the resultant level of effects on society such as unemployment, poverty alleviation, and general welfare, will have to be made.

ELECTRICITY REQUIREMENTS TO 2030

FORECAST DEMAND GROWTH

Recent electricity demand from Eskom shows a daily power requirement

of between ~22 GW and a peak of ~35 GW [9].

The current plan for South Africa's electricity system is the 2019 Integrated Resource Plan (IRP 2019) [10], which is currently being updated.

The IRP 2019 plan shows a planned total installed capacity of almost 78 GW by 2030. Of this 33.3 GW is coal fired, 1.8 GW of nuclear, ~18 GW is wind, 8.3 GW is solar PV and Hydropower is 4.6 GW. This would give a planned penetration of renewables of 40%.

To work towards meeting SA goals of reduced poverty and an economic growth of 5% per year, an increase in electricity supply of at least 5% per year is necessary.

Thus by 2030, the energy demand is forecast to increase by ~40%. This would require a 'steady-state' capacity total of ~40 GW and peak capacity of about 50 GW.

The difference between the average power and peak power requirements can be met by fast response generation such as a combination of pumped storage, open-cycle gas turbines and other 'fast' dispatchable technologies.

Putting this into perspective, and if a system EAF (Energy Availability Factor) of 80% is reached, an additional ~12 to 15 GW of dispatchable equivalent generation capacity must be added by 2030 to meet the predicted demand!

SOUTH AFRICA AND GREENHOUSE GAS (GHG) EMISSIONS

South Africa is a signatory to the Paris COP21 Climate Change Agreement which legally binds the country to limiting its carbon footprint according to regularly submitted NDC (Nationally Determined Contribution) plans.

Although South Africa is a relatively carbon intense emitter of CO_2, it emits just over 1% of the annual world total.

Just 6 countries, the USA, China, India, Russia, Japan, and Germany emit 60% of the total annual emissions.

Eskom emitted 212 Mt of CO_2 during the 2021/22 financial year. This compares to annual world total CO_2 emission of ~35 Gt of which ~40% or 14 Gt is from electricity generation. Thus, Eskom

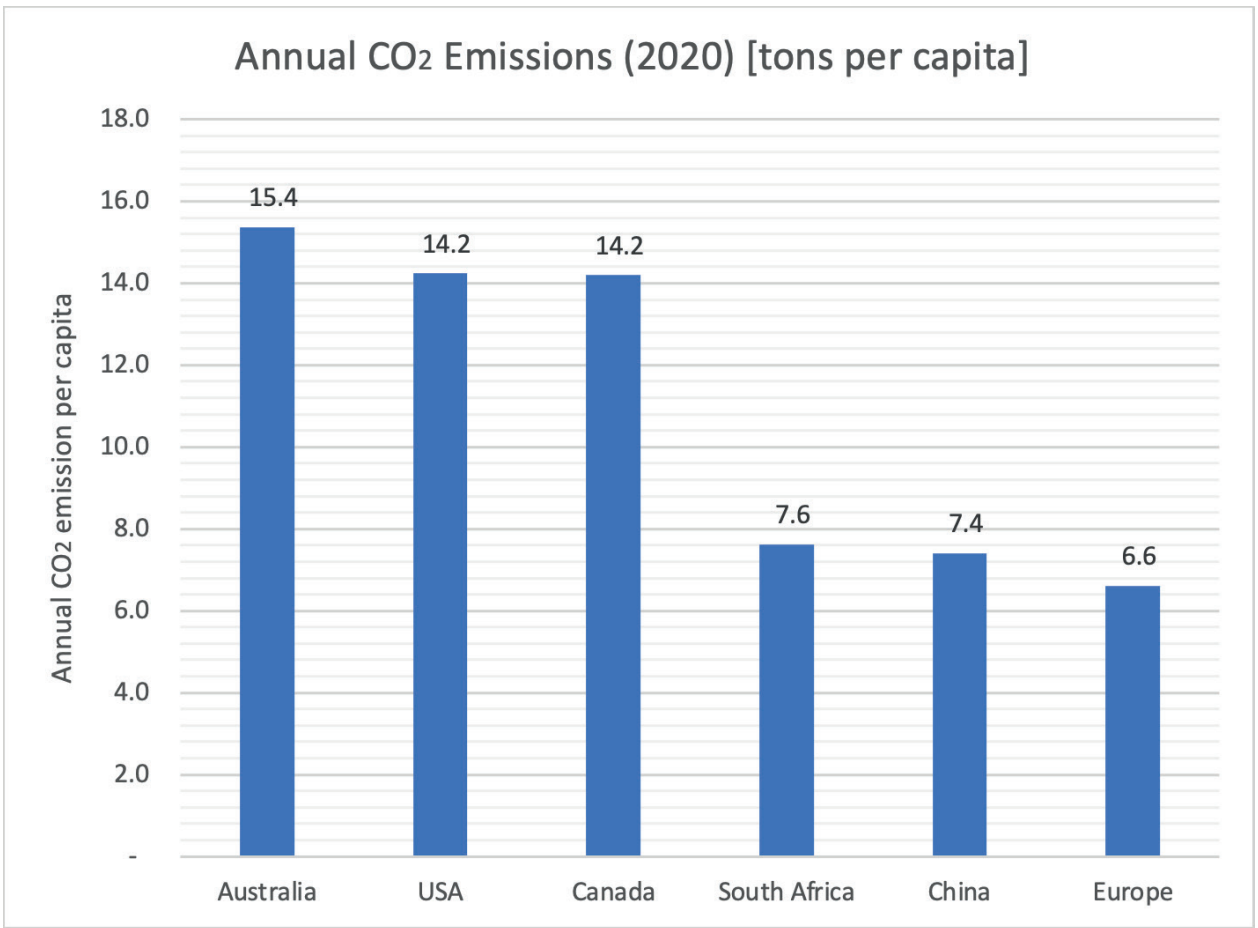


Figure 5: CO_2 emissions per Capita [t CO_2/capita]

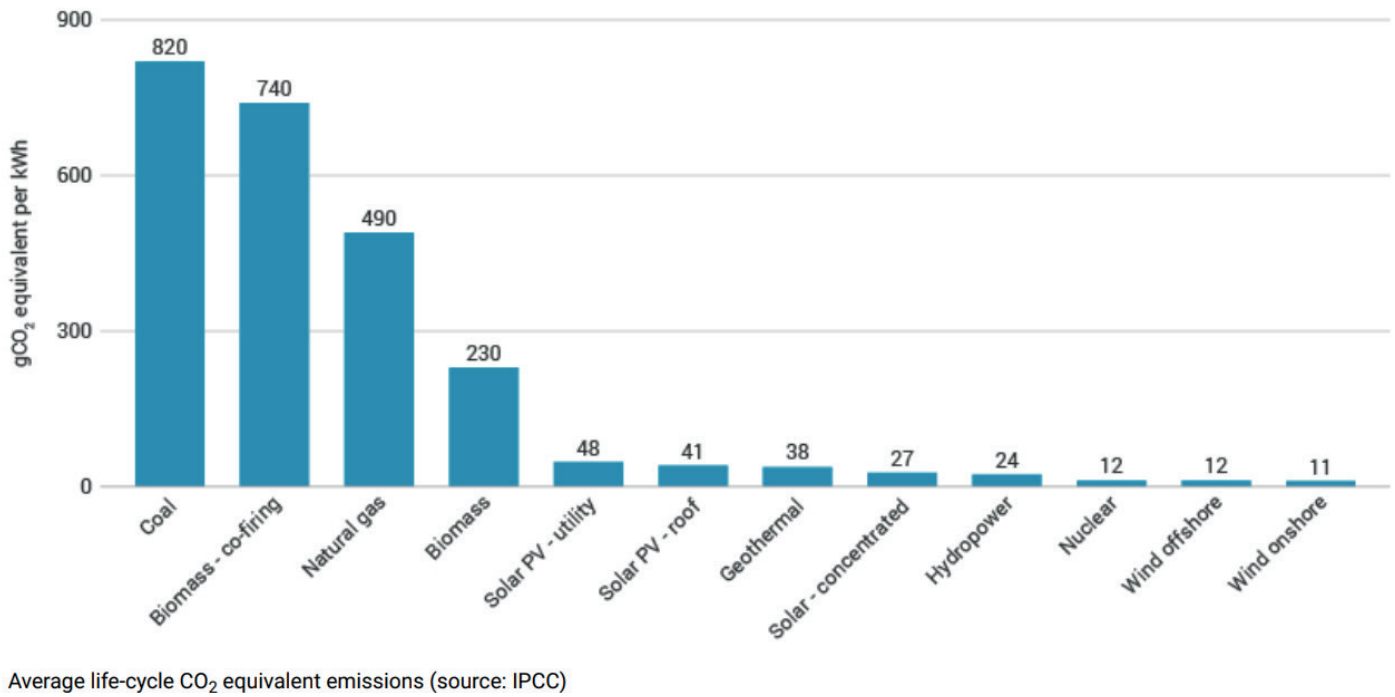


Figure 6: Lifecycle C02 Emissions for Electrical Technologies (Source: IPCC)

emitted about 1.5% of the world CO_2 emissions due to electricity generation.

The following figure is adapted from [11] and shows the relative CO_2 emission per capita for selected countries.

From Figure 5, the per capita CO_2 emission for South Africa is similar to Europe and China. As can be seen, the US, Canada and Australia have per capita emissions far greater than South Africa.

The following Figure 6 from a World Nuclear Association document [12] compares the life-cycle CO_2 emissions from various electricity generation technologies.

Note that replacing decommissioned coal-fired stations with natural gas-fired technology would reduce the CO_2 emissions by 40% and would also address the increased grid flexibility requirement.

SOME FACTORS TO CONSIDER IN THE CHOICE OF GENERATING TECHNOLOGIES FOR SOUTH AFRICA

The following sections detail some important aspects and characteristics of the various generating technologies that bear consideration in making of electricity system technology choice decisions.

FULL COST OF ELECTRICITY (FCOE)

Several electricity costing methodologies are currently used. The main parameter used to make many long-term technology decisions and comparisons is the Levelised Cost of Electricity (LCOE).

LCOE takes the generating plant capital cost, fixed operation and maintenance (O&M) costs, capacity factor and variable costs of fuel (where relevant) and O&M and lifetime energy output to calculate the cost of generating electricity.

However, the LCOE only covers part of the total electricity costs and using it only to make technology decisions may have significant negative long-term effects.

For instance, the LCOE does not consider the difference between the system integration costs of dispatchable and variable energy sources. Typically, additional system costs will have to be incurred for variable generating facilities because of their location and variability. These costs may be very significant and particularly applicable to countries planning energy transitions.

Thus, there is a considerable effort being focused on the Full Cost of electricity (FCEO) to improve the information on which electricity system decisions are made.

Although difficult to calculate, unless recognised and tackled, country administrations will not be able to

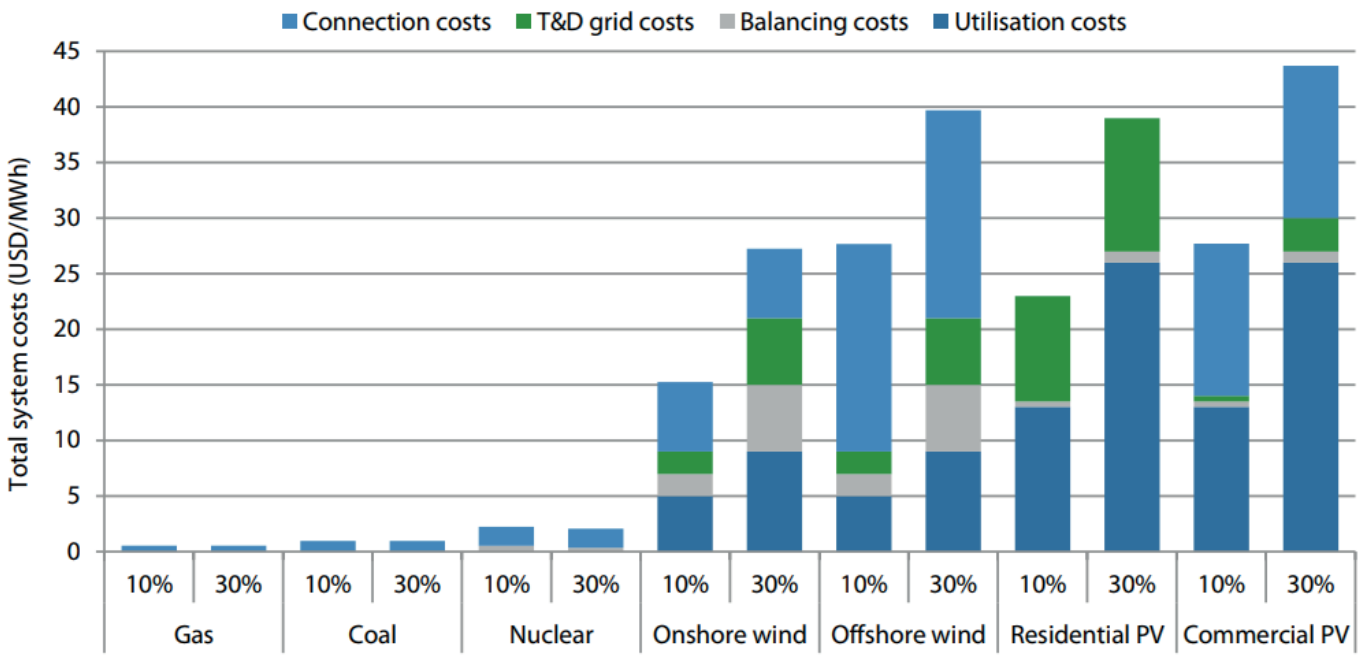


Figure 7 Grid-level system costs of selected generation technologies [5]

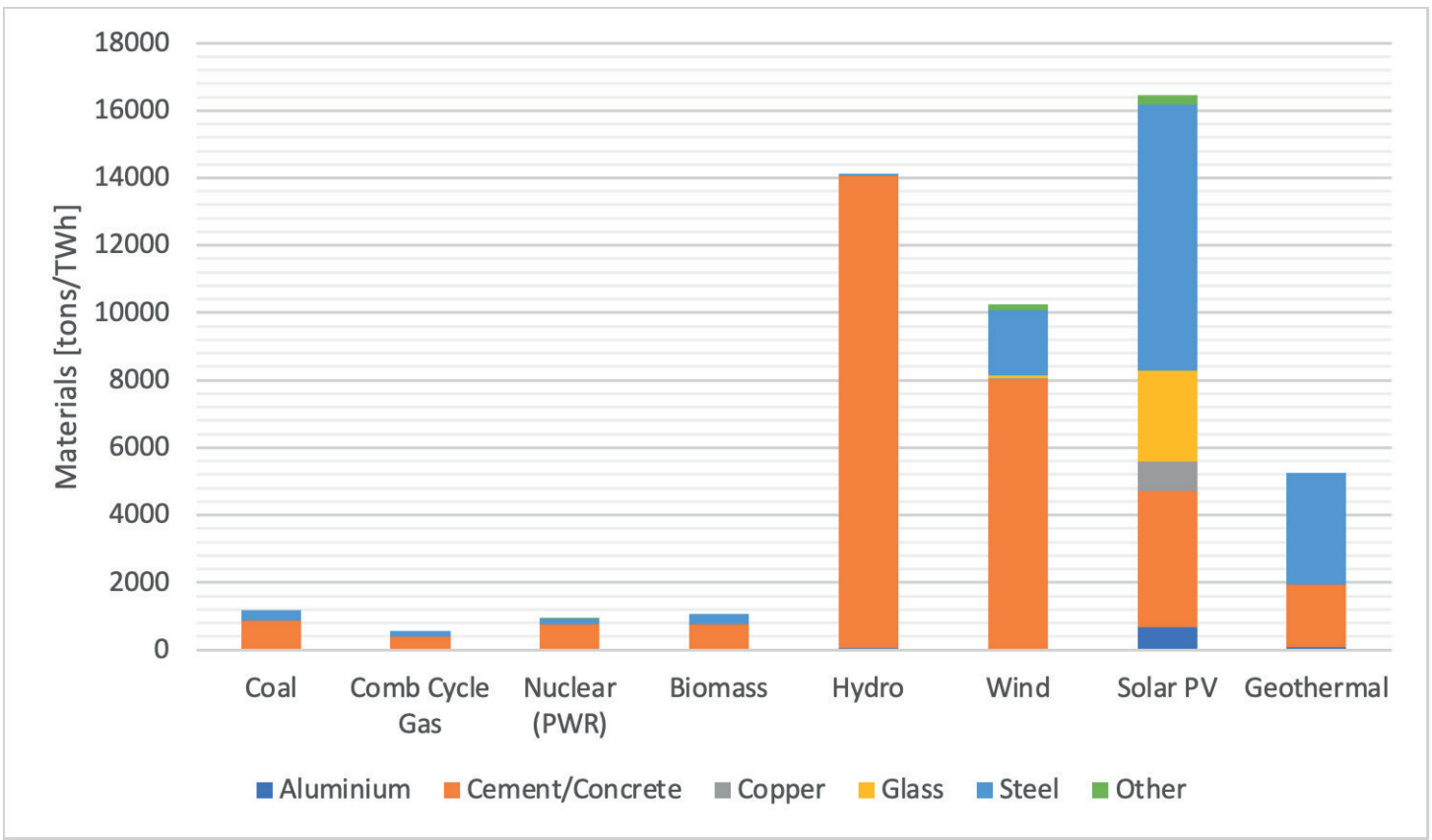


Figure 8: Material Input in tons per Unit of Service [TWh] adapted from DOE Report [16]

make informed decisions towards fully sustainable and secure electricity systems.

The FCOE addresses the true cost to society, of the provision of electricity and is separated into three areas [5].

These are:

- Plant-level Production Costs
- Grid-level System Costs, which include the cost of electricity transport and balancing, cost of electricity storage and, cost of backup electricity supply equipment
- Social Costs, including Climate change impacts, Air Pollution, Cost of Accidents, Land use, natural resource depletion and electricity supply security

Grid Level System Costs or electrical system level costs, which are related to the variability of renewable output, and curtailment and re-dispatch costs.

Grid connection costs can be significant due to the constraints of the location of renewable generating plants.

Figure 7 [5] shows the results of calculating the full integration costs of different generating technologies with different levels of variable renewable energy technology penetration.

Schernikau [13] adds further parameters such as the cost of recycling, material input per unit of service (MIPS), equipment lifetime and energy returned on energy invested (ERoEI or eROI).

Experience is showing that the cost of the generation of renewable electricity may only be 44% [14] of the total cost of provisioning that energy.

MATERIALS INPUT FOR VARIOUS GENERATION TECHNOLOGIES

Different generation technologies require different amounts of materials. Figure 8 shows various materials required per energy unit generated over the lifetime of a generating resource.

From this it is seen that the materials input for wind and solar PV are at least an order of magnitude (i.e., 10 times) larger than for the conventional dispatchable technologies.

LAND USE INTENSITY

Different generating technologies also have different footprints. [15]

Land use intensity measured as the area per energy output has a range of over 100 times for the different generating technologies ranging from 0.1 m^2/MWh for nuclear to 0.2 m^2/MWh for underground mining coal fired plants and gas turbines to 10m^2/MWh for solar PV generation.

COST OF UNSERVED ENERGY (COUE) IN SOUTH AFRICA

Modern society relies on a continuous supply of electricity with minimal outages

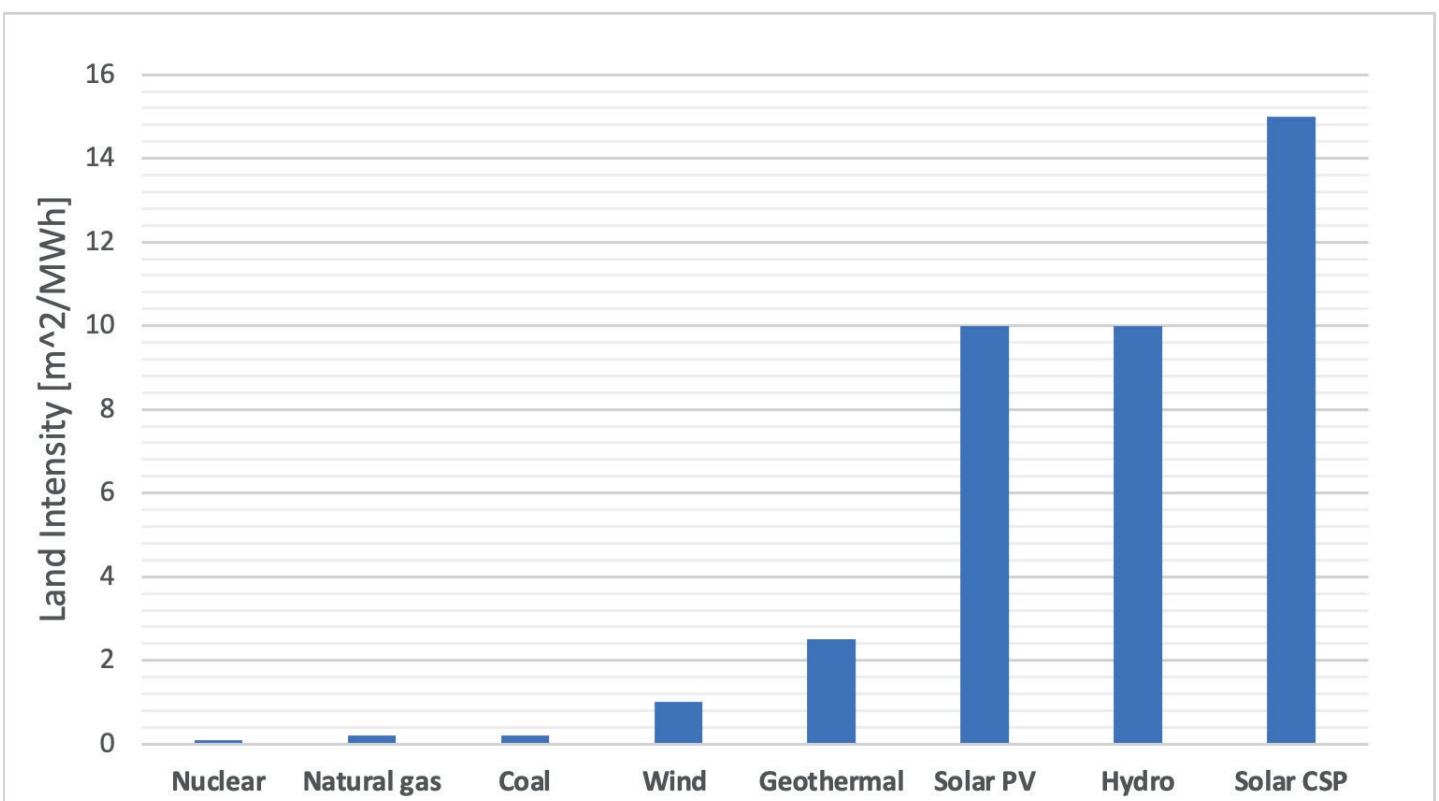


Figure 9: Generating Technology vs Land Intensity

to grow and prosper. Typical European countries experience annual outages amounting to less than 4 hours. [16]

South Africa has had widespread forced outages of over 2400 hours in the first 10 months of 2022!

According to Minnaar [17], the cost of unserved energy (COUE) to the economy averages at R84/kWh. The household COUE is calculated as R6.77 per kWh.

From load shedding records to the end of October 2022, the energy not supplied due to load shedding during 2022 was about 7 500 GWh. Assuming that half of this affected commercial enterprises, the cost to the economy was in the order of R 300 billion or 6% of expected GDP.

ENERGY RETURNED ON ENERGY INVESTED (EROEI)

While the financial approach and calculation of LCOE, FCOE and VALCOE to evaluate electricity generation technologies may be used to make many system decisions, it does not tell the whole story!

A parameter that gives [18] another insight to electricity systems is the energy return on investment or ERoEI.

An electricity system can be regarded as an energy gathering and conversion system complying with the law of energy conservation.

ERoEI measures the efficiency of an energy 'gathering' system. The higher the value of ERoEI, the more energy is returned for that invested in the development of the resource.

In essence, the higher the ERoEI the lower economic and environmental costs or lower prices and higher utility.

If we choose technologies that give an ERoEI of less than 1, we will have an energy deficit.

As Weissbach et al [19] has indicated, calculating the ERoEI of systems is complex and requires more research to formalize its approach for consistency.

All input components are translated into energy inputs including materials and labour. Thus, energy is the proxy used to calculate the life cycle energy efficiency.

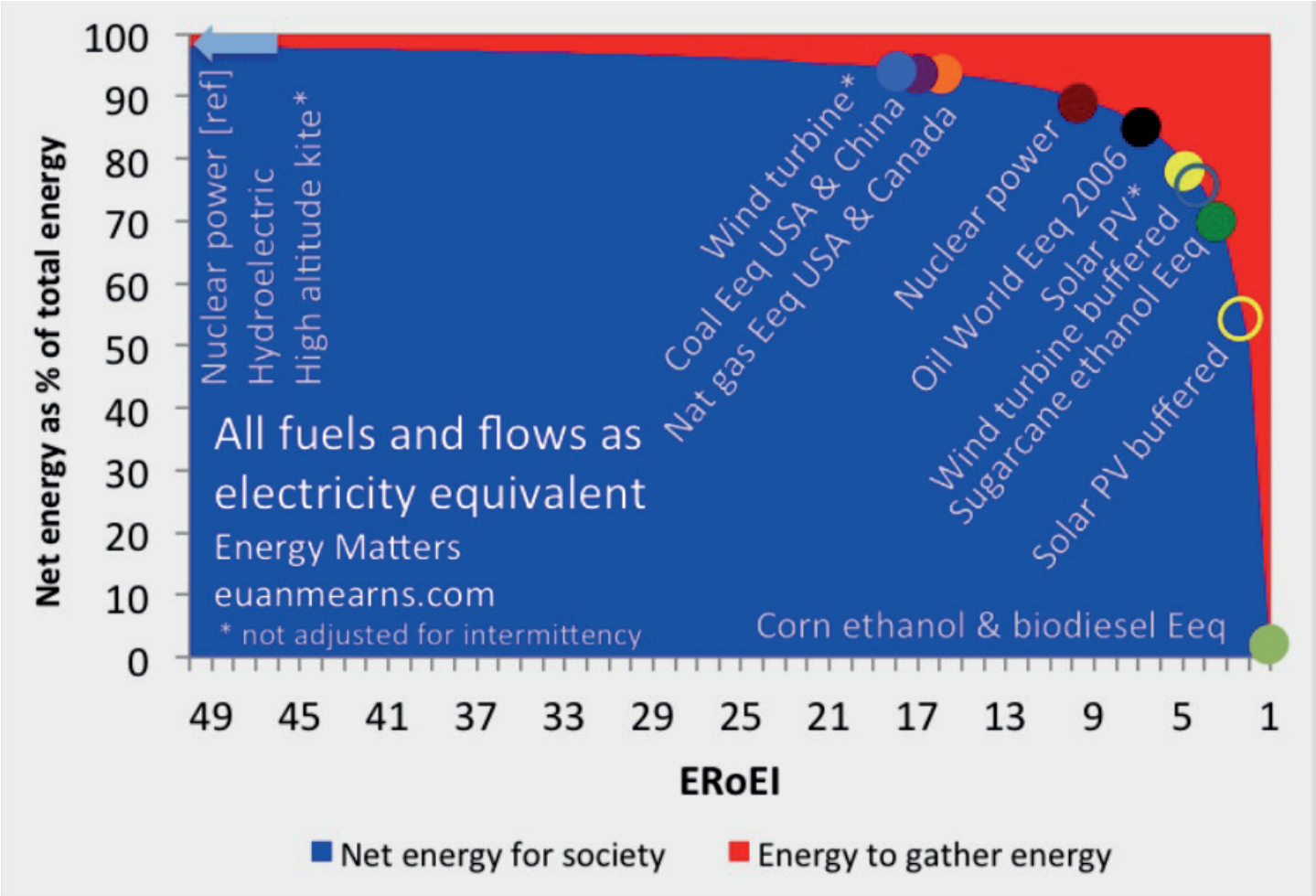


Figure 10 Net Energy 'Cliff' (Source: [20])

Figure 10 shows graphically how the ERoEI for different generating technologies changes the value of returned energy. This energy returned (shown in blue) can then be used by society for areas such as infrastructure development, capital projects, mining and manufacturing, agriculture, food processing, retail, education, healthcare, welfare, and government.

Compared to Nuclear, which has an ERoEI of 75, coal fired plants (ERoEI of 29), CCGT (ERoEI of 28), solar PV has an ERoEI of 4 or 2.3 buffered with storage.

Wind has an ERoEI of 16 and 4 buffered with storage.

It is very apparent from Figure 10 that if the input energy for an energy source is too large, there will be little excess energy left for society to use.

Weissbach and others have determined that an ERoEI of about 7 is the minimum required for our modern society to function. This compares well with the graph in Figure 10 as with an ERoEI lower than this, the net energy available falls off rapidly.

Intuitively, this seems to mean that the renewable energy sources are expensive and may give some insight to why Germany, with a high penetration of renewables, has the 2nd highest electricity price in the world.

Also referring to the McKinsey report [21] which states that the estimated capital spending on physical assets for energy and land use between 2021 and 2050 for the transition would amount to $275 Trillion or $9.2 Trillion per year. This is an annual increase of $3.5 Trillion, which is equivalent to about 7% of household spending or between 6.8% and 8.8% of GDP.

It is also stated that poorer countries may have to spend 1.5 times more than advanced countries as a share of GDP to support economic growth and to build a low-carbon infrastructure.

CONCLUSIONS AND RECOMMENDATIONS

South Africa is faced with multiple challenges as a country. Lack of electrical energy security, stagnating economy, very high levels of poverty, to name a few.

There is much discussion around these areas, often driven by emotions and limited understanding of a country as a system. One should be wary of 'miracle' solutions at the risk of economic stability. Many important decisions that will have many decades of consequences must be made. These decisions must be made using effective, dispassionate analysis supported by sound engineering and economic fundamentals and based on a social cost-benefit analysis.

ENERGY SECURITY AND A JUST ENERGY TRANSITION

Everyone would agree that a 'just energy transition' is required. However, the meaning of this phrase is often limited to the effects of the transition on the energy industry workers and associated communities only.

The transition will only be 'just' if the South African population as a whole ends up in a better position, not just a select few.

In South Africa's case, the realisation of energy security and achieving reliable, affordable, and accessible electricity must be the primary objective that results in sustainable economic growth and ultimate improvement in the quality of life for all citizens. In addition, the transition must be achieved at an acceptable level of risk to the country.

It must be recognised that the duration of this transition is not a short-term solution and will span several decades.

CLOSING THE ELECTRICAL ENERGY GAP

Currently South Africa does not have an acceptable level of electrical energy security. This is resulting in continuing and substantial costs to the country and significantly constraining critical economic growth.

Immediate, urgent, and effective action is required to improve the electrical energy security at almost any cost!

Every effort should be made to increase electricity availability using all existing facilities and adding short-term capacity to reduce load shedding.

Once an acceptable level of energy security has reached, this 'emergency' capacity may be replaced with long-term and more cost-effective solutions.

USE OF LOCAL RESOURCES

South Africa is blessed with abundant natural energy resources including natural gas. South Africa should sensibly use any and all of these resources to achieve sustainable economic growth. Any long-term plan should include the use of natural gas, at least as a transition fuel.

Replacing coal-fired electricity generation with gas-fired generation would immediately reduce CO_2 emissions by almost 50%.

USE OF WIND AND SOLAR RENEWABLE ENERGY

Currently it seems that the world is rushing headlong into the widespread deployment of solar PV and wind renewables as the solution to transition from fossil fuels. One should remember that these technologies are relatively new when compared to traditional

generating technology and that the long-term (i.e., 50 year) effects of using these are not yet fully realised.

What seems clear is that considerable work is required to fully evaluate and understand these technologies, considering factors such as their variability, equipment lifetime, the full cost of electricity generated, the return on energy invested, land footprint and base materials input, to ensure that they indeed provide a long-term sustainable and affordable energy option.

CO_2 EMISSIONS

South Africa produces just over 1% of world emissions due mainly to the heavy reliance on coal-fired electricity generation. Urgently reducing these levels will require an estimated trillions of Rand. Much of this money will have to be taken as loans, moving South Africa further into a debt trap.

Because of our unique position of high unemployment, significant poverty, and a stagnating economy, compared to developed countries, we should delay meeting the Paris Agreement limits until we have improved the electricity security and economic growth to acceptable levels. This will take at least 10 to 20 years.

During this time, Eskom will have to decommission many of their coal-fired power stations as they reach end of life. This decommissioned capacity will have to be replaced and added to with other technologies including fossil-fueled (e.g., natural gas) facilities to meet the economic growth and maintain acceptable energy security and will reduce carbon emissions as a matter of course.

TECHNOLOGY CHOICE

Any plan to achieve electrical energy security should be based on a low-risk approach. It should use existing, proven technology applied by competent people.

The temptation to rely on newer 'miracle' technologies such as 'green' hydrogen, or excessive penetration of renewables and utility battery storage systems as 'the solution' should be avoided until these technologies have properly proven themselves. An effective long-term solution will involve the application of an appropriate 'mix' of generating technologies to effectively meet the requirements.

TAKEAWAYS

From the above, it is clear that solutions to South Africa's electricity system shortcomings are not simple and will not be based on 'miracle' solutions.

In the end, a successful electrical system is extremely complex and comprise a 'mix' of technologies to meet the required level of energy security.

It will be an acceptable compromise between the laws of physics and the practical constraints of financial resources, urgency, skills availability, and environmental damage to optimise the future welfare of South African citizens. wn

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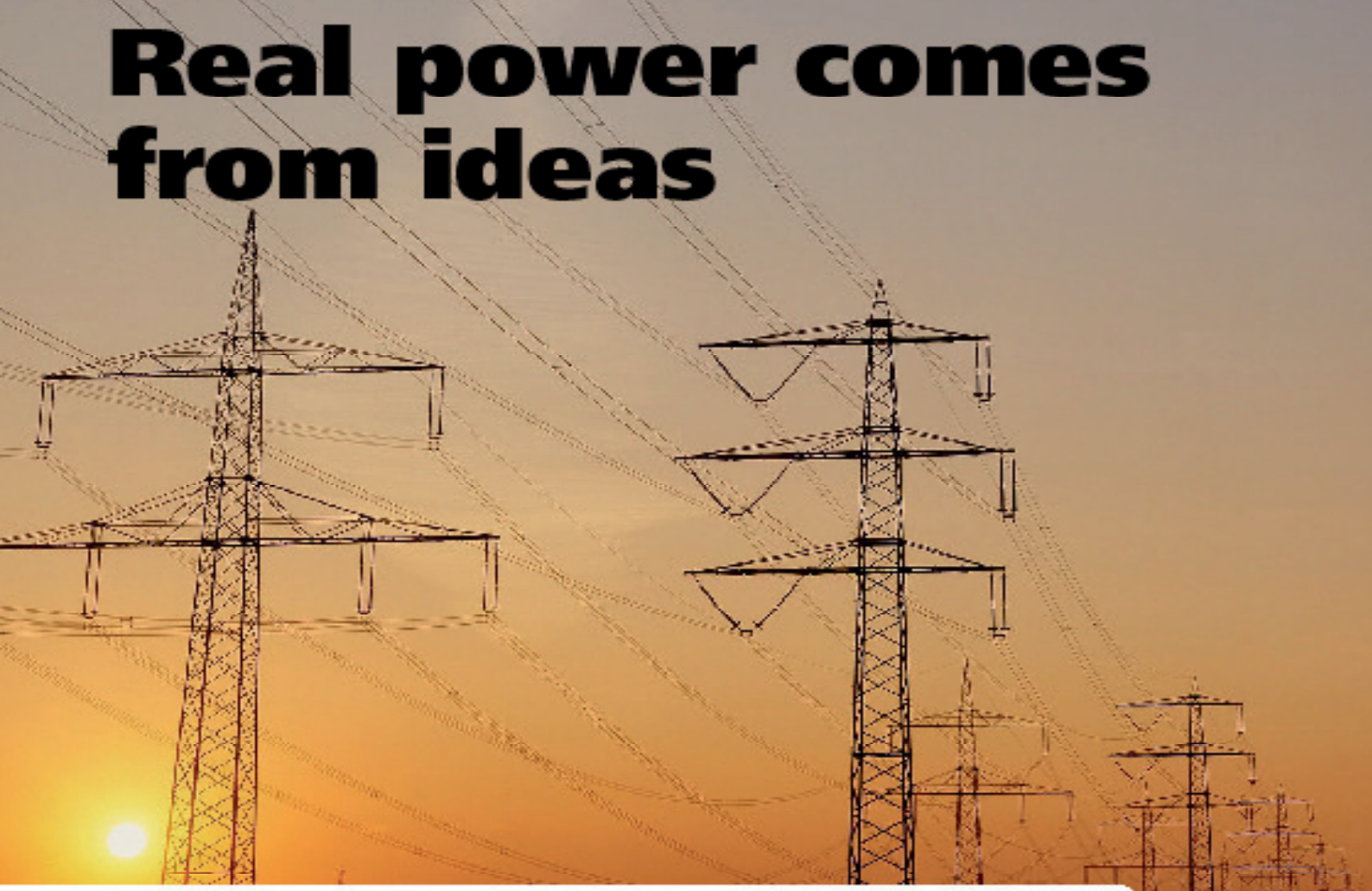
Real power comes from ideas



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The Medium Voltage CHP Plant Generator Operation and Fault Assessment

The Co-Generation Generator is part of the Combined Heat & Power Plant (CHP Plant), composed of a Prime Mover, a Reciprocating Engine or a Turbine and an Alternator. This system is very efficient compared to other systems like Power Generation and Steam Generation and has massive benefits.

By: Hosea Kwena Senyatsi | Pr Techni Eng, MSAIEE

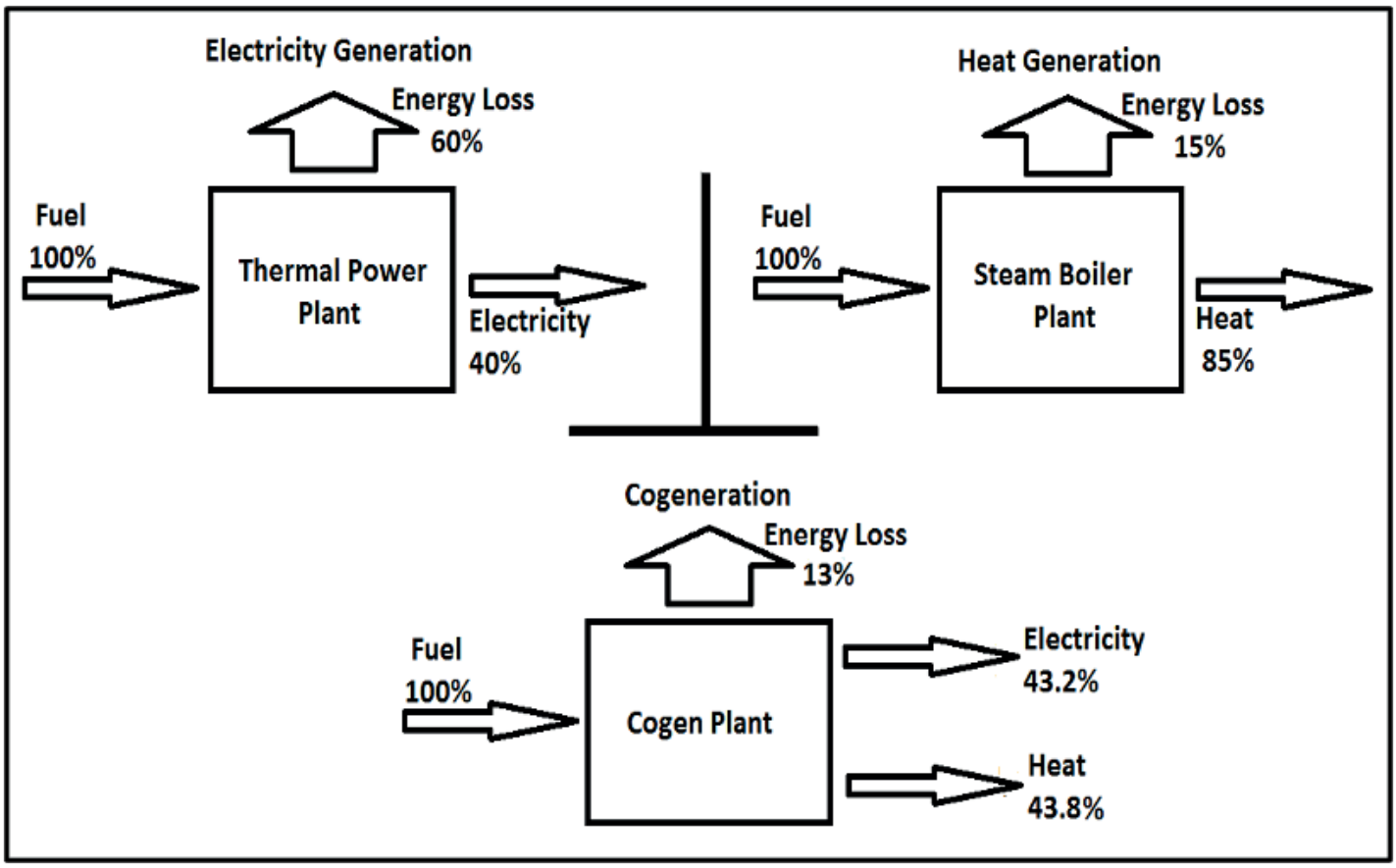

Fig. 1: Comparison of Energy Generating Systems

The alternator of the Co-Generator has a stator, a rotor, a field coil and an Automatic Voltage Regulator as its major parts. The diagram in Fig 3 is typically what the whole setup of the Alternator and Excitation System looks like.

The Alternator stator windings are connected in a Star Configuration. The star point is meant to be grounded through an impedance. The NER is capable of handling 300A fault current continuously for 10 seconds. The Neutral Current Transformer measures any earth.

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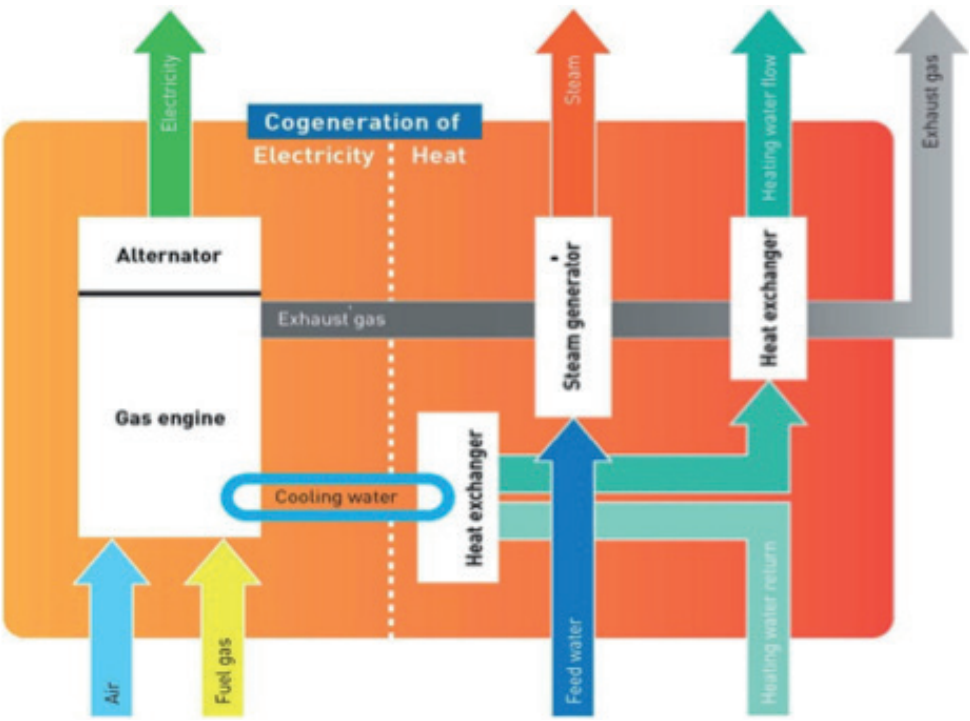


Fig. 2: Typical Flow Diagram (Courtesy of MWM)

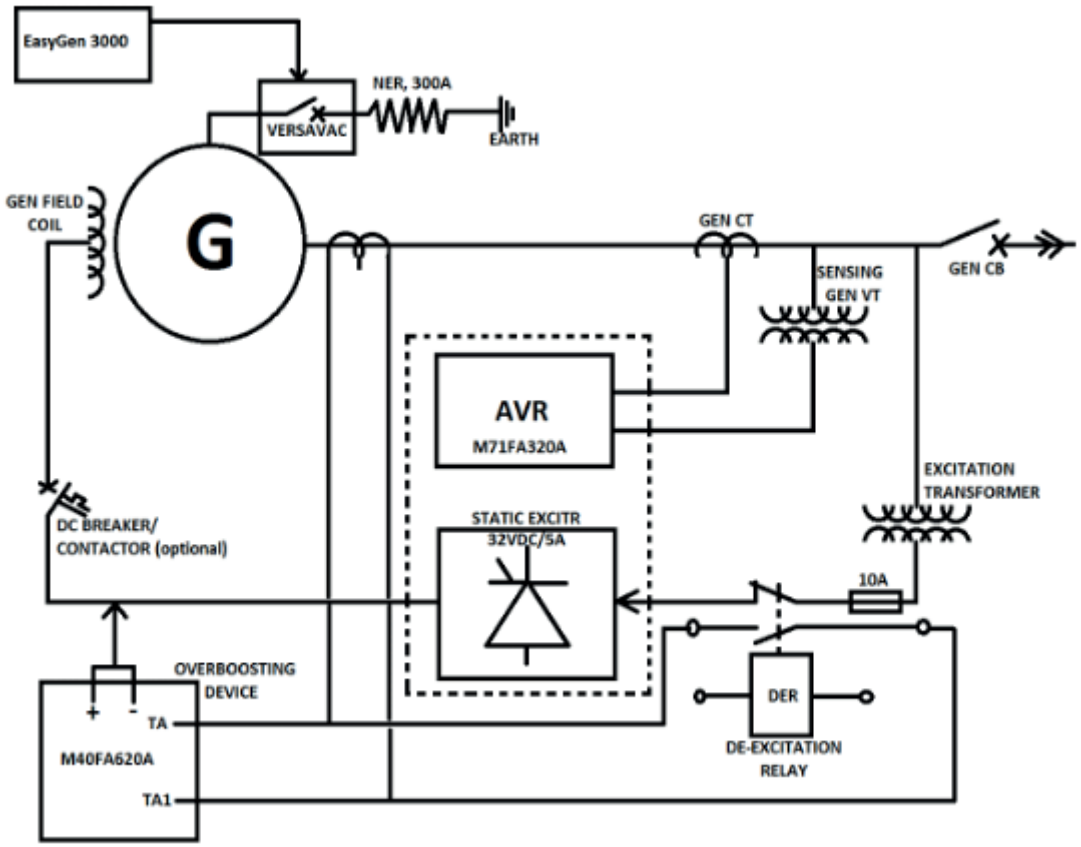


Fig 3: Application Setup of the Co-Generator Alternator & Excitation System

The Alternator stator windings are connected in a Star Configuration. The star point is meant to be grounded through an impedance. The NER is capable of handling 300A fault current continuously for 10 seconds. The Neutral Current Transformer measures any earth fault current on the neutral to ground.

The connection of the Neutral to the NER is made by a fast-closing Capacitor Switch/Breaker called VerSaVac. The breaker is sometimes called the Neutral Earthing Contactor (NEC). The Generator Controller initiated the closing of this breaker, for example, Woodward EasyGen3000. The controller can be seen on the right.

The purpose of this Neutral Isolation Breaker is to provide Neutral Interlocking. Because the Co-Generator gets paralleled with Utility Mains or Standby

Controller

Generators, only one point on the MV network should be grounded. The Co-Generator Controller can be configured to provide this interlocking using the VersaVac Breaker. This is achieved by keeping the VersaVac breaker in the OPEN Position when the Co-Generator is paralleled with Utility Mains/Standby Generators.

Multiple points of neutral earthing are avoided to prevent a path for circulating zero sequence currents and triplet harmonics (i.e. 3rd, 6th, 9th etc.).

Zero sequence currents at a rated frequency can circulate between neutrals. Circulating ZPS (Zero Phase Sequence) currents between Multiple Earthed Neutrals are a problem on the MV network as they may cause nuisance Trip operation of Earth Fault protection.

The AVR controls the Excitation System of the Co-Generator. The AVR, the MEC-100, for example, as seen in Fig 5, performs many functions besides the obvious ones. The De-Excitation of the Exciter is achieved by Switching off the power supply to the AVR using an Auxiliary relay in the local control Panel.

Fig. 4: The VersaVac Breaker and the Neutral CT

There is also an Over-boosting Device (Varicomp) to assist in sustaining excitation when the voltage drops to a low set level, i.e. 70%. Figure 5 shows the AVR.

Fig. 5: Automatic Voltage Regulator

The Over-boosting Device (VARICOMP) is connected to operate with the AVR. Below is the picture of a VariComp installed inside the AVR compartment. The RED light is an ON indication operation when the Co-Generator is running.

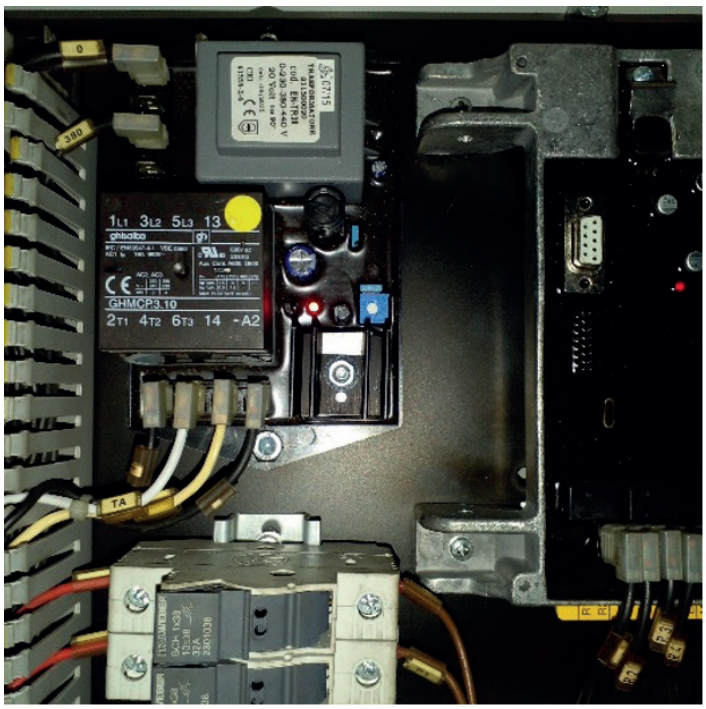


Fig. 6: Picture of a VARICOMP in position

As mentioned, its purpose (VARICOMP) is to sustain the excitation current supplied by the AVR to the exciter when the load increases and voltage drops. The following diagram shows the typical connections of all the different parts.

The Over-boost device supplies extra Excitation current to the exciter when the voltage drops to 70% of the rated voltage. The sensing is done by connecting "0 and 380V" to the voltage sense VT and adjusting a potentiometer on it. During Normal operation, when the voltage is at the rated value, the RED Light is ON. The device does not operate and is only requested when it senses that the voltage has dropped to 70%.

TYPICAL OPERATIONAL CHALLENGES

Electrical equipment such as Transformers and Generators are important in the Power System. They provide means to enable the supply of electrical energy. Nevertheless, there is always a fault condition that this equipment can suffer from.

The Co-Generator For instance, since it is a huge electromechanical machine used to generate electrical energy at very high AC voltage, it is often required to run in parallel with the power system.

The whole Co-Generating plant comprises a Prime mover, Automatic Voltage regulator, Cooling Systems, Excitation Systems and Lubrication System. Extreme unbalanced conditions in a power system network can occur if a Co-

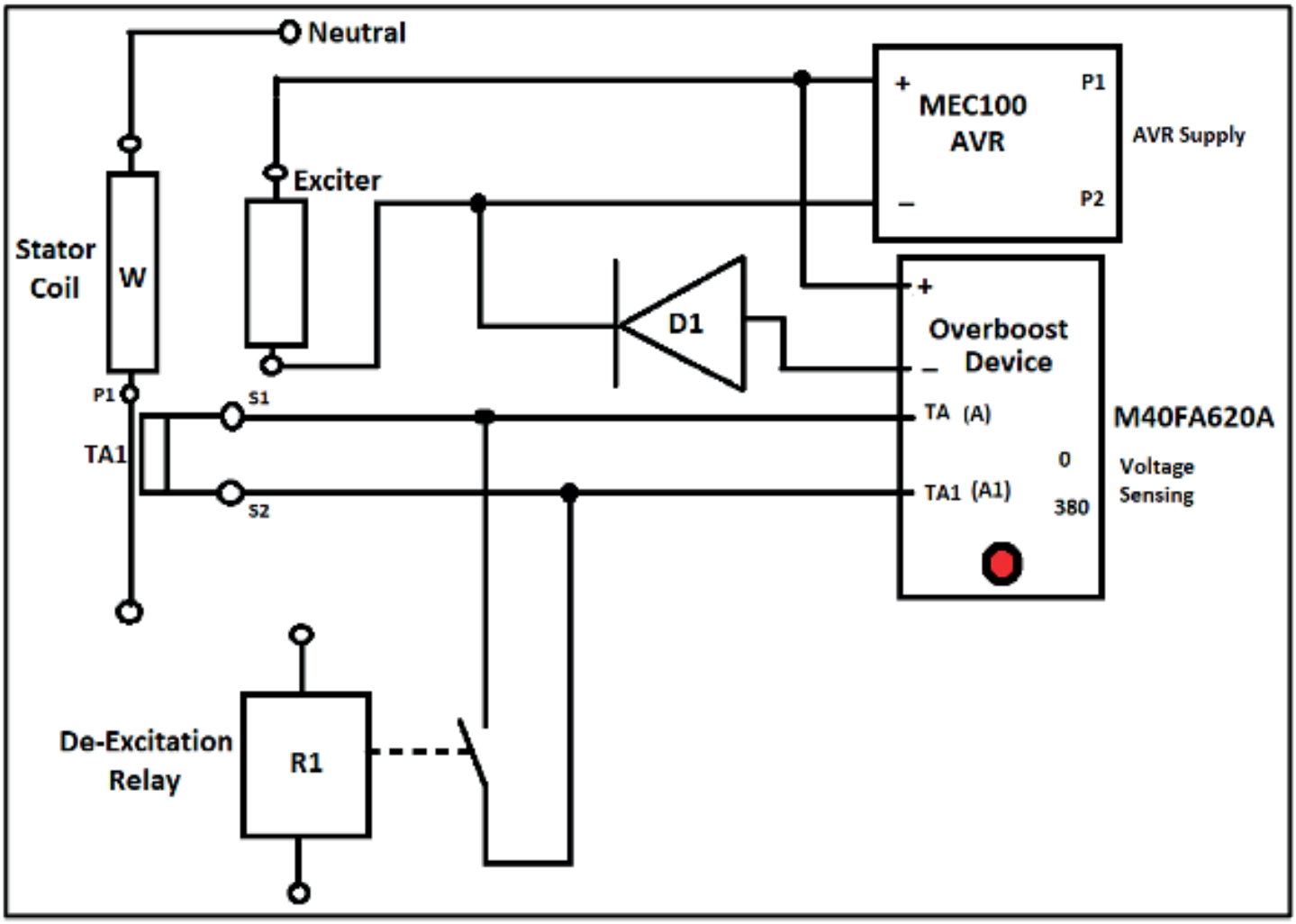


Fig. 7: Typical Schematic of the Excitation System

Generator suddenly shuts down, creating power shortages or even blackouts.

One of the fault conditions is a faulty Excitation System. When the excitation system components are faulty, the generator will lose excitation, and the voltage will drop. If the generator does not shut down due to voltage, it can be damaged severely.

Some excitation systems have an AVR and an Over-boost device, as explained. An example of an Excitation System Fault is when the generator fails to produce power up to its design capacity. Its performance declines to a point where it can only produce, for example, up to 38% of its capacity, approximately 494KW if rated at 1300KW for example.

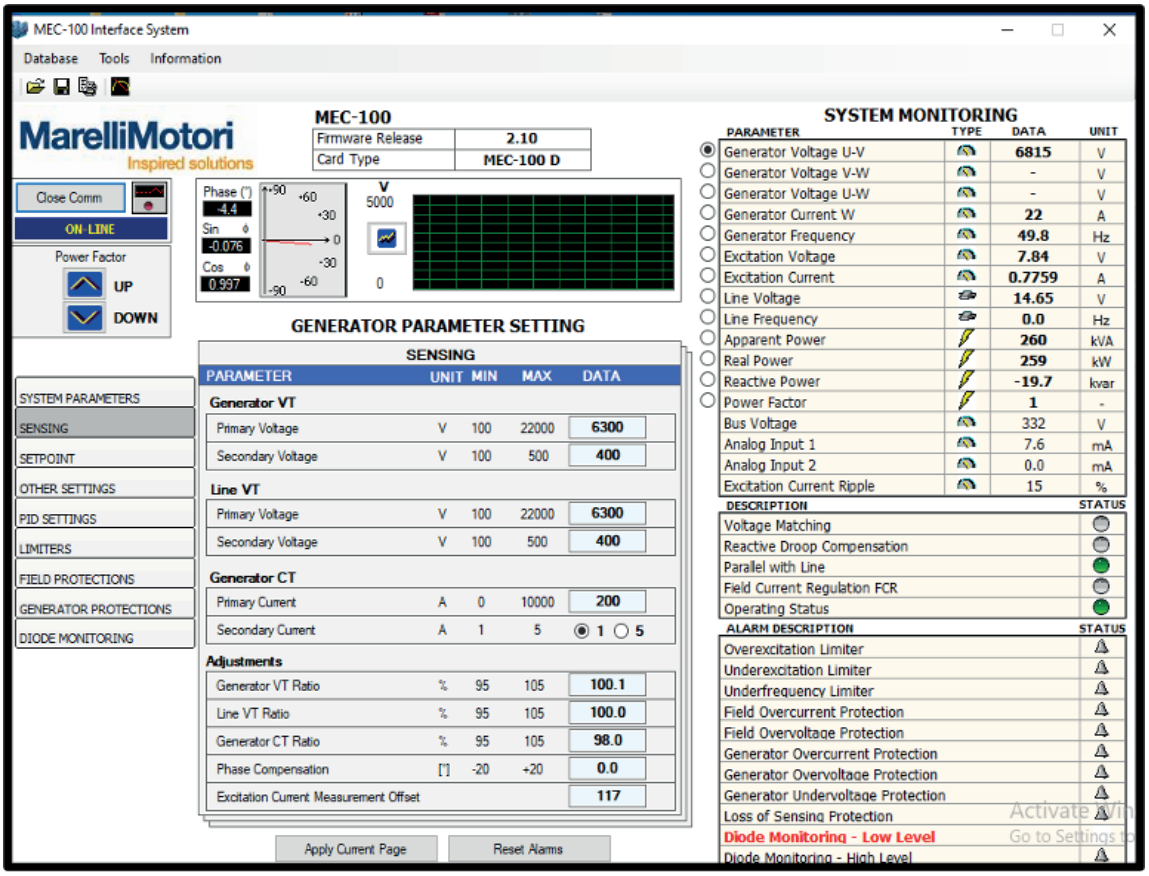
During the Load run, as the load increases, the Power factor will get more lagging, and the Reactive power will also increase. This will continue until the power factor gets below a minimum threshold set value of 0,7pu Lagging; if so, set. Then it will be shut down by the Generator Controller either on Reduced Power or low Power Factor.

Figure 8 shows an example of a faulty Excitation System showing a rotating diode monitoring fault and a trip due to under frequency and voltage.

Another fault condition is the Sensitive Earth Fault Trip of the Mains Breaker. As explained above, when a Co-Generator is paralleled with the grounded power system, either Utility Mains or other Standby Generators with a Switched Neutral Earthing Contactor (NEC), the Co-Generator Neutral must be open-circuited.

FAULT ASSESSMENT

The above fault conditions, Faulty Excitation System and SEF Trip, when investigated, revealed the following:
The first one was that the De-Excitation Contact, provided externally by the Auxiliary Relay in the Local Control Panel, was not activated. This meant during shutdown (due to Load Shedding, Power Dip, etc.) Switching off, or even stopping, intentionally or unintentionally of the Prime Mover, the AVR supply does not switch off. The alternator keeps providing power through the Voltage Sensing VT until the engine reaches a



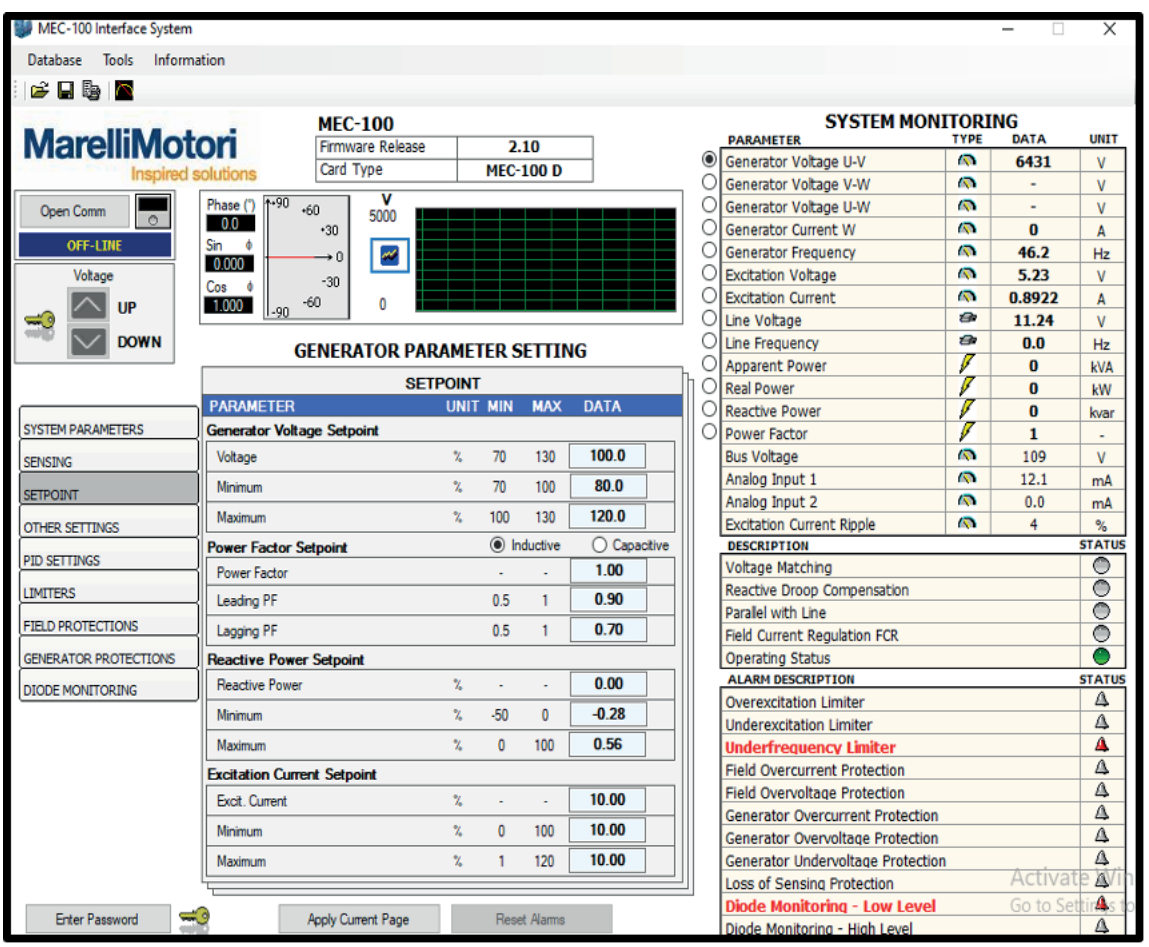


Fig. 8: Faulty Excitation System indicating "Rotating Diode Monitoring-Low Level.

standstill. During that time, the Rotor, magnetized (MMF), will create a back EMF after losing excitation. This phenomenon can result in high currents in all the alternator parts, including the AVR. As a result, failure is imminent if this carries on numerous times.

The AVR components, which are not designed to handle such high currents and voltage, for that matter, will eventually fail and render the AVR non-regulating. Also, during generator stoppage and the voltage drops below 70%, the excitation provided by the AVR drops when the generator is running down (absence of throttle). The Varicomp then tries to boost excitation, creating abnormal conditions, such as engine hunting and an abrupt shutdown of the engine, due to low voltage conditions.

Another cause can also be the faulty Varicomp (Over-boost Device) that does not provide different excitation as it should when the Co-Generator is running at rated speed.

For the SEF protection activation, it was noticed that the Main Incomer, which provides voltage sensing for the Co-Generator, does not have power. The voltmeter indicates 0V, and the cable LIVE indication lights were OFF. Checking the Incomer Protection relay, it was certain the Feeder Breaker was in an OPEN Position (Switched OFF).

Fig. 9: Operated Protection Relay (Earth Fault Flagged)

Checking what the cause of the trip was, it was noticed that the CDG Protection relay for Over Current and Earth Fault has a Flagged EF trip (Earth Fault). See Fig. 9.

Suppose the Co-Generator VersaVac Breaker control circuit is malfunctioning, and the breaker stays in a CLOSE position. In that case, it will be switched on load with its Neutral Connected to EARTH and Neutral to Earth current (ZPS) at a high level will flow and Trips the Mains Feeder Breaker. The same ZPS Currents will flow to the Standby Generator with a CLOSED NEC, and that generator will trip. Figure 7 shows an activated EF Trip after switching a Co-Generator with its Neutral Earthed. A total loss of supply could be experienced due to power system disturbances.

RECOMMENDATIONS

Periodic inspection of these components during maintenance can be very helpful in determining the existence of any faulty operation. The only time the Co-Generator Neutral can be Grounded or Earthed is when it runs on Island Mode and is isolated from any other MV power system.

The AVR also loses power when the Start Signal is removed, and the Co-Generator STOPS. The supply to the AVR must also be switched OFF immediately when the generator Breaker OPENS. This can be done by using the start relay auxiliary contact to provide a switching mechanism for the AVR supply De-Excitation Relay.

The running parameters of the Prime Mover and Alternator can be used to detect any abnormalities before a fault occurs. wn

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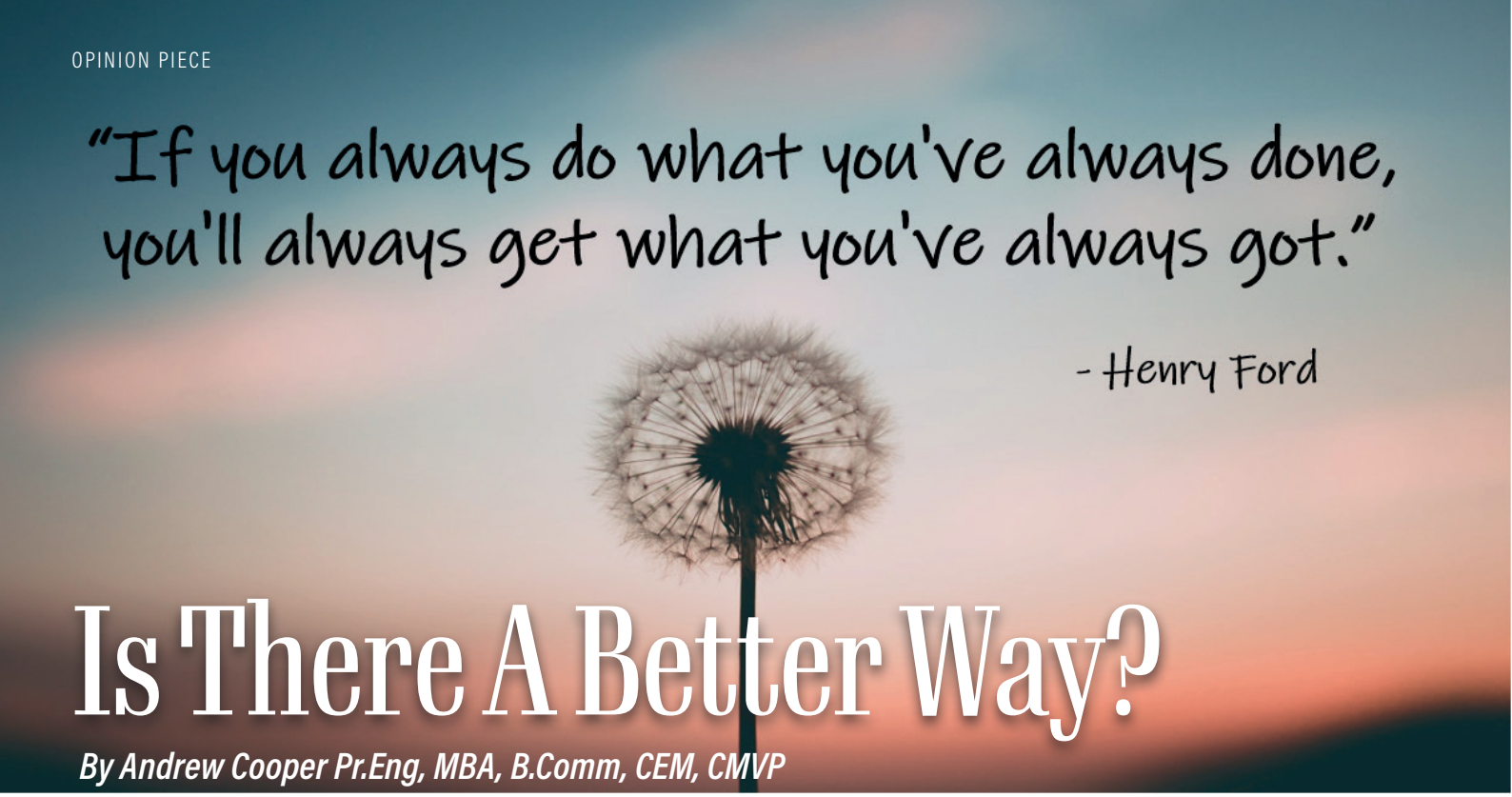

Is There A Better Way?

By Andrew Cooper Pr.Eng, MBA, B.Comm, CEM, CMVP

At home recently, I caught myself turning on the hot water tap to rinse the soap off my hands. When I finished rinsing my hands, the water was still not hot, but I had removed 10 to 15 seconds of water from the water heater, which had to be replaced with cold water, which had to be heated up. The thing is that I did not even need hot water, so why did I use the hot water tap?

Then I asked myself, why is the hot water tap on the left-hand side?
When I Googled that question, I discovered that back in the 19th century, when indoor plumbing was introduced, cold water was brought into the home by hand pump. Since most people were right-handed, the pump was placed on the right side of the sink. With the advent of hot water, the hot water tap went to the left side because that is where there was space.

We have accepted this for years, yet how many of us have questioned if there is a more energy-efficient way?

If you are right-handed, and the majority of people are, you will generally hold something in your right hand and reach to the left-hand tap with your left hand to rinse, wash or fill it. That's correct, the hot water tap. What's on the left-hand side?

Even though I am aware of this, reaching for the hot water tap when I do not necessarily need hot water has become so habitual that I still regularly catch myself doing it. Every time I do, it wastes energy and costs money. How many others are doing the same thing?

Examples like this are everywhere. Walk around almost any building or industrial facility, find something that does not seem right and ask, "Why is it being done that way?" I would be willing to bet that most of the time, the answer would be, "Because that's the way we've always done it".

Henry Ford famously said, "If you always do what you've always done, you'll always get what you've always got."

Often practices, processes and policies get passed on year after year, decade after decade and even generation after generation.

What we have always done has become chronic and acceptable, but with the various crises we are facing globally, what we have always done is no longer acceptable.

So how do we change this state of mind? I would suggest that all it takes is a decision to challenge what we do on a day-to-day basis and question what we do and how we operate.

Instead of robotically moving through life or rushing to "get it done", take a few seconds before doing something to ask:

- Can this process be improved?
- Can this new project be designed more efficiently?
- Is there a better way?

Almost everything we do on a day-to-day basis uses energy in some way. There are so many ways we can minimise waste and maximise efficiency, even if it is as simple as being aware of which tap we are using.

Instead of just accepting what has become acceptable, let's challenge the status quo and ask if there is a better way. wn

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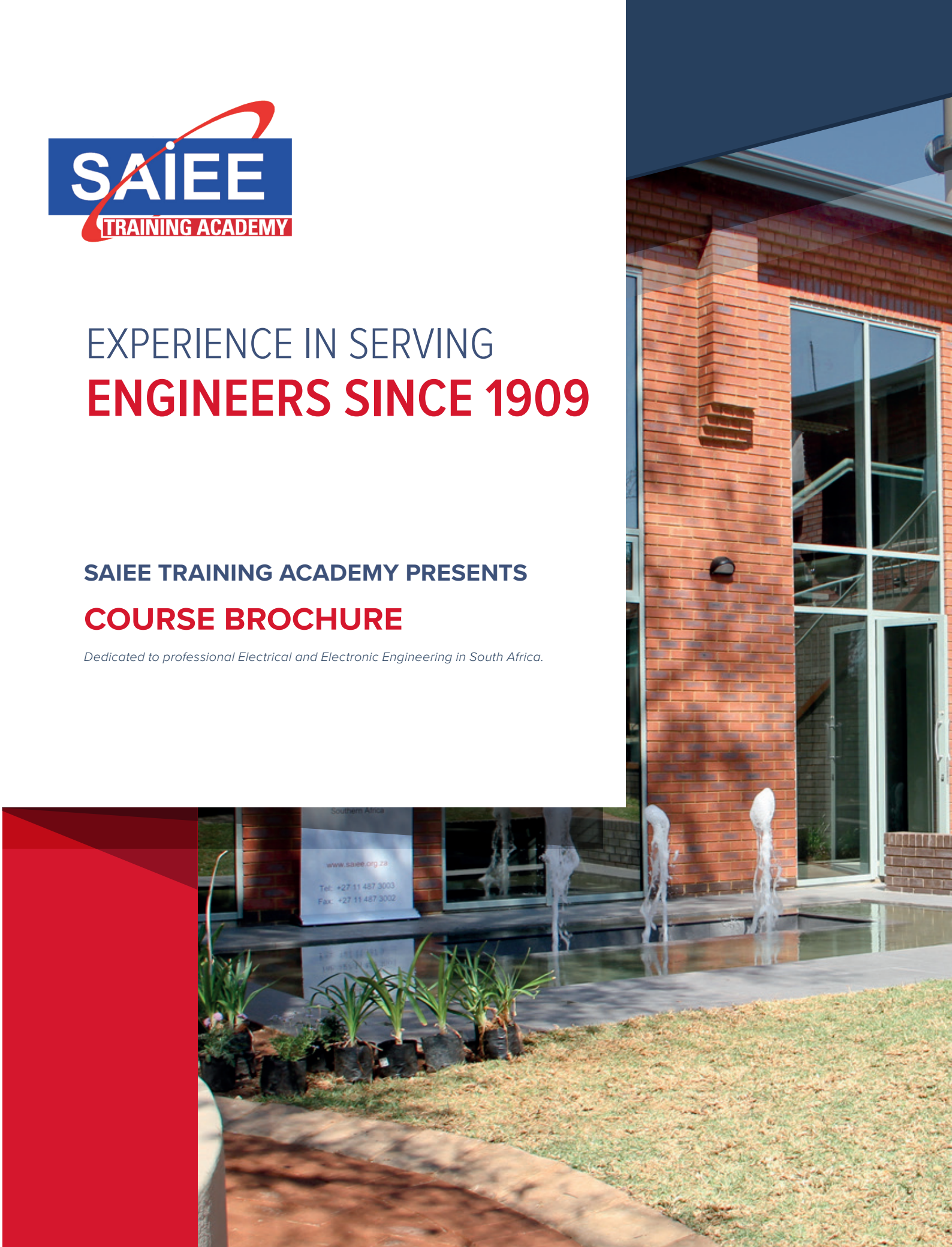

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JANUARY 2023

17/01/2023	Intro to 5G Communications
17/01/2023	Incident Investigation & Root Cause Analysis
24 - 26/01/2023	SAUPEC CONFERENCE
24/01/2023	Fundamentals of Financial Evaluation for Projects
25/01/2023	Transformer Construction, Operation, Maintenance, Testing and Protection
25/01/2023	Blockchain and Money
26/01/2023	Construction Regulations from a Legal Perspective

FEBRUARY 2023

01/02/2023	An Introduction to Artificial Intelligence
01/02/2023	Anatomy of Wind Turbine
09/02/2023	Legal Liability: Mine Health and Safety
09/02/2023	Photovoltaic Solar Systems
14/02/2023	Project Management for Engineers
15/02/2023	Design of Economical Earthing Systems for Utility Installations
15/02/2023	SANS 10142-1 Edition 3
22/02/2023	Technical Report Writing
22/02/2023	Power Systems Protection

MARCH 2023

03/03/2023	Legal Liability: Occupational Health and Safety Act (OHS Act)
07/03/2023	Operating Regulations For HV/MV Systems - ORHVS
09/03/2023	Writing Good Technical Specifications
10/03/2023	SAIEE ANNUAL AWARDS
15/03/2023	Finance Essentials for Engineer
15/03/2023	Fundamentals Of Developing Renewable Energy Plants
16/03/2023	Fundamentals Of Practical Lighting Design for Commercial and Industrial Application
23/03/2023	Cable Jointing and Selection
28/03/2023	Road to Registration
31/03/2023	Design Thinking and Innovation for Engineering Professional

Section & Chapter, Centre Webinars SAIEE Academy Online Training SAIEE Academy Classroom Training


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