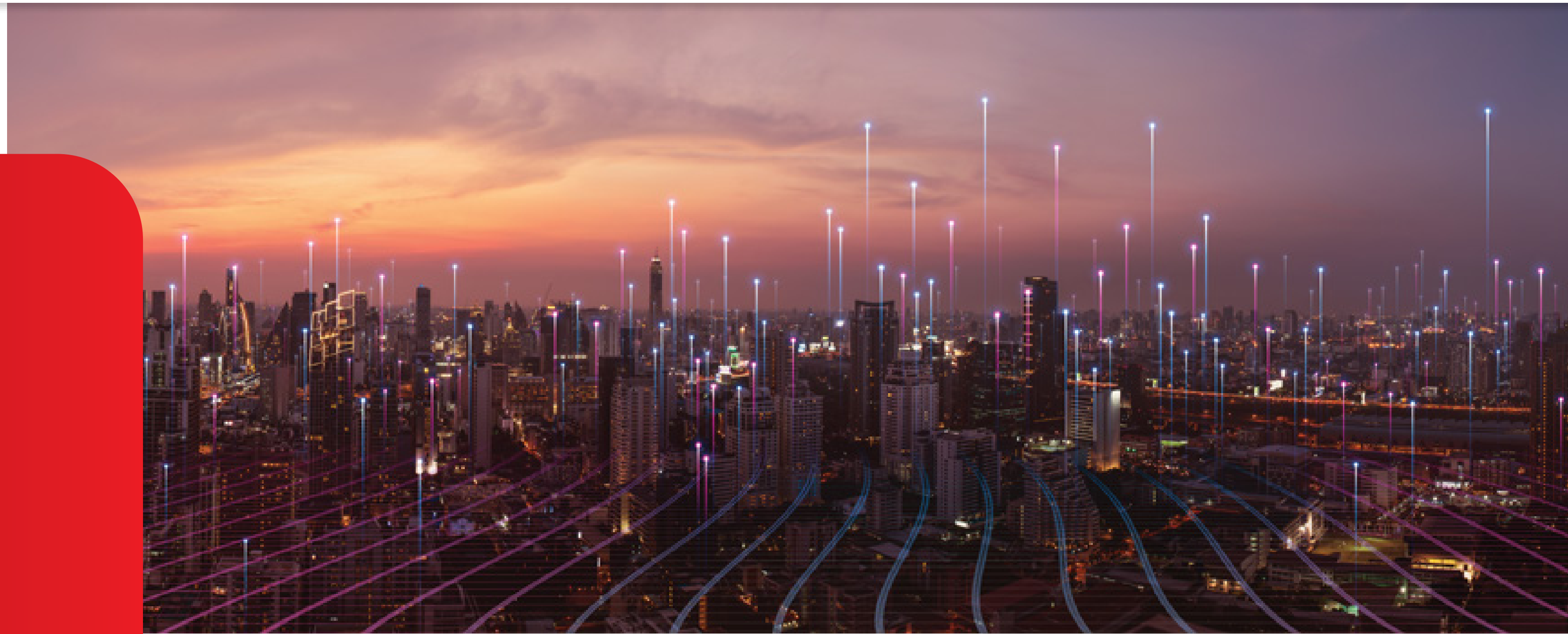
Vodacom Report:
Decarbonising Africa's ICT sector

Chapter 3

Solutions available to MNOs

April 2026

Further together



Chapter 3

Solutions available to MNOs

RECAP:

Chapter 1, titled "Challenges to decarbonisation", outlined the significant obstacles faced by the ICT and other electricity-intensive sectors in Africa, including unreliable electricity supply, financial constraints, carbon-intensive grids, and complex regulatory frameworks, which hindered their efforts to decarbonise. **Chapter 2 titled "Possible solutions to the challenges"**, explored strategies to overcome obstacles faced by the ICT and other electricity-intensive sectors in Africa in their efforts to decarbonise. It discussed improving grid infrastructure, decarbonising electricity supply through power sector reforms, public-private partnerships, and developing off-grid renewable electricity infrastructure. The chapter also highlighted the importance of overcoming institutional, policy, and regulatory barriers.

Mobile network operators (MNOs) and other corporates mainly depend on their country of operation's electricity infrastructure, policies and regulatory environments to decarbonise grid electricity – whether supplied by an IPP over the grid or by a state utility. Several decarbonisation interventions are within MNOs', mainly reducing on-site energy consumption through energy efficiency measures and using alternatives to diesel generators for backup or primary power. As base stations and data centres account for more than 70% of total MNOs' energy consumption[1], MNOs are a vital component of decarbonisation opportunities. This section focuses on decarbonising these two key areas.

Chapter 3 focuses on challenges and opportunities for improving energy efficiency in base stations and data centres and using cleaner diesel generator alternatives in sections 3.1 and 3.2, respectively. MNOs can collaborate with stakeholders in various ways to realise these opportunities. Section 3.3 identifies key collaboration themes, and Appendix 1 details specific intervention-related opportunities.

1 GSMA Intelligence. (2020). 5G energy efficiencies: green is the new black.

Contents

3.1 Energy conservation and efficiency

Energy efficiency and demand reduction are often referred to as hidden energy resources. Prioritising these actions is ideal because of their short implementation times, lasting impact, and ability to deliver continued benefits without the substantial capital expenditures associated with generation projects. Interventions that reduce energy consumption and optimise operational efficiency offer multiple benefits for MNOs, including reduced operational costs and capital expenditure. Reducing the requirement for investing in electricity generation supports improved capital allocation across the business.

Focusing on energy efficiency and reducing demand are critical to achieving societal net zero goals in the broader context of global energy sustainability. The IEA's Net-Zero Emissions by 2050 Scenario requires energy efficiency to double between 2022 and 2050[2]. This presents a significant opportunity for African MNOs to contribute to global sustainability efforts while benefiting from operational efficiency and resilience.

On the following page, we discuss energy efficiency and demand reduction interventions for African telco base stations and data centres. This section provides practical insights and real-world examples through case studies and unpacks the challenges and barriers to implementing these interventions. It explains the complexities involved in adopting these solutions.

2 IEA. (2022). Africa Energy Outlook 2022.

Base stations

Table 1 Summary of primary challenges for MNOs and corresponding solutions to improving the energy efficiency of base stations

Primary challenges	Summary of challenges	Summary of solutions
Distribution and volume base stations	Remote base stations are more challenging to access and maintain, resulting in higher capital and operational expenditures. Numerous base stations are required to serve a region, with different technology and relatively low energy consumption.	Placing base stations in better locations can reduce the number of base stations required in a region, thereby reducing overall energy demand.
Maintaining legacy technologies	Maintaining outdated technologies (EDGE, 2G, and 3G) and newer 4G and 5G increases overall power needs.	Increasing the adoption of affordable technology that can operate on 5G networks, will allow MNOs to retire older technologies.
Split incentives in tower company (TowerCo) agreements	TowerCos have little incentive to install energy-efficient passive equipment due to split incentives (where one party benefits more than the other).	Implementing contractual and cost-sharing arrangements between MNOs and TowerCos will align financial interests.

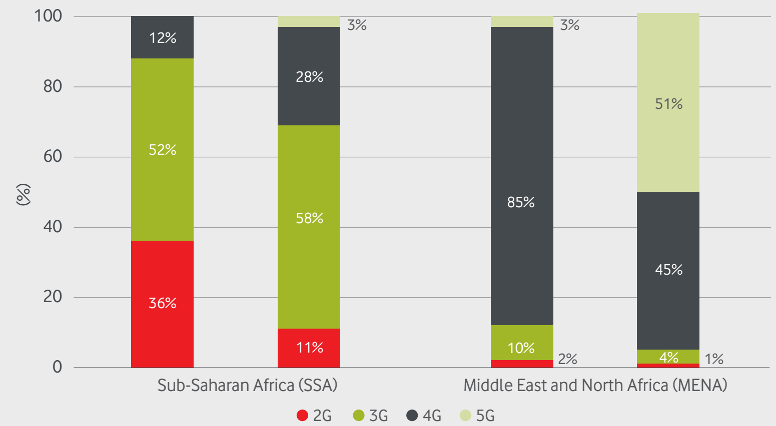
African telco base stations face energy efficiency challenges arising from their wide distribution and maintenance of legacy technologies.

Telecom base station sites consume significant amounts of electricity. Active equipment, such as base transceiver stations (the equipment that connects mobile phones to a network), accounts for approximately 60% of electricity usage. Passive equipment, including direct current power systems and cooling mechanisms, accounts for the remaining 40%[3] (Figure 2). Improving network efficiency and implementing modern technology can reduce energy consumption significantly. However, Africa faces unique challenges to implementing energy reduction strategies, including the dispersed locations of base stations with diverse technology profiles and the TowerCo model's split incentives.

African MNOs serve customers in concentrated urban areas and vast rural geographies. While urban base stations are typically easier to maintain and modernise, remote base stations present several challenges. The financial feasibility of remote base station upgrades is difficult for MNOs as they are not profitable in rural customer bases without access to newer technologies. Older, less efficient technology is prevalent in rural base stations and can be maintained less frequently by less experienced technicians, which MNO's need to take into consideration when deciding if base station upgrades are financially viable. All these factors increase capital and operational expenditures, leading to reduced or negative returns on investment.

To ensure broad coverage and accessibility for essential communications services across diverse socioeconomic groups, African MNOs must maintain legacy technologies. Many people cannot adopt newer 4G and 5G technologies, which require modern, expensive mobile devices. Base stations will need more power to accommodate 4G and 5G technology being introduced alongside legacy technologies. In advanced economies with wealthier populations, legacy networks are being phased out and replaced with higher capacity, energy-efficient 5G networks (Figure 1)[4].

Figure 1: Technology mix outlook in Sub-Saharan Africa (SSA) and Middle East and North Africa (MENA)[4].



TowerCo agreements can lead to split incentives when installing energy-efficient passive equipment on base stations. In the TowerCo model, commonly used in Africa, the TowerCo provides the passive equipment (e.g., cooling systems) and the MNO bears the energy costs. Consequently, TowerCos may prioritise equipment with lower upfront costs rather than energy efficiency. Some TowerCos have proactively introduced energy efficiency measures, demonstrating that despite these challenges, improvements can be made to benefit both parties.

Solutions to improving the energy efficiency of telco base stations lie in strategic collaboration and technological innovation.

3 Deevela, Niranjan Rao. (2022). A review of renewable energy based power supply options.
4 GSMA. (2021). The Mobile Economy.

A multi-faceted approach is essential for overcoming the barriers to reducing the energy consumption of base stations in Africa.

Base stations can optimise the energy efficiency of legacy networks and implement energy efficiency interventions (listed in Table 2) through phased technology upgrades, where the least efficient technologies are replaced with more efficient technologies. MNOs could provide governments with technical support to develop long-term legacy network phase-out plans, including increasing the adoption of new, affordable technology. These collaborations will minimise the socioeconomic impacts of phasing out legacy networks.

Various contractual and cost-sharing arrangements between MNOs and TowerCos can remove split incentives, which often dissuade TowerCos from installing newer equipment. Cost-sharing mechanisms for passive equipment upgrades (especially for cooling) can align the financial interests of MNOs and TowerCos.

Examples of contractual arrangements that benefit both parties include:

- Energy performance contracts, where payment is linked to savings achieved
- Green leases, where TowerCos and MNOs share the costs and benefits of energy efficiency improvements
- Cost pass-through clauses, where MNOs take on the costs of energy efficiency

Figure 2: Split between passive infrastructure run by TowerCos and active infrastructure run by MNOs[5].

Why 5G is more energy efficient than legacy networks

Based on a study by Nokia, 5G networks are up to 90% more efficient than 4G networks. This is mainly because 5G uses less energy per unit of traffic (W/Mbps). 5G has improved spectral efficiency, meaning spectrum is used more efficiently (bits per second per hertz).

5G employs sleep mode, which allows network components to power down during periods of low usage, and beamforming, which directs the signal only where needed, reducing energy waste.

5 Deloitte. (2021). The Rise of the Netcos - M&A & Telecom Engineering Centre of Excellence (TEE).

AI-driven, tower-level energy optimisation: a key to telco decarbonisation

While tower-level solutions are easily accessible, many network-level solutions could tackle some of the decarbonisation challenges that MNOs face. For example, AI- enabled network-level energy optimisation solutions are designed to address the growing energy consumption challenges faced by telecom operators, particularly in Africa.

These innovative solutions leverage AI to analyse site traffic demand and optimise energy efficiency across multi- radio access technology and multi-band networks. AI can adjust network operations based on real-time data, ensuring that energy is used more efficiently without compromising network performance.

These solutions have been proven to save close to 1.5 million kWh of power per year when deployed on a typical network with 1 000 sites. Despite its potential, the widespread implementation of these solutions in telcos is inhibited by several factors, including access to reliable data, system and infrastructure compatibility issues, and cybersecurity and data privacy constraints. As these obstacles are overcome, the adoption of AI in network-level energy optimisation is expected to play a crucial role in the decarbonisation efforts of the telecommunications industry.

Table 2 Energy efficiency opportunities for telecommunication base stations

Telecommunication base station energy efficiency opportunities

Site simplification/ modernisation	Modernisation involves installing newer, more efficient systems and moving network traffic to newer, more efficient bands (e.g., 5G). Multi-band technology, which combines the functionality of several radio units into a single physical unit, can help with site simplification. These solutions require a coordinated, long-term technology phase-out plan.
Shifting from indoor to outdoor base stations	Relocating equipment from indoor sites to outdoor sites reduces heating, ventilation and air-conditioning (HVAC) energy consumption, reducing overall base station energy consumption by about 35% to 40%.
Free cooling	Free cooling takes advantage of the ambient temperature outside telecom shelters to deliver the necessary cooling inside. This avoids the need for compressors, which are the most energy-intensive component of traditional air-conditioning systems.
Remote monitoring and control and smart energy management systems	These systems can manage base station energy consumption through advanced technology that enables remote monitoring and control of base station equipment. This facilitates data-driven insights for operational efficiency and predictive maintenance. These solutions allow operators to adjust site temperature, control power sources, and schedule automated actions remotely, minimising the need for site visits and reducing unplanned outages[6]. (See also Box 1 in Chapter 2.)
Sleep mode/ hibernation	With these tools, base transceiver station equipment can be turned off or adapted during periods of low call traffic. These tools can be integrated into existing site infrastructure and require minimal modifications, with different approaches and configurations offering varying potential energy reductions during low traffic conditions[7].
Co-location of equipment	In Africa and other developing markets, many operators choose to sell their base station assets, including the energy and infrastructure that power base stations, to independent base station companies (TowerCos). The TowerCo model enables infrastructure sharing, where multiple MNOs co-locate their equipment on single base stations and share the passive infrastructure required to operate the base station[8]. This business model creates operational efficiencies.

6 KED Technology (2022). Tower monitoring.
7 GSMA Intelligence. (2020). 5G energy efficiencies: green is the new black.
8 Helios. (2021). Delivering mobile connectivity and reducing carbon.

Data centres

Table 3 Summary of primary challenges for data centre operators and solutions to improving the energy efficiency of African data centres

Primary challenges	Summary of challenges	Summary of solutions
Climate and operational costs	Africa's hot and humid climate means more energy is needed for cooling. Free cooling is not viable, and cooling systems increase operational costs and require substantial upfront capital.	Climate control can be managed efficiently through investments into advanced cooling technologies (for example, closed loop liquid cooling and dynamic thermal management).
Limited pool of technical expertise	Africa has a limited pool of technical expertise, making energy efficiency improvements complex and costly. Competing financial priorities also hinder progress.	Developing training programmes and partnerships will build local technical expertise, and introducing energy audit subsidies and specific finance mechanisms will support energy-efficient projects.
Lack of regulatory framework and market fragmentation	The absence of a unified regulatory framework and the lack of collaboration among data centre operators result in the slow adoption of best practices and innovations.	Implementing a code of conduct for energy efficiency or an energy consumption decree will help set clear standards and guidelines. Establishing a climate-neutral data centres pact can promote collaboration, share best practices, and drive collective action.

Data centres provide essential services in our increasingly digital world and consume large amounts of energy.

Data centres form the backbone of digital infrastructure, enabling the delivery of essential services and applications. Data centres are crucial for MNOs, managing large volumes of data and voice traffic. This data volume is expected to soar with the ongoing deployment of 5G and Internet of Things (devices connected to the internet that transmit data). African MNOs are investing in data centres to meet growing demand driven by digital transformation.

Data centres primarily consume electricity to power IT equipment and cooling infrastructure, with the rest going to lighting and uninterrupted power supplies[9]. Data centres' energy efficiency is measured using the power usage effectiveness (PUE) ratio, which determines how much of the total energy consumption goes to powering IT equipment like servers, storage devices, and network equipment[10]. A PUE of 1.0 indicates that all energy consumption is attributable to powering IT equipment, with no consumption by support infrastructure. Best practice benchmarks suggest that data centres can reach a PUE of 1.4 in hot climates, such as equatorial African countries, compared to 1.2 in South Africa, which has a more temperate climate[11]. The average African PUE is estimated at 1.67, 8% above the global average[12].

PUE only measures how efficiently the data centre's support services are operating and does not indicate absolute energy consumption or the energy efficiency of the IT equipment. In an increasingly digital world, especially with advances in AI, measuring energy consumption will rapidly become more prevalent.

9 Carbometrix. (2022). What consumes the most energy in a data center?
10 DC PUE. (2023). What Is Data Center PUE? Defining Power Usage Effectiveness.
11 Climate Neutral Data Centre. (2022). Energy Efficiency.
12 CAP DC & Africa Data Centre Association. (2024). African Climate & Datacentre PUE.

African data centres face unique challenges due to the hot and humid climate, higher initial investment costs for advanced cooling systems and limited pool of technical expertise specific to data centres. These factors make energy efficiency improvements complex and costly.

Free cooling is not as feasible in Africa as in Europe due to climate differences. With Africa's hot and humid climatic conditions, especially in regions like Lagos, data centres, cannot use free cooling. Although free cooling is feasible for three-quarters of the year in the European Union, African data centres require more active cooling, resulting in a higher PUE.

To meet their cooling needs, African data centres need to import advanced systems, increasing the equipment's capital cost and resulting in long waiting periods. The business case for these cooling solutions is thus weak, with extended payback periods and lower returns on investment deterring their adoption.

Africa's data centre industry is relatively new compared to sectors such as mining and manufacturing. There is a limited pool of skilled professionals with expertise in energy management and operating sensitive data centre systems. While the energy service company (ESCO) market is growing in countries like Kenya and Nigeria, they often lack specific data centre experience. South Africa has a longer history of data centres in banking and telecommunications, with a larger workforce and more ESCOs with relevant experience.

Addressing barriers requires a multi-faceted approach, covering policy drivers, skills development and incentive mechanisms.

Creating and professionalising national data centre associations as registered institutions can significantly enhance the industry's development. The African Data Centre Association operates continent-wide, but national associations can address local needs and advocate for tailored policy changes, incentives and support. These associations can foster collaboration, knowledge sharing, and standardisation.

National data centre associations can establish training centres in partnership with organisations (for example, the Energy & Water Sector Education Training Authority in South Africa) to develop a skilled workforce. These centres can offer specialised courses in data centre management and energy efficiency. Their programmes emphasise hands-on training and practical experience, ensuring a steady supply of well-trained professionals ready to contribute to industry growth.

Locally manufactured data centre equipment, like cooling systems, can reduce costs, create jobs, develop a reliable supply chain and enhance competitiveness. The African Continental Free Trade Agreement can facilitate this by promoting intra-African trade and reducing barriers, enabling regional manufacturing hubs that serve the entire continent.

Implementing a code of conduct for energy efficiency in data centres or an energy consumption decree specific to Africa can drive the market towards more sustainable practices. This framework would set clear standards and guidelines for energy usage in data centres, encouraging operators to adopt energy-saving technologies and practices. Related regulations would also facilitate benchmarking and monitoring of energy performance, helping to identify areas for improvement and promoting a culture of continuously enhancing energy efficiency across the sector.

Introducing incentives to improve energy efficiency can encourage widespread adoption. Incentives like South Africa's Section 12L tax incentive can bolster the business case for energy efficiency. Implementing an energy audit subsidy programme and policies that mandate regular energy audits for large energy consumers can further support business development and create a pipeline for energy-efficient projects in African data centres. These subsidies would help offset the costs of comprehensive energy audits, enabling operators to identify inefficiencies and potential energy-saving opportunities.

3.2 Alternatives to diesel generators

Due to Africa's many energy-related challenges, MNOs heavily rely on diesel generators to ensure uninterrupted service for customers. Although this solution is reliable and safe, it comes at a significant operational and environmental cost. Electricity produced by diesel generators typically costs three to four times more than grid-based electricity in Africa and is the largest source of greenhouse gas (GHG) emissions for African MNOs. While alternatives exist (such as solar, wind, biofuel and emerging technologies such as green hydrogen) each come with limitations and challenges to implementation.

Chapter 2 explored the policy and regulatory challenges and opportunities associated with improving access and quality of grid electricity. While these underscored the importance of state-wide and regional-level interventions, this section will delve into barriers and opportunities within the control of African MNOs to replace diesel generators from a technological and supply chain perspective. By harnessing Africa's abundant renewable energy resources and addressing some of the implementation barriers and bottlenecks, African MNOs can reduce their reliance on fossil fuels, reduce emissions and ensure more stability within their operations.

On-site solar PV and battery systems

Table 4 Summary of primary challenges and corresponding solutions for MNOs to consider when using on-site solar power and batteries as alternatives to diesel generators

Primary challenges	Summary of challenges	Summary of solutions
Space constraints and installation challenges	Solar panels require a substantial footprint, posing challenges in areas where land is expensive or limited.	Using new technology, such as more efficient bifacial solar panels, optimises the design and placement of solar PV for maximum efficiency. Panels can be installed in different locations.
Limited power generation hours	Solar PV systems can only generate power during sunlight hours, necessitating additional power sources.	Coupling solar PV systems with alternative batteries (e.g., sodium-ion) will allow operation to store energy for use when the sun is not visible.
High cost of batteries	Batteries are an expensive power source compared to diesel generators.	Alternative battery technologies are more cost-effective and environmentally friendly.
Susceptibility to vandalism and theft	Solar panels and battery storage systems are vulnerable to vandalism and theft, requiring secure housing.	Solutions include enhancing security measures, including physical and digital security, and using secure housing (e.g., encasing batteries in concrete).
Logistical challenges for security enforcement	Base stations are widely dispersed, presenting significant logistical challenges for comprehensive security enforcement.	Developing centralised security management systems and collaborating with local communities will enhance surveillance and security.

Challenges to realising the full potential of solar PV and battery systems include space requirements, the cost of batteries and theft.

Integrating renewable energy, particularly solar PV systems, into the power supply for base stations and data centres is a widely adopted solution in Africa, given the abundance of solar energy and the affordability of solar PV. However, several challenges prevent this technology from fully meeting the power needs of telecom base stations and data centres.

Solar panels need a substantial footprint to generate sufficient power, which poses challenges for installation, especially in areas where land is either expensive or limited. This limitation is pronounced in densely populated urban areas or rugged terrains where finding space for installations is particularly challenging. For instance, a medium-sized telecom base station might have a peak power requirement ranging between 4kWp to 8kWp. To fully power an off-grid 4kW base station with solar panels and a battery system, a ~15kWp solar power system is required. This requires approximately a 10mx10m area, which most base station sites do not have access to (Carbon Trust analysis).

Given that solar PV systems can only generate power in sunshine, they cannot function as standalone solutions and must be coupled with large batteries or diesel generators to provide continuous power. However, batteries are expensive compared to alternatives like diesel generators.

Solar panels and battery storage systems are susceptible to vandalism and theft and need secure housing to protect them from potential criminal activities. While MNOs have taken measures to reduce theft, such as increasing physical and digital security and encasing batteries in concrete, dispersed base station sites present significant logistical and cost challenges for security enforcement[13].

Innovative solutions for addressing these barriers include alternative battery chemistries and bulk purchasing equipment.

Despite these challenges, innovative solutions are available to enhance the viability of on-site solar PV and battery systems for telecom base stations and data centres.

In built-up areas, leasing adjacent roof space for solar panel installation is a viable option, if regulations allow this. This approach could work, depending on several factors:

- The proximity of the roof spaces to minimise cable lengths, ensuring the space is accessible for maintenance
- Access to proper insurance coverage
- Clearly defined liabilities for any damages caused during installation, operation and maintenance are essential

Alternative battery chemistries can address cost and space constraints. A promising alternative to lithium-ion batteries is sodium-ion batteries, which utilise sodium ions as charge carriers. This rechargeable battery technology capitalises on the abundance, cost-effectiveness and low environmental impact of sodium. Sodium-ion batteries offer higher thermal stability and reduced risk of overheating, making them safer than lithium-ion batteries. Recent advancements in sodium-ion technology have significantly improved their performance metrics, with energy storage similar to lithium-ion batteries. The versatility and improved safety features of sodium-ion batteries make them suitable for grid storage and other large-scale energy storage applications[14].

Bulk purchasing is another way to reduce costs for solar panels and batteries. By procuring these components in bulk through collective buying power, MNOs can negotiate better prices, while abiding by regional competition and non-exclusivity regulations. A sectoral organisation, such as the GSMA, could act as an intermediary to leverage bulk purchasing power for solar panels and batteries on behalf of various MNOs, streamlining the procurement process and reducing costs.

Integrating solar PV and battery systems is an innovative solution that addresses challenges and provides an effective and sustainable option for powering telecom base stations and data centres in Africa.

13 GSMA. (2023). Energy Challenges for Mobile Networks in Sub-Saharan Africa: The need for clean and reliable energy for universal connectivitiy and digital transformation.
14 SolarReviews. (2023). Are sodium ion batteries the next big thing in solar storage?

Wind energy

Table 5 Summary of primary challenges and corresponding solutions for MNOs using wind energy as an alternative to diesel generators

Primary challenges

	Summary of challenges	Summary of solutions
Economic and site feasibility	Wind power requires favourable conditions to be economically feasible and can only be implemented in areas with sufficient and consistent wind resources.	Small and micro wind energy systems are designed to leverage low wind speeds and optimise performance in varying wind conditions.
Power output and technical constraints	Small and micro wind turbines are less cost effective as they typically have lower power output, with size limitations due to telecom base station constraints. Furthermore, wind turbines can create vibrations (if installed on the mast) and electromagnetic interference, which could impact network performance.	Integrating wind turbines with solar PV and battery systems will enhance overall power output and reliability. There is an option to create compact, efficient turbine designs or use tune dampers to reduce the amplitude of mechanical vibrations.
Market demand and technical support	Application is limited to favourable sites, resulting in a small market. Africa's lack of after-sales support, maintenance services, and replacement parts restricts adoption.	Hybrid energy systems that combine wind and solar will increase market appeal and demand, and there is an opportunity to establish partnerships with local service providers for technical support and maintenance.

Site feasibility, power output and space constraints are key challenges to MNOs using on-site wind energy for telecom base stations.

Small and micro wind energy systems are key to addressing many of these challenges.

On-site wind energy from micro and small wind turbines could be a viable solution for telecom base stations. Telecom base stations are often situated on high grounds, such as hilltops. This makes them well-suited to wind generation as elevated locations experience higher wind speeds and consistent wind patterns. This geographical advantage makes wind energy a viable and efficient option for powering telecom base stations.

Wind power requires favourable conditions to be economically feasible, so implementation is restricted. Adopting small and micro wind turbines to power telecom base stations presents several techno-economic and market growth limitations. The cost of using small wind turbines depends largely on available wind resources. They are only cost effective in areas with high enough and consistent average wind speed, making them impractical for widespread, large-scale adoption. Small and micro wind turbines typically have lower power output than larger turbines. Telecom base stations limit the size of the wind turbine that can be used, impacting cost-effectiveness. Small wind turbines can only work in favourable wind conditions, resulting in limited demand and a small market. As with any technology, limited after-sales technical support, maintenance services, and availability of replacement parts in Africa further restrict the adoption of small wind turbines.

Some innovative solutions are available to harness wind resources. Technology companies are creating small and micro wind energy systems designed to overcome many problems that prevent the use of small wind turbines. These innovations include leveraging low wind speeds and integrating wind energy with solar PV and battery systems, specifically for telecom base stations (Figure 3). There is an opportunity to complement solar panel installations with wind turbine technology, ensuring a continuous power supply even under varying environmental conditions.

Figure 3: Telecom base station with wind turbine technology (Revayu Energy) (left) and (Diffuse Energy)(right)

Biofuel

Table 6 Summary of primary challenges and corresponding solutions for countries to utilise biofuel as an alternative, clean fuel for generators

Primary challenges	Summary of challenges	Summary of solutions
Limited industrialisation and infrastructure	Africa is limited by its lack of infrastructure and limited industrial capacity, making biofuel production, storage and transport challenging.	Investing in infrastructure development and modernisation of industrial sectors will support biofuel production.
Technical expertise	Lack of technical expertise hinders the maturity of biofuel markets in Africa.	Solutions include establishing financial support mechanisms, providing training programs, and building local technical capacity.
Competition for land and food security concerns	Using crops for biofuel production raises concerns about food security, land use competition and environmental impacts.	Solutions include prioritising food security and sustainable land use while developing biofuel industries.
Unsupportive policy and regulatory frameworks	Unsupportive policies and regulatory frameworks limit the adoption and growth of biofuels.	Implementing supportive policies, renewable energy targets and regulatory frameworks will incentivise biofuel use.
Market development and supply chain issues	Challenges relate to establishing a market for biofuels and ensuring a reliable supply chain to compensate for logistical challenges.	Solutions include developing robust supply chains, investing in storage and transport infrastructure and promoting market development initiatives.

Using biofuels as an alternative to diesel presents challenges due to lack of infrastructure and technical expertise, and unsupportive policy and regulatory frameworks.

Biodiesel is a sustainable alternative to diesel for backup energy, derived from renewable biomass sources (plant or animal material). Biodiesel is produced from organic materials, such as vegetable oils, animal fats and recycled cooking oil, making it a sustainable energy option. Africa faces several challenges in adopting biofuels, including limited industrialisation, competition for land resources, and unsupportive policy and regulatory frameworks.

Biofuel markets in Africa have not matured due to lack of technical expertise, land availability, and government policies. Developed markets, such as the United States of America, and Europe, and some emerging markets such as Brazil benefit from well-established regulatory frameworks, renewable energy targets, and blending mandates that incentivise biofuel use. These regions benefit from advanced agricultural practices, diverse feedstocks, and robust economic landscapes that favour investment and established supply chains.

Using crops for biofuel production in Africa is controversial due to concerns around food security, land use competition, and potential environmental impacts. Diverting agricultural resources for fuel production could worsen food shortages and lead to land degradation, particularly in regions already vulnerable to food insecurity. Land plays a crucial role in the livelihoods of Africans; therefore, food security and poverty alleviation must be prioritised over biofuel industries.

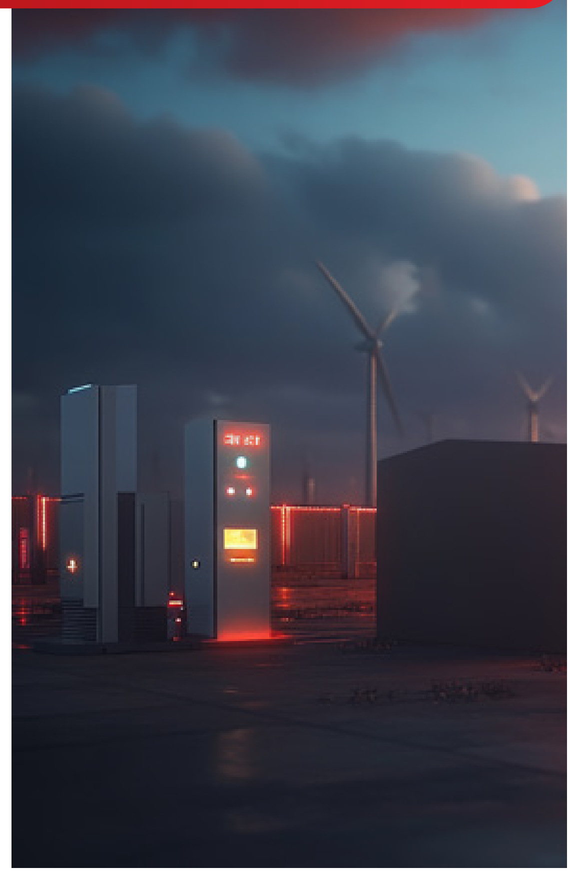
Africa's agriculture sector needs to be modernised to support biofuel production. This includes improving farming practices, increasing crop yields and enhancing feedstock quality and quantity. A reliable biofuel supply chain requires adequate infrastructure for storage, transport, and conversion of feedstocks and fuels to overcome logistical challenges. Africa's limited industrialisation, inadequate infrastructure and difficulty establishing a market for biofuels pose significant hurdles to developing a robust biofuel industry.

Biodiesel made from animal fat or vegetable oil needs to be chemically changed for use in a diesel generator, as these sources are typically thicker. Some engine manufacturers will void warranties if biodiesel is used. Biodiesel can affect maintenance cycles, which drives up operational costs.

Solutions to these challenges include supporting the development of biofuel policies and investment into supporting infrastructure.

Biodiesel and biodiesel blends are a viable alternative to diesel for backup energy. Initiatives to develop biofuel have been successfully implemented in regions including Brazil, the United States, Indonesia, China and the European Union. In 2022, the United States was the top global producer of biofuels, generating approximately 1 627 petajoules. Brazil and Indonesia followed suit, producing around 915 and 390 petajoules, respectively. Germany's biofuel output reached approximately 138 petajoules, making it one of the top five biofuel producers globally and the primary producer in Europe. The success of biofuel production in these countries is driven by supportive policies, blending mandates and significant investment in facilities and infrastructure.

Biofuels are also used to power non-mobile equipment in the Information Communications and Technology sector as an alternative to diesel generators. Addressing the challenges in Africa requires approaches tailored to each country's unique needs and circumstances. Emphasising sustainable biofuel production practices, capacity building and policy support can unlock the potential of biofuels as a renewable energy source in Africa. Africa needs significant investment in infrastructure development to facilitate the integration of biofuels into its energy mix.



Case study 1

Caterpillar and Eneria support groundbreaking transition of LCL Brussels-West data centre to 100% HVO for backup power

LCL Data Centers operates multiple facilities in Belgium and recently installed a new 13.5MVA standby power system at its Brussels-West data centre in Aalst. This was Belgium's first data centre to utilise 100% hydrotreated vegetable oil (HVO) fuel for backup power. This initiative helps LCL to achieve its ambitious climate targets. LCL plans to transition all its data centre standby power solutions to operate on HVO within the next two years, signalling a significant stride towards their sustainability aspirations[15].

Case study 2

Caterpillar collaborates with Microsoft to provide backup power to its Swedish data Centres

Microsoft has partnered with Caterpillar Inc. to implement Cat generator sets for backup power solutions in the initial phase of constructing data centres in Sweden. Installed and commissioned by a local Cat dealer, these generator sets align with Microsoft's sustainability objectives by enabling operation on Preem Evolution Diesel Plus, a renewable liquid fuel. This eco-labelled fuel is produced at the Preem refinery in Gothenburg, Sweden, and contains over 50% renewable raw materials, making it a pioneering product in the global market.

The collaborative efforts with Caterpillar and its dealer network to develop innovative power solutions that support Microsoft's carbon reduction goals underscore Microsoft's dedication to designing and operating data centres with the highest standards of sustainability worldwide[16].

15 Caterpillar. (2023, June 27). Caterpillar and Eneria suport groundbreaking transition of LCL Brussels-West data center to 100% HVO for standby power.
16 Caterpillar. (2021, June 1). Caterpillar collaborates with Microsoft to provide standby power to its Swedish data centres.

Hydrogen fuel cells

Table 7 Summary of primary challenges and corresponding solutions for MNOs and energy providers to use on-site hydrogen fuel cells as an alternative to diesel generators

Primary challenges	Summary of challenges	Summary of solutions
Infrastructure and supply chain challenges	Developing extensive infrastructure for hydrogen production, storage and distribution and establishing a reliable supply chain requires substantial investments, increasing costs and risks.	Financial support mechanisms and partnerships to fund infrastructure and supply chain development need to be established, with risk-sharing in mind. On-site generation is another solution.
Storage and safety concerns	Managing complex, costly hydrogen storage safely is challenging due to hydrogen's flammability and explosiveness.	Innovations are needed to provide safer, more efficient storage solutions such as solid-state storage vessels.
High Levelised Cost of Energy (LCOE)	The LCOE for green hydrogen fuel cells remains higher compared to diesel generators, with high upfront expenses.	Technological advancements and economies of scale will reduce costs over time.
Commercial viability and perceived technology risk	Green hydrogen fuel cells are an emerging technology, perceived as high-risk without proven large-scale success.	Commercial viability needs to be demonstrated through pilot projects and large-scale implementations to build confidence.

17 White & Case. (2023, December 19). Green hydrogen in Africa: A continent of possibilities?
18 Green Hydrogen Organisation. (n.d.). Africa Green Hydrogen Alliance.
19 Digitalisation World. (2023, May). Fuel cell use in data centres – How much do you know?

Hydrogen fuel cell technology is still new and faces many challenges to its wide-scale deployment.

Hydrogen is being advanced as a possible alternative to diesel generators for data centres and telecom base stations. However, transitioning to green hydrogen involves navigating significant challenges. Unless hydrogen can be produced on-site, establishing a robust supply chain for hydrogen production and distribution is crucial. Extensive infrastructure needs to be developed to support large-scale hydrogen production. Substantial investments in transmission infrastructure are required to connect energy sources to production facilities and export hubs, with infrastructure to transport and store the hydrogen. While some countries have existing gas transportation infrastructure, others must build this from scratch, which increases costs and risks. These infrastructure development needs contribute to the overall capital cost of large green hydrogen projects and introduce significant risks[17,18].

Despite many data centres piloting fuel cells and predicting strong growth, further advancements and cost reductions are necessary to overcome barriers and achieve broader adoption. Cost, safety and infrastructure challenges need to be addressed. Although costs are expected to decrease over the next decade, the LCOE for green hydrogen fuel cells remains higher compared to diesel generators in most cases, with lower operational costs but high upfront expenses. Hydrogen fuel presents safety and storage challenges due to its flammability and explosiveness, necessitating complex and costly storage systems. Due to the high-value material used in fuel cells, they are at a high risk of theft.

Hydrogen fuel cells need to demonstrate commercial viability beyond pilot projects to support widespread adoption. As green hydrogen fuel cells are an emerging technology, their adoption will be perceived as high-risk until there are more cases of reliability and large-scale success at a commercial scale. Ensuring the reliability and availability of power systems is particularly important for data centres, which rely on uninterrupted power to perform their essential operations[19].

Solutions for overcoming these barriers include advancing hydrogen fuel cell technologies and supporting pilot projects.

Green hydrogen fuel cells are a promising alternative solution for powering telecom base station sites and data centres, especially in scenarios with space constraints, where large-scale solar and battery systems are impractical. Green hydrogen fuel cells are a compact, high-energy-density power solution. A key advantage of hydrogen fuel cells is their ability to operate continuously, as long as fuel is supplied. This makes them an excellent standalone renewable energy solution to replace diesel generators at telecom base stations.

In January 2024, Microsoft and Caterpillar successfully powered a data centre in Cheyenne, Wyoming, for 48 hours using hydrogen fuel cells. This demonstrated the viability of this low-carbon technology as a sustainable alternative to diesel backup generators. In this project, a 1.5MW hydrogen fuel cell was integrated into the data centre's electrical system, supported by a micro-grid controller and battery energy storage system. Microsoft and Caterpillar's success highlights hydrogen fuel cells as a promising technology for sustainable data centre operations[20].

Africa has some of the world's best and yet untapped renewable energy resources, with the potential to emerge as a leading producer of green hydrogen. North African countries like Morocco, Egypt and Tunisia, have significant solar and wind resources and are strategically located near European markets. These countries are suited to using hydrogen for own use, with the potential to export to Europe. In East Africa, Kenya and Ethiopia have strong potential for geothermal and hydropower, which can be harnessed for hydrogen production. Southern Africa, particularly South Africa and Namibia, have strong wind and solar potential and are already exploring hydrogen production, by leveraging their platinum resources for fuel cell technologies. West African countries such as Nigeria and Mauritania have abundant solar resources that could support hydrogen production. In 2022, the Africa Green Hydrogen Alliance was established between Egypt, Kenya, Mauritania, Morocco, Namibia and South Africa – key countries leading Africa's green hydrogen efforts[17].

Solutions to provide on-site hydrogen generation need to be explored to overcome large infrastructure and supply chain barriers. To overcome safety concerns and storage requirements, safer and more efficient storage solutions, such as solid-state storage vessels, should be investigated.

Innovative solutions are being developed to overcome barriers and support the adoption of fuel cells, as exemplified by the GSMA through their case study on the GenCell A5 fuel cell.
The GenCell A5 fuel cell system uses ammonia to generate hydrogen on-demand, providing a clean, reliable power source. This technology reduces operating expenditure by up to 33% compared to diesel generators. Key components include the ammonia cracker, fuel cell generator, energy bridge and heat utilisation unit (GSMA). Research and development efforts are being directed towards developing micro turbines that can use hydrogen as a fuel source.

20 Microsoft. (2022, July 28). Hydrogen fuel cells could provide emission free backup power at datacenters, Microsoft says.
See footnote 17 on page 13.

3.3

Collaboration opportunities

To overcome technical and supply chain barriers to decarbonise Africa and realising oportunity, Table 8 outlines opportunities for various stakeholders to collaborate and implement practical solutions to the challenges.

Collaboration is key to overcoming decarbonisation barriers and realising opportunities. The primary technical and supply chain decarbonisation interventions identified inthis chapter relate to improving base station and data centre energy efficiency and replacing diesel generators with clean alternatives. These include on-site solar PV and battery systems, wind energy, biofuel and hydrogen fuel cells. A full list of collaboration opportunities for each of these interventions is provided in Appendix 1. As described in Table 8 alongside, many of these opportunities are interrelated and can be grouped. Potential GHG emissions mitigation impacts and the level of complexity of realising each opportunity are ranked as high, medium or low.

Table 8 Collaboration opportunities for overcoming decarbonisation barriers and realising the opportunities identified

Collaboration opportunity	Opportunity description	Decarbonisation interventions covered	Potential GHG emissions mitigation impact	Complexity of realising opportunity
Bulk purchasing	MNOs, TowerCos and original equipment manufacturers (OEMs), considering applicable competition laws, can collaborate on rural, distributed base stations and data centres to achieve economies of scale, reduce implementation and maintenance barriers, and lower overall costs.	Base station energy efficiency, data centre energy efficiency, on-site solar PV and batteries, wind energy		Medium
Developing alternative cooling solutions	Collaboration between MNOs, OEMs and investors is necessary to develop and scale advanced cooling solutions like liquid cooling, phase change materials and hybrid cooling systems for efficient operation in hot climates.	Base station energy efficiency, data centre energy efficiency		High
Finance mechanisms and cost-sharing agreements	Investment into renewable energy with be enabled through establishing specific finance mechanisms like low-interest loans, grants and other financial incentives, and identifying mutually beneficial cost-sharing arrangements to fund and implement energy-efficient measures and remove split incentives.	Base station energy efficiency, data centre energy efficiency, on-site solar PV and batteries, hydrogen fuel cells		High
Hybrid renewable energy systems	MNOs can partner with technology companies to develop hybrid renewable energy systems that combine solar PV, batteries, wind turbines and other sources to provide reliable and continuous power.	On-site solar PV and batteries, wind energy, hydrogen fuel cells		High
Policy and regulatory support	Collaborating with government agencies to develop supportive policies, blending mandates and regulatory frameworks that incentivise the adoption of renewable energy and energy-efficient technologies.	Base station energy efficiency, data centre energy efficiency, biofuels, hydrogen fuel cells		High
R&D and technology advancement	Organisations can partner with academic institutions and research organisations to conduct R&D on alternative technologies and integration solutions, focusing on improving efficiency, reducing costs and advancing renewable energy technologies.	On-site solar PV and batteries, wind energy, biofuels, hydrogen fuel cells		High

Potential GHG emissions mitigation impact

High Medium Low

Table 8 Collaboration opportunities for overcoming decarbonisation barriers and realising the opportunities identified continued

Collaboration opportunity	Opportunity description	Decarbonisation interventions covered	Potential GHG emissions mitigation impact	Complexity of realising opportunity
Capacity building and knowledge sharing	Establishing partnerships with international organisations and educational institutions can help transfer knowledge, build capacity and train local technicians in renewable energy and energy-efficient technologies.	Base station energy efficiency, data centre energy efficiency, biofuels, hydrogen fuel cells		Medium
Infrastructure development and investment	Partnering with investors, financial institutions, and infrastructure developers will help secure funding and develop the necessary infrastructure for large-scale renewable energy production, storage and distribution.	On-site solar PV and batteries, wind energy, biofuels, hydrogen fuel cells		High
Best practices and innovation sharing	Creating a unified framework for collaboration among MNOs, data centres, and renewable energy suppliers will enable stakeholders to share best practices, innovations and collectively strive towards reducing environmental impact.	Base station energy efficiency, data centre energy efficiency, on-site solar PV and batteries, wind energy, biofuels, hydrogen fuel cells		Medium

Potential GHG emissions mitigation impact

High Medium Low

Case study 4

Anglo American and EDF Renewables agree to renewable energy partnership in South Africa to form Envusa Energy

Anglo American partnered with EDF Renewables to form a new jointly owned company, Envusa Energy, to develop a regional renewable energy ecosystem (RREE) in South Africa.

In March 2022, the two companies signed a memorandum of understanding to explore the ecosystem's development. The agreement aims to meet Anglo American's operational power requirements in South Africa, support resilient local electricity supply systems and contribute to decarbonising South Africa's energy sector.

Envusa Energy is expected to supply Anglo American with a blend of on-site and grid-supplied renewable energy. This approach will combine energy from dispersed generation infrastructure and allocate it to meet Anglo American's load demand.

The roll-out of the RREE will also provide a source to produce green hydrogen for Anglo American's nuGen™ Zero Emission Haulage Solution – a planned fleet of hydrogen-powered ultra-class mine haul trucks (which carry heavy loads). This will significantly reduce on-site diesel emissions, contribute to a carbon-neutral future, and support the development of South Africa Hydrogen Valley (a hub to store, generate and use hydrogen as an energy supply). The RREE is expected to drive economic activity in South Africa's renewable energy sector, supporting the country's broader just energy transition[22].

Case study 3

RuralStar

For many rural telecom base station sites, the cost of transporting fuels over poor infrastructure presents a significant financial and logistical barrier. Telcos may benefit from a more versatile solution to expand into rural areas and address energy-related challenges. RuralStar, developed by Huawei in collaboration with Safaricom and MTN Ghana, is a solution aimed at extending mobile network coverage to remote and rural areas. Rural areas are traditionally underserved due to the high costs and logistical challenges associated with deploying traditional infrastructure.

RuralStar's approach uses relay remote node technology, which uses small, low-power network infrastructure to extend network coverage. This technology enables wireless backhaul – a system that links smaller networks to the main network via a nearby 4G base station, eliminating the need for expensive ground or satellite cabling. This method is affordable and energy-efficient. RuralStar installations use simple pole base stations powered by renewable energy sources, such as solar panels, coupled with battery storage to ensure uninterrupted supply.

RuralStar's design is particularly beneficial for areas where creating physical infrastructure is not viable, either due to geographical challenges or high costs. This adaptable and scalable system allows telecom operators to tailor capacity to accommodate and adapt to changing power demands[21].

21 GSMA Future Networks. (2019). Case Study: RuralStar Huawei Safaricom.
22 Anglo American. (2022, October 4). Anglo American and EDF Renewables agree to renewable energy partnership in South Africa to form Envusa Energy – launching 600MW of wind and solar projects in first phase.

3.4 Conclusion

Overcoming technological challenges related to energy efficiency and alternatives to diesel generators, as well as supply chain issues that prevent or impede the adoption of certain technical solutions again require various stakeholder to work together.

To enable bulk purchasing of solar panels and batteries, the following stakeholders would need to collaborate:

- **Industry associations and trade groups:** Industry associations, such as the GSMA and trade groups representing the renewable energy and telecommunications groups, can facilitate collaboration among stakeholders, share best practices, and advocate for industry-wide standards and initiatives. Collaboration can involve participating in working groups, conferences, and forums to exchange knowledge and promote collaborative solutions.
- **MNOs:** MNOs are the primary users of base stations and data centres and would drive the demand for solar panels, batteries, and other renewable energy solutions. They would need to collaborate internally to assess their needs, budget constraints, and procurement processes to facilitate bulk purchasing.
- **Renewable energy suppliers and manufacturers:** Suppliers and manufacturers of solar panels, batteries, and renewable energy systems would need to collaborate with MNOs to provide competitive pricing, volume discounts, and customised solutions tailored to their specific needs. Collaboration can involve exploring partnerships, supply chain optimisations, and technology innovations to reduce costs and improve efficiency.
- **Government and regulatory authorities:** Government agencies and regulatory authorities can support bulk purchasing initiatives and battery reuse programs through policy incentives, tax breaks, and regulatory frameworks that promote renewable energy adoption and circular economy principles. Collaboration with government stakeholders can involve advocating for supportive policies, regulations, and incentives to encourage investment in renewable energy and battery reuse initiatives.
- **Financial institutions and investors:** Financial institutions and investors play a critical role in providing financing, capital investment, and funding support for renewable energy projects, bulk purchasing agreements, and battery reuse initiatives. Collaboration with financial stakeholders can involve securing financing, structuring investment deals, and assessing the financial viability and returns on investment for renewable energy and battery reuse projects.

Maturing/establishing new and emerging technologies i.e. sodium-ion batteries, biofuels, green hydrogen and fuel cells, the following stakeholders would need to collaborate:

- **Government:** These include Ministries of Energy, Technology and Infrastructure, and Finance. Government is responsible for developing strategies, frameworks, policy and regulations that will foster an enabling environment and provide developers and investors with certainty about market development in the country. The government also has a responsibility to ensure that the associated and supporting infrastructure needed to deploy the technology are developed.
- **Research institutions and academia:** Research institutions, universities, and academic researchers contribute to technology development by conducting fundamental and applied research, innovation, and knowledge dissemination. They collaborate with industry partners, government agencies, and international organisations to advance scientific understanding, develop new technologies, and train skilled professionals in relevant fields.
- **International organisations and multilateral agencies:** International organisations, such as the United Nations, World Bank, and International Energy Agency, provide technical assistance, capacity building, and financial support to countries for technology transfer, adoption, and demonstration projects and implementation. They facilitate collaboration, knowledge sharing, and best practices exchange among countries, regions, and stakeholders to accelerate technology development and deployment on a global scale.
- **Industry and technology developers:** Technology companies, energy firms, and manufacturers, plays a critical role in developing, commercialising, and scaling up new technologies. Private companies invest in research and development, pilot projects, and commercialisation efforts to bring the technology and innovative solutions to market. In addition, industry and technology developers can also play a role to facilitate north-south technology and skills transfer.
- **Investors and financial institutions:** Investors, venture capitalists, and financial institutions play a crucial role in providing funding, capital investment, and financial support to technology developers and projects. They assess risks, provide financing, and support innovative ventures through equity investments, loans, grants, and other financial instruments. Their involvement is essential for funding research, development, demonstration, and deployment of new technologies.

Appendix 1: Detailed collaboration opportunities

Technology and supply chain

Base stations

Collaboration opportunity	Description of collaboration opportunity	Primary Focus	Technology	Potential magnitude of decarbonisation opportunity	Complexity of realising opportunity
Standardisation and Bulk Purchasing	MNOs, TowerCos, and OEMs can collaborate to standardise base station equipment and technologies across rural, distributed base stations to achieve economies of scale, reduce the skills barrier for implementation and maintenance, and lower overall costs, thereby improving the ROI for upgrading rural base stations.	Energy efficiency	General equipment		Medium
Development of Alternative Cooling Solutions	Collaboration between MNOs, OEMs, and investors is necessary to develop and scale solutions such as liquid cooling, phase change materials, and hybrid cooling systems to allow for base stations to run efficiently in high-temperature environments.	Energy efficiency	Cooling systems		High
Internet Connectivity Expansion	MNOs, governments, international aid organisations, and other parties can work together to expand urban and rural internet connectivity through developing, for example, hybrid systems that combine satellite communication and terrestrial networks.	Energy efficiency	Connectivity		High
Phased Technology Upgrades	MNOs and TowerCos should partner to improve the energy efficiency of legacy networks through phased technology upgrades, replacing the least efficient technologies with more efficient ones, and to standardise equipment to lower costs and improve ROI.	Energy efficiency	Network equipment		Medium
Support for Legacy Network Phase-Out	MNOs should support governments with the phase-out of legacy networks and the adoption of affordable technology capable of operating on 5G networks, thereby minimising socio-economic impacts.	Energy efficiency	Network equipment		Medium
TowerCo/MNO Cost-Sharing Mechanisms for Efficiency Upgrades	TowerCos and MNOs should work together to identify mutually beneficial contractual and cost-sharing arrangements that can remove split incentives and align financial interests for energy efficiency upgrades.	Energy efficiency	Passive equipment		Medium

Potential magnitude of decarbonisation opportunity: High | Medium | Low

Data centres

Collaboration opportunity	Description of collaboration opportunity	Primary Focus	Technology	Potential magnitude of decarbonisation opportunity	Complexity of realising opportunity
Climate Neutral Data Centres Pact	Establishing a Climate Neutral Data Centres Pact in Africa to promote energy efficiency and sustainability through commitments from data centre operators.	Energy Efficiency	General Practices		Medium
Development of Advanced Cooling Solutions	Collaboration between MNOs, data centre operators, OEMs, and investors to develop and implement advanced cooling technologies like liquid cooling and evaporative cooling systems.	Energy Efficiency	Cooling Systems		High
Code of Conduct for Energy Efficiency	Implementing a Code of Conduct for Energy Efficiency in Data Centres or an Energy Consumption Decree specific to Africa to drive sustainable practices.	Energy Efficiency	Regulatory Framework		Medium
Energy Audit Subsidy Program	Introducing an energy audit subsidy program to support business development and create a pipeline for energy-efficient projects in African data centres.	Energy Efficiency	Auditing, Financing		Medium
Finance Mechanisms for Energy Efficiency Projects	Establishing specific finance mechanisms like low-interest loans, grants, or other financial incentives to fund the implementation of energy-efficient measures in data centres.	Energy Efficiency	Financing		High
Best Practices and Innovation Sharing	Creating a unified framework for African data centres to collaborate on best practices, share innovations, and collectively strive towards reducing their environmental impact.	Energy Efficiency	Knowledge Sharing		Low
Benchmarking and Monitoring Standards	Developing benchmarking and monitoring standards to facilitate energy performance assessments and identify areas for improvement in data centres.	Energy Efficiency	Monitoring Systems		Medium

Potential magnitude of decarbonisation opportunity

High Medium Low

Collaboration opportunity

Developing a Code of Conduct for Energy Efficiency in Data Centres or Decree on Data Centres Energy Consumption that is specific to Africa

Description

Industry Associations: Industry associations, such as Africa Data Centre Association represent the collective interests of data centre stakeholders and provide platforms for collaboration, knowledge sharing, and capacity building. Their involvement facilitates consensus-building, stakeholder engagement, and the dissemination of best practices across the industry.

Data Centres Operators: Data centre operators are directly responsible for the design, construction, operation, and maintenance of data centres. Their input is vital in developing practical and implementable guidelines for improving efficiency, reducing energy consumption, and optimising resource utilisation in data centre facilities.

Technology Providers: Technology providers, including hardware manufacturers, software developers, and IT service providers, contribute expertise in developing innovative solutions, products, and services for enhancing data centre efficiency. Collaboration with technology providers ensures that the code of conduct incorporates the latest advancements in energy-efficient technologies and best practices.

Energy and Environmental Experts: Energy and environmental experts bring specialised knowledge and expertise in energy management, renewable energy integration, sustainability, and environmental impact assessment. Their input is valuable in developing strategies, methodologies, and metrics for measuring and improving data centre efficiency while minimising environmental footprint.

Energy audit subsidy and financing mechanisms

Description

Financial Institutions: Banks, development finance institutions, and other financial entities would be essential partners in establishing the finance mechanism. They could provide low-interest loans, grants, or other financial incentives to data centre operators to fund energy-efficient projects. Financial institutions would also evaluate the financial viability of projects and manage the disbursement of funds.

Industry Associations: Industry associations representing data centre operators and stakeholders would be instrumental in promoting the subsidy program and finance mechanism within the sector. They could provide guidance, advocacy, and support to members interested in participating in energy audits and accessing financing for energy-efficient initiatives.

Energy Service Companies (ESCOs): ESCOs specialise in providing energy audit services and implementing energy-efficient solutions. They would be key partners in conducting comprehensive energy audits for data centres and identifying potential energy-saving opportunities. ESCOs could also assist data centre operators in developing and implementing energy-efficient projects.

On-site solar PV and battery systems

Collaboration opportunity	Description of collaboration opportunity	Primary Focus	Technology	Potential magnitude of decarbonisation opportunity	Complexity of realising opportunity
Exploring Alternative Battery Chemistries	Collaboration between MNOs, OEMs, and battery manufacturers to develop and implement alternative battery chemistries such as sodium-ion batteries to address cost and space constraints.	Diesel Generator Alternatives	Sodium-ion Batteries		High
Bulk Purchasing Agreements	MNOs can leverage sectoral organisations like GSMA to negotiate bulk purchasing agreements for solar panels and batteries to reduce costs and streamline the procurement process.	Diesel Generator Alternatives	Solar PV, Batteries		Medium
Enhanced Security Measures	MNOs can work with security firms to develop and implement advanced security measures for protecting solar panels and battery systems from theft and vandalism.	Diesel Generator Alternatives	Security Systems		Low
Development of Hybrid Energy Systems	MNOs can partner with technology companies to develop hybrid energy systems that combine solar PV, batteries, and other renewable energy sources to provide reliable and continuous power.	Diesel Generator Alternatives	Solar PV, Hybrid Systems		High
Research and Development for Solar and Battery Integration	Partnering with academic institutions and research organisations to conduct R&D on the integration of solar PV and battery systems, focusing on improving efficiency and reducing costs.	Diesel Generator Alternatives	Solar PV, Batteries		High

Potential magnitude of decarbonisation opportunity

High Medium Low

Wind

Collaboration opportunity	Description of collaboration opportunity	Primary Focus	Technology	Potential magnitude of decarbonisation opportunity	Complexity of realising opportunity
Development of Small and Micro Wind Turbines	Collaboration between MNOs, technology companies, and OEMs to develop and implement small and micro wind turbines that can leverage low wind speeds and integrate with solar PV and battery systems.	Diesel Generator Alternatives	Small Wind Turbines		High
Site Feasibility Studies	Partnering with research institutions and wind energy experts to conduct feasibility studies and identify optimal sites with sufficient wind resources for small wind turbine installations.	Diesel Generator Alternatives	Site Analysis		Medium
Hybrid Renewable Energy Systems	MNOs can collaborate with technology companies to develop hybrid renewable energy systems that combine wind turbines, solar PV, and battery storage to provide continuous power supply.	Diesel Generator Alternatives	Hybrid Systems		High
Bulk Purchasing Agreements for Wind Turbines	MNOs can leverage sectoral organisations like GSMA to negotiate bulk purchasing agreements for wind turbines and related components to reduce costs and streamline procurement processes.	Diesel Generator Alternatives	Wind Turbines		Medium
Enhanced Technical Support and Maintenance	Collaborating with local service providers and OEMs to establish robust after-sales technical support, maintenance services, and availability of replacement parts for small wind turbines.	Diesel Generator Alternatives	Maintenance Services		Medium
Public-Private Partnerships for Wind Projects	MNOs can work with governments and international aid organisations to fund and expand the deployment of small wind turbines in optimal locations.	Diesel Generator Alternatives	Wind Turbines		High
Integration with Solar PV and Battery Systems	Collaborating with renewable energy suppliers to integrate small wind turbines with existing solar PV and battery systems to ensure a continuous power supply under varying environmental conditions.	Diesel Generator Alternatives	Hybrid Systems		High

Potential magnitude of decarbonisation opportunity

High Medium Low

Biofuels

Collaboration opportunity	Description of collaboration opportunity	Primary Focus	Technology	Potential magnitude of decarbonisation opportunity	Complexity of realising opportunity
Policy and Regulatory Support	Collaborating with government and regulatory authorities to establish supportive policies, blending mandates, and frameworks that incentivise biofuel use.	Diesel Generator Alternatives	Policy Frameworks		High
Agricultural Modernisation	Partnering with agricultural institutions and development agencies to modernise farming practices, increase crop yields, and enhance feedstock quality and quantity.	Diesel Generator Alternatives	Agricultural Practices		High
Infrastructure Development	Working with infrastructure developers to build adequate storage, transport, and conversion facilities for biofuel production and supply chain.	Diesel Generator Alternatives	Infrastructure		High
Financial Support and Investment	Collaborating with financial institutions and investors to secure funding, capital investment, and financial support for biofuel production projects.	Diesel Generator Alternatives	Financing		High
Capacity Building and Technical Training	Partnering with educational institutions and training providers to build technical expertise and capacity for biofuel production and maintenance.	Diesel Generator Alternatives	Training		Medium
Sustainable Biofuel Production Practices	Collaborating with environmental organisations and biofuel producers to implement sustainable biofuel production practices that prioritise food security and environmental protection.	Diesel Generator Alternatives	Sustainable Practices		High
Technology Transfer and Knowledge Sharing	Establishing partnerships with countries and organisations with successful biofuel initiatives to transfer technology and share knowledge on best practices.	Diesel Generator Alternatives	Knowledge Sharing		Medium
Local Biofuel Production Initiatives	Supporting local biofuel production initiatives by working with local farmers, cooperatives, and biofuel producers to develop and scale production.	Diesel Generator Alternatives	Biofuel Production		Medium

Potential magnitude of decarbonisation opportunity

High Medium Low

Hydrogen fuel cells

Collaboration opportunity	Description of collaboration opportunity	Primary Focus	Technology	Potential magnitude of decarbonisation opportunity	Complexity of realising opportunity
Development of Hydrogen Supply Chain	MNOs, governments, and energy companies can collaborate to establish a robust supply chain for hydrogen production and distribution, including infrastructure for production, transmission, and storage.	Diesel Generator Alternatives	Hydrogen Production & Distribution		High
Infrastructure Investment	Partnering with investors and financial institutions to secure substantial investments for developing the necessary infrastructure to support large-scale hydrogen production and export.	Diesel Generator Alternatives	Infrastructure		High
Cost Reduction and Technology Advancement	Collaborating with technology companies and research institutions to advance hydrogen fuel cell technology, reduce costs, and improve efficiency and safety.	Diesel Generator Alternatives	Hydrogen Fuel Cells		High
Pilot Projects and Demonstrations	MNOs can work with technology providers and data centres to pilot and demonstrate the commercial viability of hydrogen fuel cells at a larger scale.	Diesel Generator Alternatives	Pilot Projects		Medium
Local Production Initiatives	Partnering with local governments and renewable energy companies to explore and develop green hydrogen production leveraging Africa's abundant renewable resources.	Diesel Generator Alternatives	Renewable Energy		High
Policy and Regulatory Support	Collaborating with government agencies to develop supportive policies, regulatory frameworks, and incentives that promote the adoption of hydrogen fuel cells.	Diesel Generator Alternatives	Policy Frameworks		High
Technical Support and Maintenance	Establishing partnerships with OEMs and local service providers to ensure robust technical support, maintenance services, and availability of replacement parts for hydrogen fuel cells.	Diesel Generator Alternatives	Maintenance Services		Medium
Knowledge Sharing and Capacity Building	Partnering with international organisations and educational institutions to transfer knowledge, build capacity, and train local technicians in hydrogen technology.	Diesel Generator Alternatives	Knowledge Sharing		Medium
Renewable Energy Integration	Collaborating with renewable energy suppliers to integrate hydrogen production with renewable energy sources such as solar and wind to create a sustainable hydrogen supply.	Diesel Generator Alternatives	Renewable Energy		High

Potential magnitude of decarbonisation opportunity

High Medium Low