PART III: MENDING AND EXTENDING THE GRID

MAKING NATIONAL SYSTEMS WORK BETTER

The cheapest way to bring sufficient power to meet most Africans' daily needs is through connection to the national grid, the centralized system of generators, transmission and distribution. This is the cheapest option where people want to use a large or continuous amount of energy, such as for air conditioners or other equipment, and in places where there are many houses or industrial users, and where an existing grid connection is near. As Africans increasingly move into cities and as small settlements grow, often the best way to get them effective power is to ensure that the national grid is working well and that the many inefficiencies are tackled. This section will follow the traditional breakdown of the national grid into:

- Generation – power stations that create the electricity
- Transmission – grid power lines that move electricity around the country
- Distribution – connecting power to users and collecting revenues.

Each of these components can be made to work better through reform, liberalization, public-private partnerships, restructuring, improved management and investment.

We also look at the potential of renewable energy and the vital role of regional cooperation in enabling cross-border power trade.

NATIONAL GRIDS ARE FAILING AFRICANS

Despite its abundance of energy resources, Africa is home to some of the world's worst-functioning grid systems, which have suffered from decades of neglect and mismanagement. Sub-Saharan Africa's power situation is particularly acute, with an electrification rate of just 32 per cent – the lowest in the world[126]. Only Cameroon, Côte d'Ivoire, Gabon, Ghana, Namibia, Senegal, South Africa, and island states such as Cape Verde and Seychelles have electricity access rates over 50 per cent[127].

Unreliable power supply is cited as the main hurdle for businesses in Africa[128]. Thirty countries in Africa South

of the Sahara experience regular power shortages and blackouts, costing their economies on average 2 per cent of their GDP, and up to 5 per cent[129] in some cases.

> UNRELIABLE POWER SUPPLY IS CITED AS THE MAIN HURDLE FOR BUSINESSES IN AFRICA.

To make matters worse, the continent's overall demand for power, projected to grow by 4 per cent annually, is likely to continue to outpace power supply, pushing electricity access rates further down by 2050[130]. The resulting energy deficit is expected to reach almost 400GW of generation capacity by 2030[131].

Africa faces a daunting energy "trilemma": to fuel its socio-economic transformation it needs to provide electricity that is reliable, clean and affordable[132]. How can Africa turn around its ailing grid sector to improve and scale up grid power supply, while accommodating renewable energy? Making the best use of existing resources and new investments requires old and new planning approaches.

A coherent approach: The power value chain

An increase in power supply capacity is not enough on its own to raise energy access. Countries also need to build an extensive transmission and distribution infrastructure, revise electricity tariffs, enhance power efficiency and introduce smart technologies. Determining strategy, planning and investment need is best handled through a coherent, holistic approach. The Power Value Chain concept developed by the professional services company KPMG is one such example[133].

The KPMG concept helps to visualize all stages through which energy flows, from natural resources all the way to energy delivery to end-users. In doing so, it seeks to capture the requirements at each stage properly and to understand the linkages and interactions among the various elements of the value chain. The aim of the concept is to provide guidance to energy stakeholders on policy and strategy design.

Holistic energy planning can avoid serious drawbacks: Angola failed to plan the connection of three independent electric grid systems and is unable to dispatch surplus power from the North to the centre and South. Uganda's recently completed hydropower plants are sitting idle for lack of a transmission and distribution network[134].

According to KPMG, many countries in Africa have placed a high premium on power generation at the expense of all the other elements along the value chain. The focus on generation has shifted the emphasis of investments away from transmission and distribution, which remain largely underdeveloped, and which, in turn, undermine efforts to increase supply capacity.

An efficient transmission and distribution network is essential. It optimizes power-generation capacity. As African countries move from state monopolies to partnerships, from a single energy resource to energy mixes, from on-grid versus off-grid solutions to integrated power-supply systems, they should also consider taking a long-term, holistic view of their power value chains. They should lift constraints along the value chain and ensure that every obstacle, such as the lack of adequate transmission and distribution, is removed so they can achieve their goal of energy access.

Experience in other regions sheds light on the importance of a coherent approach. Vietnam's electrification story would not have been successful without the deployment of high-quality transmission and distribution infrastructure[135]. Vietnam went even further by linking energy access to a wider socio-economic development agenda[136].

MAKING POWER SECTOR REFORMS WORK FOR ALL

Restructuring of African power utilities

Power utilities across Africa have embarked on a series of reforms in recent years. The reforms are intended to unlock the full potential of the power sector by improving its efficiency and profitability. Governance and organizational structural reforms can redress inefficiencies, mobilize and leverage investments for expansion, and accommodate emerging forms of energy.

Although the need for an overhaul is indisputable, the reforms must be relevant to Africa's fast-evolving energy space and need to support the continent's electrification efforts.

In most countries, the main thrust of the reforms is to curtail government intervention, which is often thought to distort the energy market, and open up the power sector to private operators. This has led to the gradual unpacking of state-owned, vertically integrated utilities (VIU) through restructuring, breaking the vertically integrated utilities into separate entities, and privatization. The United Nations Industrial Development Organization (UNIDO) has identified[137] five categories of power-sector reforms in Africa: management contracts, corporatization, electricity law amendments, unbundling and independent power producers (IPPs).

Management contracts include a private entity contracted to undertake the operational management of the utility, while assets remain owned by the utility. This has been adopted in several countries, especially in West Africa. Corporatization or commercialization is the transformation of the state-owned utility into a corporate entity with limited liability, in which the government is the major stakeholder. This usually entails an increase in electricity tariffs, primarily to recover costs.

Amendments to electricity laws include restructuring utilities' governance systems and creating an independent regulatory body to oversee the power sector and subsequently to include private-sector participation. Almost all African countries have amended their electricity laws, improving the regulatory framework of the power sector, and 27 Sub-Saharan countries have established independent regulatory bodies[138].

Unbundling, otherwise known as restructuring, is a major step towards full liberalization of the power sector. Horizontal unbundling seeks to decentralize power generation, transmission and distribution at the provincial level. Vertical unbundling unpacks national utilities into autonomous generation, transmission and distribution entities. Unbundling occurs later in the reform process, since it requires that several conditions are fulfilled, such as establishing new institutions and completing asset-transfer procedures. Vertical unbundling is more common: Examples of a higher degree of vertical unbundling include Ghana, Nigeria, Sudan and Uganda[139]. Only a few countries have considered horizontal unbundling: Ghana, Nigeria and Tanzania. Private-sector participation grows with the introduction of independent power producers (IPPs), which are power generators set up by private investors (see below).

Restructuring and privatization processes in Africa have improved the operational and financial efficiency of public utilities[140]. But the shift from state monopoly to liberalized market systems has not always been focused on bringing energy access to all and supporting the broader development agenda.

Emphasis has been on unbundling the power-generation segment, leaving transmission and distribution in the hands of the government. As a result, energy generation has benefited from considerable investment, while transmission and distribution have remained largely underdeveloped. This tends to hinder all development and expansion efforts.

Privatization is desirable but not necessary

Despite the push for liberalization, no African country has fully privatized its power sector. African governments' pick-and-choose stance reflects the inadequacy of prescriptive reform models. Countries have preferred to err on the side of caution by selecting options that best suit their needs and circumstances.

Egypt, Mauritius and South Africa are examples of African state-owned public utilities which have, on the whole, performed impressively, although some now face management and maintenance challenges. Increasingly, the dominant structure is hybrid governance whereby the government is the major stakeholder and operates alongside a multitude of energy players.

Tying the performance of the power sector solely to its financial viability ignores the larger electrification and development needs of African countries. A negative experience with reforms forces countries to reconsider privatization, as was the case of Mali and Senegal, where the power sectors reverted to state ownership.

Given the limitations of the privatization model, new arrangements have emerged. African countries and the international development community are gradually shifting to the public-private partnership model[141]. This option makes more sense for African countries, particularly as it relates to the capacity constraints and the need to balance efficiency with improved access to the poor.

GENERATION

African governments' strong recent push to increase generation capacity has boosted deployment of power infrastructure, both traditional and renewable. From a low base, Africa´s grid-based installed capacity has grown steadily to reach 194GW in 2015[142]. Gas accounts for the largest share with 38 per cent, followed by coal (24 per cent), oil (18 per cent), renewable energy (17 per cent, all sources included) and nuclear (1 per cent). Still, the continent requires additional generating capacity of 250GW by 2030, which means a two-fold increase in current growth rates to 7GW a year.

Much of the new capacity comes through independent power producers (IPPs), as in Côte d'Ivoire and South Africa **(Box 4)**. Investors set up power-generation plants after detailed examination of the legal framework and the promised prices for the power they generate, which are usually sold to the transmission and distribution networks through off-take agreements covering many years. The transmission network is often still a state-owned utility, and several IPP developments have been hampered by concerns over how capable these are at paying bills on time.

In recent years, the number of IPPs has grown rapidly. At present, South Africa comes top (6,376MW procured from renewable energy IPPs under the REI4P programme[143], plus energy from other IPPs), followed by Nigeria (1,521MW), Kenya (1,066MW), Côte d'Ivoire (866MW), Ghana (656MW) and to a lesser extent Tanzania and Uganda[144]. The IPP model has tended to focus on large power projects that require significant financial and infrastructure investment outlays. New modalities are needed for smaller projects and participation by the local private sector in generation.

Figures on installed capacity do not tell the full story. Nigeria, Africa's most populous nation with more than 170 million people and economic growth of 7 per cent a year, has an installed capacity of 12.5GW but only 4.5GW of this is available and working[145] (in contrast, South Africa has an installed capacity of 50GW for a population one-third that of Nigeria's). More often than not, power-supply systems across the continent operate well below their installed capacity due to a host of physical and governance-related constraints, including ageing infrastructure, outdated technology, poor maintenance, disruptions to energy supply, transmission and distribution losses, and insufficient power coverage[146].

BOX 4: IN CÔTE D'IVOIRE AND SOUTH AFRICA, REFORMS ENCOUNTER SUCCESS AND CHALLENGES

Côte d'Ivoire was one of the first countries in Africa to privatize its power sector, starting in 1990[147]. Since then it has gone through several phases of reforms, including management contracts, corporatization and independent power producers (IPPs), which led to a rapid increase in private-sector participation. The trend is likely to continue: of the 1,500MW in power-plant projects scheduled for development by 2020, the country plans to award 85 per cent to IPPs. Côte d'Ivoire has been able to boost its power generation capacity, increase national electricity coverage and meet growing domestic demand, while becoming a net electricity exporter in the subregion.

Côte d'Ivoire's privatization experience has succeeded because of the attractiveness of the regulatory and business environment provided to IPPs. There is a danger, however, that some reform provisions will constrain development prospects, particularly the Take-or-Pay clause that guarantees the priority purchase of power generated by IPPs, as well as the government's involvement in the deployment of transmission and distribution infrastructure and its role as the major risk off-taker. There is a risk of customer dissatisfaction over tariff hikes, especially during economic hardships.

South Africa epitomizes the success of the IPP option because of an institutional set-up that allowed partial liberalization of the power market[148]. As a result, IPPs have been able to raise close to US$43 billion in private investment over the last four years. The reforms also helped boost the utility's capacity to plan, procure, contract and regulate the power market. Perhaps the most notable achievement is South Africa's flagship initiative, the Renewable Energy Independent Power Producer Procurement Programme (REI4P). This auction system has been hailed as a model for other countries for its success in providing a clear and transparent policy and regulatory framework, in promoting competition among energy stakeholders, in leveraging substantial investments and in ensuring the rapid execution of energy projects at no extra cost to end-users[149].

South Africa's reforms are still falling short, however. The power sector is facing a growing number of challenges: rising costs and tariffs, the utility's looming financial crisis that is threatening to derail the REI4P, the lack of investment in maintenance and service delivery at the municipal level, and the utility's control over power purchase from IPPs and over energy transmission[150]. As the South African model evolves, there are calls to widen the scope for IPPs by amending the Electricity Regulation Act, to deepen the reform process to unbundle the utility further into separate entities, and to decouple the utility from political interests.

BOX 5: COAL'S FUTURE IN AFRICA

Africa has abundant reserves of coal and other fossil-fuel resources[151]. Coal is the primary energy resource for several countries and accounts for 24 per cent of all grid-installed capacity, second only to gas (38 per cent), followed by renewables (17 per cent) and nuclear (1 per cent). While African countries are far down the list of the world's biggest consumers of coal, any credible scenario for achieving Sustainable Development Goal 7 by 2030 needs to factor in the extent to which a handful of countries, most of them with high coal deposits, depend on the fossil fuel to generate electricity.

Over 90 per cent of the continent's coal is used in Southern Africa, predominantly in South Africa, which has historically relied heavily on coal for its power production and where coal still provides an estimated 80 per cent of the energy supply. South Africa is the fourth largest producer of coal in the world, representing close to 30 per cent of its exports. Coal mining is the country's third highest employer and generates more income for the economy than gold[152].

Countries with proven coal reserves (such as Nigeria and Southern African countries) view coal as a cheap option to expand energy access. Countries such as Morocco, Kenya and Ghana, which harness cheap coal imports to power their economies, see the continuing slump in international coal prices as a bonanza. Several African countries – Botswana, Zambia, Zimbabwe, Mozambique and Namibia in Southern Africa; Nigeria, Ghana and Senegal in West Africa; Kenya and Tanzania in East Africa; and Egypt and Morocco in North Africa – are scaling up or building coal-fired power plants.

This has raised concerns that scaling up the use of coal might contravene the countries' respective commitments to the Paris Agreement. Pressure is mounting to leave Africa's coal in the ground and to limit coal-fired generation projects. However, given the enormity of the energy challenge, African countries are opting to strike a balance between their emission commitments and their development priorities. Often, this means using more coal and less oil.

South Africa has spelled out its plans in an Intended Nationally Determined Contribution (INDC) document. It aims for a peak in CO2 emissions by 2025, with a fall expected a decade later. Coal will continue to play a major role in power generation, with coal projects planned for implementation over the medium term. The country also plans to use clean coal technologies as part of its mitigation contributions[153].

Elsewhere in Southern Africa, efforts to bolster thermal-energy capacity by increasing the share of coal in the energy mix – for example in Zambia and Zimbabwe – come in response to the severe energy crisis that has hit the hydropower sector. Implementation of a 600MW, US$1 billion coal-fired power-plant expansion project in Hwange, Zimbabwe, was due to begin in late 2016, subject to financing. Botswana, a coal-dependent country, has declared its intention to cut emissions by 15 per cent, including going ahead with its plan to increase its coal capacity and reduce oil-fired power generation by 2025. (continued)

In West Africa, the Nigerian Bulk Electricity Trading Agency (NBET) recently signed a 300MW 20-year power purchase agreement with Zuma Power, following the same rationale. Nigeria is Africa's fourth largest emitter of CO2 and there are fears that the proposal to meet 30 per cent of energy needs using coal could jeopardize the country's Intended Nationally Determined Contribution commitment, which sets out a 20 per cent emission reduction by 2030. Senegal has committed to reducing emissions by 5 per cent by 2030, including turning to coal to expand generation capacity and meet growing domestic demand. The Sendou 125MW coal power station is expected to come on-stream in 2018.

Egypt, despite its Intended Nationally Determined Contribution commitment to increase the share of renewables in its energy mix and phase out energy subsidies, is considering increased use of coal as an alternative to dwindling reserves of natural gas, particularly to power its cement industry. Morocco, which relies on imported coal to generate 40 per cent of its electricity, has set an ambitious target of generating 50 per cent of its power from renewable sources and cutting its emissions by 13 per cent by 2030. However, it just completed the 700MW extension of the new 693MW Jorf Lasfar coal-fired plant, set to become operational in 2018.

Despite recent restrictions imposed on international financing in relation to coal projects, driven by the high carbon content of the energy, there is an influx of Chinese investments in coal projects in Botswana, Mozambique and Zimbabwe. Coal has attracted support and financing from multilateral institutions such as the New Development Bank established by the BRICS states (Brazil, Russia, India, China and South Africa) and the African Development Bank, which considers coal a priority.

For many countries, the transition to clean energy will not be as swift as previously thought, since current levels of growth in generating energy from renewable sources are not sufficient to displace fossil fuel and retrofitting installed electricity-generation capacity involves considerable cost. In reality, coal will only be phased out from the overall energy mix gradually and incrementally.

Aggressive promotion of renewables would help reduce the carbon intensity of Africa's power generation more rapidly. On one estimate, increasing installed grid capacity of renewables by 24 per cent through to 2040 would reduce CO2 emissions by 21 per cent, from 625 Mt to 495 Mt a year, but would increase the capital cost of generation by around US$108 billion. Given the investment constraints faced by governments in Africa, the case is compelling for international cooperation to expand the choices available to energy planners through incentives rather than penalties.

UNLEASHING AFRICA'S RENEWABLE POWER POTENTIAL

Integrating renewable energy into the grid system

African countries are very willing to shift from fossil fuels to renewable and low-carbon energy. Many have very significant resources, including hydropower, solar, geothermal and wind, and are successfully injecting renewable energy, albeit in small amounts, to boost the national grid using an array of regulatory and policy mechanisms, including setting tariffs for off-take agreements[154] which favour energy generated through diversified renewable sources.

Challenges in integrated renewable energy as a major part of the national grid include variability, which calls for greater flexibility of energy sources, technologies and systems; and limitations of existing grid infrastructure[155]. In the context of weak transmission and distribution infrastructure, some developers recommend the integration of modest renewable energy capacities, in the range of 5-10MW, for easy deployment across the grid[156].

In 2015, global investments in renewable energy reached a record US$329 billion, signaling that the world has reached an energy turning point[157]. Africa is at the forefront of this movement towards clean power. In December 2015, African countries launched the Africa Renewable Energy Initiative (AREI), an unprecedented effort to give all Africans access to energy that is mostly based on renewable sources by 2030 **(Box 6)**.

South Africa already features among the world's top 10 destinations for clean energy investments, attracting US$4.5 billion in 2015 – up from US$1 billion a year ago – to make it the continent's largest renewable power producer. Morocco comes in a close second with US$2 billion, while Kenya, Uganda and Ethiopia also attracted sizeable investments[158]. Renewable energy represents 17 per cent of total power generation in Africa, and 95 per cent of this comes from hydro resources[159]. With a marginal contribution of only 1 per cent, the potential of clean power excluding hydroelectricity is yet to be unlocked.

> **AFRICAN COUNTRIES ARE VERY WILLING TO SHIFT FROM FOSSIL FUELS TO RENEWABLE AND LOW-CARBON ENERGY.**

BOX 6: AFRICA RENEWABLE ENERGY INITIATIVE: CREATING ENERGY SYSTEMS FOR THE FUTURE

The Africa Renewable Energy Initiative (AREI) was launched in December 2015 at the 21st Conference of Parties to the United Nations Framework Convention on Climate Change (COP21). It charts a course for the continent that is climate-compatible and caters to the needs of all of its people.

The key goal is to enable 1 billion more people to access energy by 2030 than would do so on a business-as-usual trajectory. It envisages that most of the required new generation capacity will be met by renewable energy – at least 300GW from a range of renewable energy sources. And it shows how Africa, by doubling its capacity to generate energy using renewable sources, can leapfrog to smart, distributed, people-centred, renewable energy systems.

The initiative outlines how African countries can avoid locking in fossil-fuel energy systems and bring renewable energy to people where they live. It envisages a highly diversified ownership base that will secure energy for productive sectors – small-scale agriculture, small and medium-sized enterprises, and larger companies – and for the public sector. As more households, communities, cooperatives, companies and public institutions become both producers and consumers of electricity, thriving local economies will create jobs.

African leaders and institutions are putting the initiative into operation by establishing accountable and transparent governance structures, and an Independent Delivery Unit to undertake concrete work and coordinate with other actors and initiatives. International partners have shown great interest and have committed US$10 billion for the initiative's first phase (2017-2020).

Success will depend on addressing critical issues:

African ownership: The Africa Renewable Energy Initiative can only prosper and deliver on its goals if African governments exercise real ownership and their populations are actively engaged in shaping their energy futures through locally appropriate solutions. It offers a unique change from the usual donor-driven model. International partners should be genuine allies and allow the initiative to engage thoroughly with all African governments and their multiple stakeholders, and respond to their requests and plans. Funding from within Africa is crucial to bolster financial support from partners.

Ensuring real, additional action: The initiative outlines a number of core work areas and concrete actions that are necessary to deliver its bold goals. These must truly add to what would otherwise have happened and means that all actions and activities must be carefully assessed and scrutinized to make sure that the initative brings extra value.

Ensuring social and environmentally sound solutions: Social and environmental safeguards must be put in place from the outset. Renewable energy solutions that are effective, appropriate and people-centred must be chosen, with measures to ensure that harmful and short-sighted vested interests do not prevail.

Independence of its delivery unit: Particularly because of the unconventional and transformative approach of Africa Renewable Energy Initiative, its Independent Delivery Unit must be ensured the space and freedom to pursue its work unhampered by bureaucracy, institutional interests and inertia. As a continent-wide effort that transcends the many initiatives and programmes that already exist, the Africa Renewable Energy Initiative needs to be able to function as a non-partisan body that coordinates ongoing work and can put forth bold new ideas for countries to consider.

African governance structures: The governance structures of the initiative will be formed based on summit decisions taken by the Assembly of Heads of State and Government of the African Union. The Board will represent the whole continent, and must have full independence, which means having its own legal personality with power to organize and institutionalize the work of its Independent Delivery Unit and other structures in the most effective way possible. The Africa Renewable Energy Initiative offers a promising path to a prosperous low-carbon future. Like all new initiatives, however, it is fragile and vulnerable to a range of challenges and competing interests.

Hydropower dominates energy market

Hydro and solar power, which have increased their capacity and secured large shares of clean power investments in recent years, will continue to dominate Africa's energy market. Even so, Africa has harnessed less than 10 per cent of its huge hydropower potential. With an installed capacity of 28GW and an additional 17GW in the pipeline, large-scale hydropower initiatives – notably the Grand Inga Dam in the Democratic Republic of the Congo and the Grand Renaissance Dam in Ethiopia – are being developed to improve affordable energy access[160] dramatically. However, growth in hydropower and other renewable power may be subdued, due to inadequate financing to support the deployment of extensive infrastructure and grid networks.

Climate change and competing demands for water threaten to constrain the performance and prospects for growth of hydropower. Diversification of the renewable power portfolio is vital to improve energy security.

Solar power has become the energy of choice for many

From a low base, solar power has grown spectacularly across Africa over the last five years, attracting the bulk of renewable energy investments[161]. Solar power's share of electricity generation soared as installed capacity jumped from 127MW in 2009 to 1.3GW by the end of 2014. Solar became an energy of choice for clean power generation for many countries because of a combination of the continent's unique potential, the flexibility of technology and the wide range of solar-power generation solutions.

In particular, the solar photovoltaic (PV) market expanded rapidly as the cost of PV modules fell by 75 per cent, lowering the cost of electricity from solar PV and making the segment especially competitive. Utility-scale, grid-connected solar power is on the rise across the continent, with the development of projects including a recently completed 8.5MW solar-power plant in Rwanda, the Nzema solar plant under construction in Ghana and a 100MW solar plant planned for Northern Nigeria[162].

Alongside solar PV, concentrated solar power (CSP) is also spreading, from mature energy markets in South Africa, Algeria, Morocco and Egypt to planned installations in Botswana, Namibia and Sudan. The six concentrated solar power plants already existing in Africa have combined installed capacity of 180MW. The launch in early 2016 of the first phase of Morocco's Ouarzazate concentrated solar power plant – destined to become the world's largest – added another 160MW[163] to the capacity.

Beyond hydro and solar power

The exponential growth in energy demand creates plenty of scope to exploit and scale up other forms of renewable energy, including wind and geothermal power, natural gas and less conventional power sources such as biomass and methane.

Wind power has considerable potential in Africa. With medium- to large-scale wind-power projects coming on line in Cape Verde (whose share of wind energy has reached 20 per cent)[164], Egypt, Kenya, Morocco and South Africa, among others, the sector is slowly but surely gaining prominence[165]. Recent undertakings such as the 300MW Lake Turkana plant in Kenya and the 225MW Ayitepa wind farm in Ghana, which mobilized US$525 million in investments, will boost the continent's wind-power generation capacity[166].

Geothermal energy offers a promising form of power generation in the Rift Valley[167]. The current share of geothermal power in renewable energy generation is 210MW of installed capacity[168]. The Olkaria plant in Kenya is an example of geothermal generation with utility-scale capacity. Geothermal power is poised to contribute a greater share of Africa's power. Kenya plans to increase the share of geothermal to 26 per cent by 2030[169]. Ethiopia is going ahead with its 1GW Corbetti project, and Tanzania recently announced a US$350 million investment plan[170].

Natural gas is not renewable but is lower in carbon emissions and pollution than other fossil fuels. Africa is discovering substantial onshore and offshore gas reserves. Gas-fired power capacity has reached 40 per cent and the outlook for gas power generation is bright[171]. Few countries have initiated gas-to-power development plans so far, but the sector is likely to expand if initiatives are properly planned and adequate gas infrastructure investment is available.

Ghana's gas-to-power initiative is expected to add 2.5GW of power-generation capacity[172]. Egypt will start exploiting the Zohr gas field from 2017 to boost the country's gas production and consumption. Morocco is developing infrastructure for gas imports and processing to meet its growing demand for gas in power generation. In Southern Africa, gas fields in Mozambique, Tanzania and, to a lesser extent, South Africa are due to come online in the near future[173].

Biomass is emerging as a promising renewable power option. The use of biomass has so far been limited to more advanced African economies. More than 50 per cent of the continent's capacity is installed in Southern Africa[174]. Mauritius' successful experience in cogeneration using bagasse — a byproduct of sugar production from sugarcane — has led to a 40 per cent share of bagasse in electricity generation[175].

Other countries are following the example set by Mauritius. Manulis Energy in Uganda is an African-led initiative that seeks to unleash the biomass potential of agri-waste, estimated at more than 1.6GW[176]. It

plans to develop a 20MW biomass-to-grid project and deploy hybrid (solar-biomass) micro-grid systems with a generating capacity of 8MW in rural areas. Another example is a 12MW biomass power-to-grid project under way in Baringo County, Kenya[177]. This innovative scheme uses biomass gasification technology to process the invasive Juliflora plant and generate electricity that feeds into the national grid.

Methane has recently entered the power market as a possible option for expanding grid-power supply[178]. A pioneer project in Rwanda aims to extract methane from Lake Kivu to generate affordable electricity. The first phase of the 100MW project was launched in December 2015, producing an initial 25MW[179]. If risks are properly managed, the initiative could become a game-changer given its potential to increase Rwanda's power supply dramatically to 1GW by 2020.

How can African countries expand renewable power?

To foster the expansion of Africa's renewable power supply, it is vital that governments implement measures that create conducive conditions. African countries are already deploying a vast array of policy instruments and public-private partnerships to support the development of power generation from renewable sources. South Africa's Renewable Energy Independent Power Producer Procurement Programme (REI4P) is very successful. Other countries wishing to adopt a similar model will need to adapt it to their own specific needs and conditions.

Increasing energy supply: Policy measures aimed at boosting the clean power sector and the supply of renewable energy include clear targets. Rwanda, for example, aims to obtain 22 per cent of its energy from renewable sources by 2018. Feed-in tariffs (FiTs) compensate renewable energy producers for the higher cost of generating clean power, thus helping to mobilize financing in renewables. Uganda's GET FiT programme has generated significant donor interest and support. Energy market auctions encourage producers to reduce their operating costs so they can offer lower power prices. In the 13 countries where the auction system has been implemented, including Morocco and South Africa, the result has been major expansion in large-scale power generation capacity[180]. Other countries have relied on tax waivers and reductions, mostly targeting solar technology.

Increasing energy demand: Energy demand is not generally an issue in Africa, given the huge gap between the amount of power available and the large number of Africans who do not have access to modern energy. But efforts to expand renewable power need to take into account the high upfront costs of clean energy and the limited ability of many consumers to pay for it. Subsidized pricing, widely used elsewhere in the world, is often unfeasible in countries with limited financial capacity. Alternative policy tools are needed to help stimulate and support demand for renewable power.

Some policy measures prove more successful than others. Ghana's feed-in tariff programme resulted in large investment inflows for wind and solar initiatives, including more than US$500 million for the Ayitepa wind farm. Building on this success, Ghana is planning to shift to the auction system, considered a more attractive way to increase investments in renewable power[181].

Different countries have succeeded through creating programmes that best suit their own resources and the local environment and needs, including legislative, policy, investment and other frameworks; and end-consumers' ability to pay. Examples across the continent include the support of two successive Kenyan governments for the Lake Turkana wind power project[182]. In Mauritius, the bagasse cogeneration success story bears a strong testimony to the need for continuous political commitment and close collaboration with all stakeholders[183].

REI4P: South Africa's renewable energy success story

South Africa's Renewable Energy Independent Power Producer Procurement Programme has not only scaled up capacity to generate power from clean sources – mainly wind and solar PV – to 1.4GW[184], it has also produced numerous socio-economic benefits over the course of successive bidding rounds since its launch in 2011[185]. The programme succeeds by introducing competition, which has driven down the costs of renewable energy, making it an attractive alternative to traditional forms of power and boosting the business case for investing in renewables compared to coal[186]. Sustained political commitment has been also instrumental to the solid track record of delivering clean power projects.

The programme's success hinges on creating backward and forward linkages with the rest of the economy, complementing African countries' industrialization agenda and their quest to ensure that the windfalls of clean power initiatives are distributed fairly.

The programme's local-content requirement (LCR) aims to build local manufacturing capacity and skills, so that a significant share of investments into renewable energy– at least 45 per cent – benefit the local economy[187]. The requirement sets out the ambitious target of manufacturing and sourcing locally 75 per cent of components used in clean power generation, such as solar PV panels, wind towers and turbines – up from 35 per cent in 2011. Over the first three bidding rounds, South Africa has been able to capture more than 30 per cent of total clean power investment[188].

In the Western Cape, for example, solar PV manufacturing industries have been established. The solar manufacturing sector generated 26,000 jobs in the fourth round of bidding, double the amount in the first round. Furthermore, an innovative joint venture, I-WEC, is planning to manufacture wind turbines and blades locally. Several international companies are also setting up manufacturing sites for clean-power components in South Africa[189].

> **SUSTAINED POLITICAL COMMITMENT HAS BEEN INSTRUMENTAL TO THE SOLID TRACK RECORD OF DELIVERING CLEAN POWER PROJECTS.**

Elsewhere on the continent, Egypt aims to expand local manufacturing of components for wind and concentrated solar power generation, while Algeria plans to manufacture solar PV equipment[190].

Several countries, at varying stages of clean power development and uptake, are seeking to emulate South Africa's experience with the Renewable Energy Independent Power Producer Procurement Programme[191], but they will need to exercise caution when adapting it to their specific contexts. In South Africa, the local content requirements are critical to boost and sustain the expansion of renewable power. Technical capabilities to design and implement similar policy tools need to be strengthened to help expedite clean energy procurement processes[192].

Overcoming the limitations of the REI4P model

Despite the huge success of the Renewable Energy Independent Power Producer Procurement Programme, persistent problems need to be overcome as the model evolves:

- Unrealistic local content requirements heighten the risk of non-compliance, forcing the programme to consider a termination strategy. Policymakers need to ensure that the requirements are compatible with available capacity
- Eskom, South Africa's public electricity utility, faces budgetary constraints that threaten to limit financial allocations beyond the third round of bidding
- Job creation and social benefits have fallen short of expectations
- A lack of sufficient consultation with local government structures sometimes results in delays and disputes (over land, for example, as in the case of the Lake Turkana wind development project in Kenya)
- The concentration on local content requirements can divert attention from the need to develop all elements along the renewable power value chain.

South Africa's programme has been instrumental in shaping the development of independent power producers in South Africa and elsewhere. New models are emerging, such as municipality power procurement. In South Africa, Tombolo Energy seeks to develop independent power producer agreements between municipalities and large consumers, following the example of the agreement between Amatola Green Power and Nelson Mandela Bay Municipality[193]. However, regulations are needed that allow municipalities to purchase power directly from independent producers without having to go through public utilities such as Eskom. In addition, there is a need to strengthen the financial position of municipalities so they can take on the role of guarantor, which South Africa's National Treasury does[194] in the case of the Renewable Energy Independent Power Producer Procurement Programme.

Key factors that determined the successful outcome of South Africa's programme provide important lessons for policy-making and planning[195]. The following were instrumental in building market confidence and fostering competition, as well as generating significant interest and investment into the renewable sector: strong political will and sustained commitment; clear policy and regulatory frameworks; transparent bidding procedures and processes; proper allocation of risks; an adequate tariff-setting system; incremental increase of the target on local content requirements; and structured and timely implementation. This new direction in public-private partnerships can be applied to other infrastructure development programmes. Each country will tailor its energy-procurement programmes according to the requirements, capacities and level of development of the domestic market.

Expanding the clean power space for African investors

High transaction costs of and the lack of adequate financing for smaller players tend to crowd out African investors, despite efforts to involve small and medium enterprises (SMEs). In a recent 100MW tender in Zambia, for example, only one African company (from South Africa) qualified but no Zambian companies qualified. Suggestions to resolve the financing challenges include using pension funds to provide long-term financing to smaller players and mobilizing impact investors in search of positive financial and social outcomes[196].

A small but significant development is the recent expansion of South African companies in Africa[197]. A few compete alongside international companies on the African renewable market, largely driven by the prospects of higher power tariffs elsewhere on the continent as prices for clean power are declining on the domestic market.

Renewables still face technical challenges

To expand significantly, renewable power needs to be connected to the national grid. However the grid needs constant or baseload power, while power from renewable sources such as solar and wind varies according to weather and daylight. Current technological limitations make it difficult for clean energy to play a central role in power supply. A handful of African countries are using energy-storage systems, but these are an expensive way of dealing with the variability of renewable power.

Pumped hydro storage can prove effective for load management and balancing, while thermal storage has the potential to considerably increase the reliability of concentrated solar power[198]. The unique potential of geothermal energy lies in its ability to provide cost-effective baseload power, making it particularly suited for power balancing, as is the case with the Ethiopia-Kenya hydropower connection project[199].

TRANSMISSION

Transmission and distribution - the weak link

Losses are incurred in electricity transmission and distribution (T & D) because of physical and technological deficiencies, known as technical losses, and because of non-technical losses, mostly in the form of electricity theft[200] (see special section). Africa's high transmission and distribution losses, well above the world's average of 7 per cent, represent a major challenge. The impacts are felt throughout the power chain[201], severely affecting the quantity and quality of energy supply and causing attendant economic costs. Corruption and mismanagement, in addition to theft and vandalism, exacerbate the problematic power situation. A classic example is Nigeria's notorious grid-power supply chain[202].

Progress is being registered. Senegal, for example, has managed to reduce its losses significantly[203]. These successes can be attributed to major reforms aimed at enhancing the efficiency of power-supply systems.

In addition to policy measures and technological solutions for improving revenue-collection systems and protecting power-supply infrastructure, existing transmission and distribution infrastructure is being revamped and new grid networks are being deployed. Ghana has been leading the race in expanding grid connectivity to rural areas[204]. Even the Democratic Republic of the Congo, which has one of the lowest electrification rates in Africa (9 per cent), invested in 2014 in the rehabilitation of its transmission line linking Inga Falls to Katanga, a copper-mining district[205].

Strong political commitment, backed by financial support from multilateral banks and the private sector, has helped move major transmission and distribution network development plans from the drawing board to effective implementation in countries such as Kenya, Ethiopia, Mozambique, Ghana and Nigeria. Most of these investments are directed towards regional transmission and distribution infrastructure projects, however, and are not specifically intended to connect the underserved. To accelerate the pace of energy access for all, African countries must ensure that all urban and rural areas within the power grid's reach are included in the planning and development of transmission and distribution networks.

Although current efforts are commendable, the crisis in the power supply chain persists. African countries need to redouble their investments in transmission and distribution lines, which currently fall very short[206]. The huge network losses and the need to expand grid coverage require investments to the tune of US$800 billion through 2040[207].

DISTRIBUTION

Scaling up the grid

Experience shows that even where the grid could be connecting people, for instance people living in rural areas close to power-generation sources and on the periphery of cities, the policymakers behind grid energy tend to overlook them. One major reason is that the power supply, overly strained physically and financially, is unable to cope with additional demand from these areas.

Lack of access to energy is particularly severe in peri-urban areas — home to Africa's urban poor and often unplanned and growing rapidly. Close to 200 million Africans, most of whom have migrated from rural areas or been displaced by the urban housing markets, are forced to live in poorly planned and ill-equipped settlements. West Point in Monrovia, Liberia, and Kibera in Nairobi, Kenya, are among the biggest slums in Africa[208]. Left to fend for themselves, slum dwellers usually resort to illegal connections to the grid, as small off-grid devices do not meet their energy needs[209].

A range of quick-fix solutions, which require limited or no transmission and distribution infrastructure, have sprung up to bridge the energy gap, as is the case of the flourishing market for diesel generators[210]. However, developing the grid is the best way to scale up affordable energy access in such areas.

A novel approach to grid extension by a private utility company in India, Tata Power Delhi Distribution Limited, has successfully extended grid connectivity to 217 slums (175,000 customers) in New Delhi. The model, premised on community engagement, was able to expand grid extension by linking energy access to a wider socio-economic development agenda[211]. Over the last five years, the utility company has been able to reduce its non-technical losses, expand its customer base and improve its revenues from a mere US$0.3 million to US$17 million.

Quick fixes are no guarantee of a lasting solution. In the Democratic Republic of the Congo, power-supply systems set up by mining companies have rarely benefited neighbouring communities and businesses. However, the Indian model of energy access could be replicated and adapted to African contexts, especially for grid-extension projects in peri-urban areas where the majority of the urban poor resides.

SPECIAL SECTION

PREVENTING ELECTRICITY LOSSES AND THEFT

Electricity losses, including electricity theft, are a problem for distribution companies worldwide, but nowhere more so than in Africa. **(See infographic: Africa's Energy Theft and Losses)** Total losses in industrialized countries are typically between 7 per cent and 10 per cent[212]. The Africa Infrastructure Country Diagnostic found that transmission and distribution losses were as high as 50 per cent in some African countries.

Technical losses occur when power is lost in transmission and distribution lines, transformers and meters. Poorly maintained or low-quality infrastructure and equipment increase the level of technical losses. The World Bank's suggested benchmark for technical losses in Africa is 10 per cent of total power produced.

Non-technical losses are caused by individual actors, either purposely (theft) or unintentionally (for instance through errors in accounting), and by faulty equipment that is not directly used to supply power (e.g. meters). The World Bank's suggested benchmark for non-technical losses in Africa is also 10 per cent of total power produced, but losses are more than two or three times higher than this in some countries.

Most non-technical losses are caused by electricity theft, usually by tampering with or by-passing meters, sometimes in collusion with corrupt utility officials[213]. Electricity theft also occurs through the systematic non-payment of bills. Globally, electricity theft costs US$89.3 billion a year[214]. In the United States, the world's biggest consumer of electricity, US$6 billion a year is lost through the theft of electricity.

In Africa most electricity theft is not carried out by people too poor to afford electricity, but by people and organizations that consume large amounts of electricity and could pay for it, including government, corporate, industrial and commercial groups. Power sectors are often inefficient and unable to deliver adequate or reliable electricity supplies. Theft, fraud and corruption compound the problems facing companies responsible for electricity distribution.

The theft of electricity reduces the revenues of financially stretched utilities, which reduces their ability to invest in system improvements and extend services to those without access and increases the cost of electricity for African consumers. Reduced revenue and profits also make the sector less attractive for private-sector investment.

Electricity theft can contribute to power outages by placing an unmanageable load on the system, and by damaging transmission and distribution infrastructure. Outages can affect large numbers of consumers. Similarly, the inability of distribution companies to invest, because of poor revenue, affects all consumers.

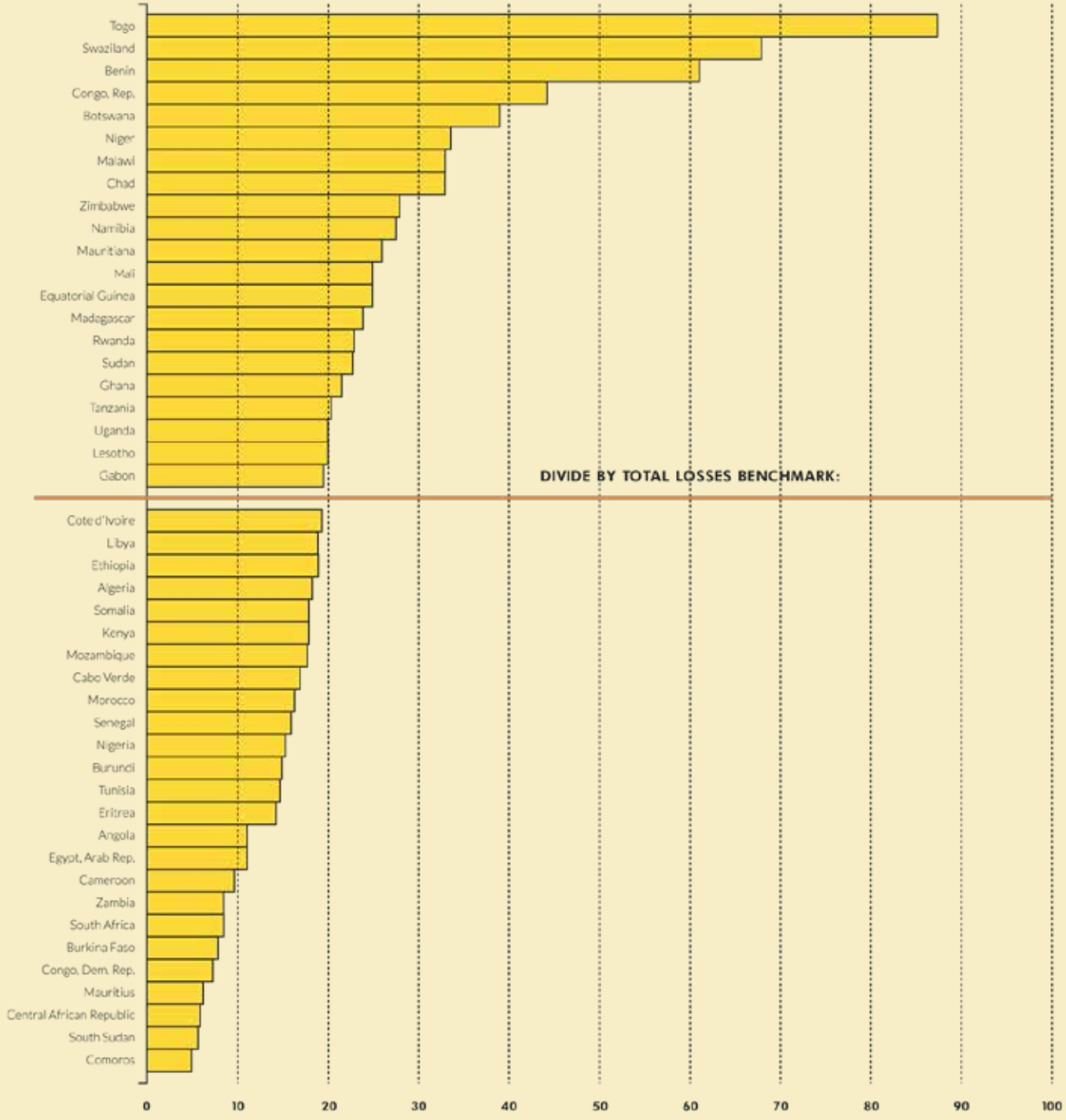
How pervasive is electricity theft?

Data on electricity losses in Africa are neither comprehensive nor up-to-date, but transmission and distribution losses in Africa in 2000 were estimated to be about 20 per cent of total power generated[215]. Other estimates have put the average at 27.5 per cent[216] and distribution losses alone to average 23 per cent[217]. These regional averages conceal the wide variation between countries **(Figure 20)**. Angola, Botswana and Burundi, for example, had losses of 15 per cent, while Swaziland's losses were 68 per cent.

The non-payment of electricity bills accounts for the more than half of electricity theft. Annually, US$1.73 billion is not collected across the region, compared with US$1.48 billion in system losses[218]. In economic terms, the under-collection of electricity bills was equivalent to 0.4 per cent of the region's gross domestic product (GDP) and system losses were equivalent to 0.34 per cent.

FIGURE 20: TOTAL ELECTRICITY LOSSES BY COUNTRY

% of total generation, most recent year available



Sources: Eberhard and others (2011); World Development Indicators

AFRICA'S ENERGY THEFT AND LOSSES

HOW IS ELECTRICITY LOST?

- **Technical losses** take place during transmission and distribution due to energy dissipation and weak infrastructure.
- **Non-technical** losses are due to theft, vandalism, non-payment of bills and accounting errors.

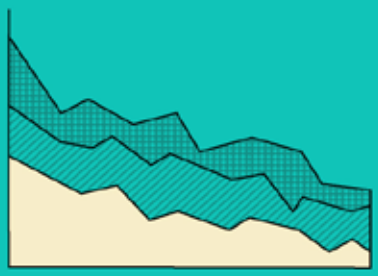
WHY IS ELECTRICITY STOLEN?

- The greatest proportion of electricity theft is by individuals and organisations that consume large amounts of electricity and can afford to pay for it.
- Some people are unable to pay because they are too poor. Many Africans live below the poverty line.
- Non-payment of bills may be due to a lack of trust between customers and suppliers.

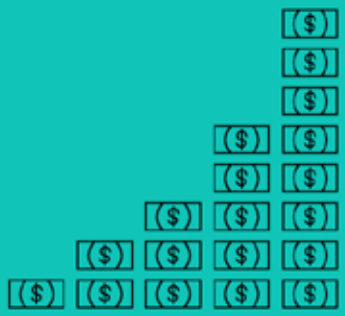
IMPACT

Electricity theft is more significant in Africa than in most other regions.

Electricity theft:
Reduces revenue for financially stretched utilities, which...



lowers investment in system improvements and the extension of services to those without access, and...

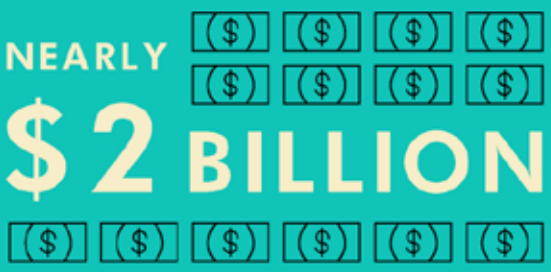


increases the cost of electricity for paying consumers.

HOW ELECTRICITY IS STOLEN

The **non-payment of electricity bills** accounts for more than half of electricity theft.

Annually, nearly **US$2 billion** is not collected across the region



Illegal connections:

- Illegal connections to overhead wires overload the system and lead to blackouts.
- Illegal connections to bare wires or underground cables make up 80% of global power theft.

Meter tampering: Meter is intentionally altered so that it doesn't record correct usage.

Meter by-passing: The input and output terminals of the meter have been shorted

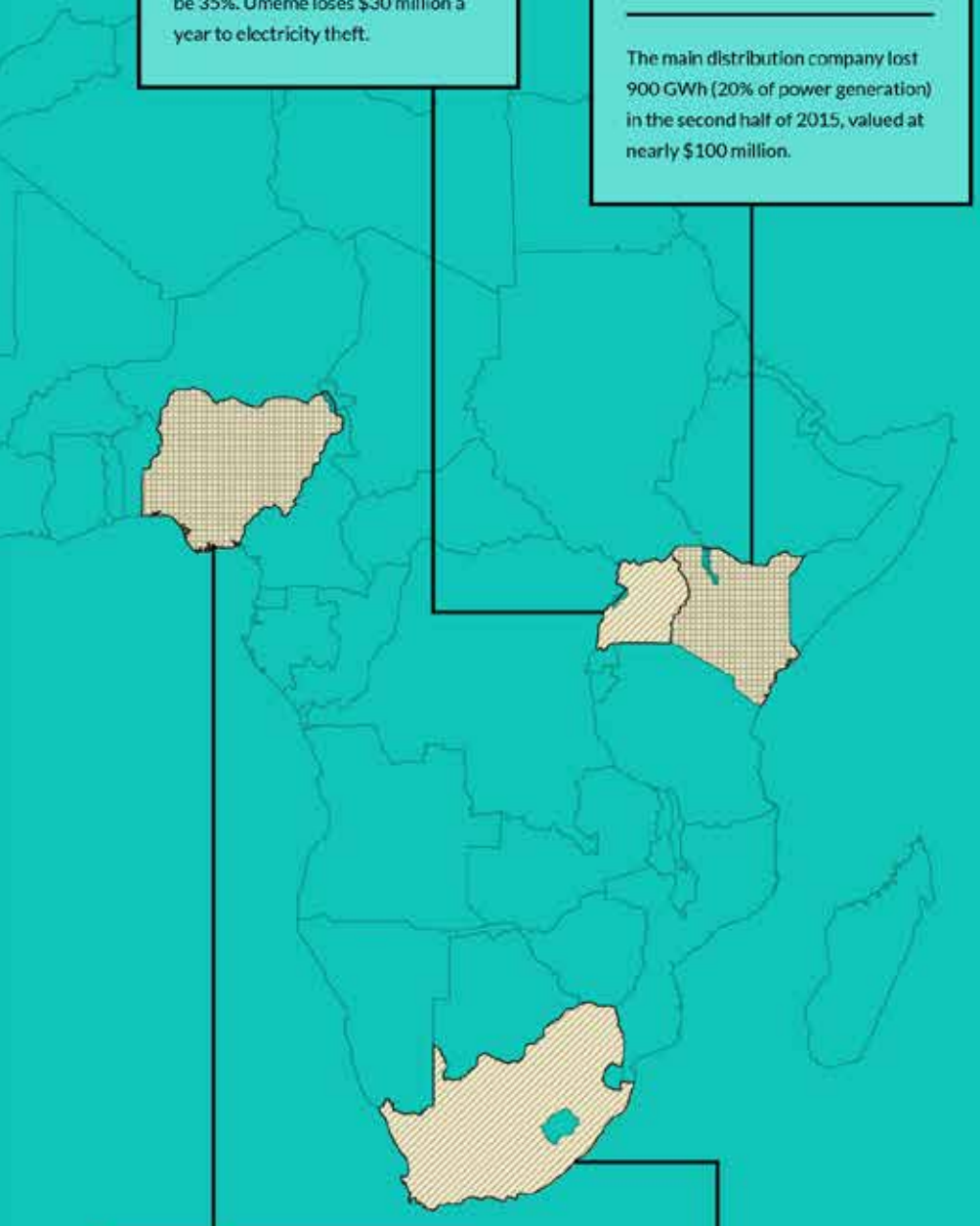
HOW IT'S BEING TACKLED

UGANDA

Uganda's main distribution company, Umeme, estimated losses in 2009 to be 35%. Umeme loses $30 million a year to electricity theft.

KENYA

The main distribution company lost 900 GWh (20% of power generation) in the second half of 2015, valued at nearly $100 million.



NIGERIA

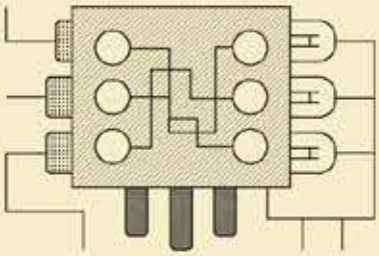
The Port Harcourt Distribution Company estimates that 60% of its customers do not pay their electricity bills, including a large proportion of customers with prepaid meters.

SOUTH AFRICA

Eskom's non-technical losses in 2015/16 were over $350 million, largely due to theft.

TECHNICAL/ENGINEERING METHODS

The Kamata, used in Uganda, measures current flowing through the mains cable and detects any attempt to by-pass the meter. If tampering is detected, it automatically cuts the power and sends details of the customer and location to the electricity distributor.

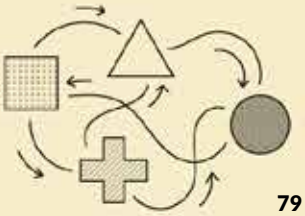


MANAGERIAL METHODS

Management contracts for state-owned utilities have been introduced in several countries to improve the efficiency of electricity services. These have increased collection rates and reduced losses.

SYSTEM CHANGE

- Restructuring the power sector and opening it up to commercial private sector actors.
- Building a relationship of confidence, greater transparency and trust between customers and distribution companies.
- Consumer education and information campaigns that build an understanding and awareness of electricity theft and its consequences.



Why is electricity stolen?

Most electricity theft is by individuals and organizations that consume large amounts of electricity and can afford to pay for it. In South Africa, two-thirds of collection losses were found to be by corporate, industrial and commercial customers. In Uganda, theft by large users accounted for 65 per cent of the collection losses of the largest distribution company[219]. Government organizations were among the biggest non-payers, owing US$19 million. Similarly, in Nigeria, where collection losses amount to 40 per cent of the power distributed, government organizations owed the distribution companies over US$390 million in unpaid bills at the end of April 2016, more than half of it owed by the army[220]. This shows a lack of accountability for non-payment within the public sector.

If poverty or inability to pay is not the driver behind most of the theft, the largest form of theft - non-payment of bills - may be due to a lack of trust between customers and suppliers[221]. This arises because customers mistrust the personnel who read meters and collect revenue; they mistrust bills, particularly estimated bills; they lack information and knowledge about their own electricity consumption; and they are frustrated by the poor reliability of the electricity supply. Distribution companies, for their part, may not be customer-oriented, having evolved out of the public sector, and may not trust their customers because of meter tampering and non-payment.

Both businesses and individuals steal electricity because they feel it is worth taking the risks of being caught and sanctioned. There may be little likelihood of disconnection or other sanction because of inefficiencies, corruption or the use of patronage relationships.

How is it being tackled?

Approaches to reducing electricity theft include technical and engineering methods, managerial methods and system change[222]. Utility companies and governments prefer technical approaches to reducing losses[223]. When losses are very high, it is clear that these alone will not be enough.

Technical and engineering methods: Pre-payment meters, introduced to Africa during the 1980s when power supplies were being extended to low-income families in South Africa[224], are a way to reduce non-payment. They are now in use in many countries including Ghana, Kenya, Nigeria, Sierra Leone and Uganda. Customers benefit from greater control over electricity expenditure and use, and avoidance of debt. Companies that distribute electricity benefit from improved revenue collection.

Revenue collection rates can also be increased through the use of bulk meters for supplies to groups of micro- and small enterprises. In Uganda, the use of bulk meters relies on the relationship between the enterprise operators and the individual responsible for the bulk meter and the group's payments to the electricity company.

In Nigeria, however, where a large proportion of customers do not have any kind of meter, the use of bulk meters is to end[225]. The high level of distrust with electricity billing throughout Nigeria may have contributed to this decision.

Increasingly, electronic "smart meters" are being deployed, which both record electricity consumption and communicate this information to the distribution company. Smart pre-payment meters record and display the amount of credit a customer has, and provide a way for customers to add credit to their account.

In Kitwe, Zambia, for example, pre-payment meters were introduced for all customers in 2010. Credit can be purchased from the state electricity utility, licensed vendors, banks and mobile-money systems. The customer

receives a 12-digit number to enter into the meter[226]. In this way, customers have direct control over how much they spend on electricity.

The introduction of pre-payment meters does not reduce all electricity theft. Meters, including digital meters, can be bypassed, at the meter or by illegal connections directly to a low-voltage overhead line. Smart meters themselves can be subject to hacking and fraud.

Managerial methods: Switching to pre-payment instead of billing customers after they have consumed electricity is a management change made possible by meter technology. In some pre-payment systems, customers face difficulties or extra costs (such as transport) when purchasing credit. Digital systems can automate the monitoring of consumption and tracking of payments, which both reduces costs for the electricity company and eliminates opportunities for theft. Digital systems also allow electricity companies to analyse the flow of electricity through their distribution network to understand where theft may be taking place, automating the task of inspection. It does, however, require new technical capabilities within the company to take advantage of this.

Management contracts for state-owned utilities have been introduced in several countries to improve the efficiency of electricity services. These have increased collection rates and reduced losses. In Tanzania, collection rates increased from 67 per cent to 93 per cent between 2002 and 2005 under a management contract[227].

In Kenya, management reforms increased revenue-collection rates from 81 per cent to 100 per cent between 2004 and 2006[228]. Since then, the main distribution company Kenya Power (Kenya Power & Lighting Company) has adopted a community-based approach to reduce the number of illegal connections in informal urban settlements. This includes actively promoting the advantages of a legal connection (safety, reliability, and affordability), backed by subsidized connection fees and tariffs[229].

System change: Power-sector reforms can help to reduce losses. Prevailing cultural and governance environments shape how sector reform has been undertaken and help determine the extent of electricity theft and the effectiveness of measures to tackle it. Restructuring needs to be accompanied by improved transparency and availability of information, which contribute to better governance within the sector[230]. The reduction of electricity theft also requires building confidence and trust between customers and distribution companies.

Consumer education and information campaigns can also help tackle electricity theft. An example is Operation Khanyisa, which was launched by Eskom in 2010 to address the problem of electricity theft in South Africa **(Figure 21)**. The campaign builds understanding and awareness of electricity theft and its consequences, educates consumers about energy efficiency and how to deal with electricity theft, and encourages the public to report electricity theft. Between 2010 and 2014, Operation Khanyisa recovered 689 million rand (about US$52 million) and led to over 138,000 disconnections[231].

FIGURE 21: OPERATION KHANYISA BROCHURE

Source: http://integratedreport.eskom.co.za/bec-customer.php

The restructuring of public utilities through privatization has not resolved the theft. Part of the answer lies in setting up effective governance and accountability systems to ensure that government ministries and agencies are held accountable for payment defaults of their energy bills, and to oversee private energy companies' activities and protect consumers against predatory practices.

Electricity theft can never be totally eradicated[232]. The challenge for many African power systems is to reduce theft to manageable proportions. Where systems are efficient by the standards of regional or international benchmarks, the efforts to control theft can focus on technological and managerial measures. In countries with very high losses, where the power system is inefficient and governance is likely to be poor, technological and managerial approaches will have more limited effects in cutting losses and increasing revenue.

BOX 7: THE GRAND INGA DAM – PROMISES AND PITFALLS

The Grand Inga Dam project in the Democratic Republic of Congo could generate almost half of the current power consumption of Sub-Saharan Africa[233]. The finished project, with a total capacity of about 40GW, would be able to generate at least 200 TWh. With an estimated generation cost of just US$0.03 per kWh, it encapsulates the ideal solution to Africa's energy trilemma of reliability, affordability and sustainability.

It involves a series of dams at the Inga site on the Congo River to be built in phases. It aims to connect regional power pools covering most of Africa, with transmission lines stretching as far as South Africa and Egypt.

The Democratic Republic of the Congo will be the main beneficiary. Although it accounts for half of Africa's technically exploitable potential hydropower, only 2.5 per cent of its hydro capacity has been developed. Tapping into even a fraction of the potential is likely to transform the energy-poor country into an international powerhouse, on the scale of China and Russia.

The scale and potential of the Grand Inga initiative is not complex from a technical and engineering perspective. It has captured the imagination of African governments and the international development community for decades. The first two dams at Inga were completed in 1972 and 1982. However, only 20 per cent of their initial 2GW total generating capacity is currently operational. The project's failure to deliver is the result of huge debts contracted during construction coupled with low utilization rates and insufficient revenues, which fuelled a constant cycle of poor performance. Rehabilitation is under way but has repeatedly been delayed amid financing and governance concerns.

These can be overcome through building political consensus and implementing Grand Inga as a pan-African project. It has strong support and backing from the African Union, its New Partnership for Africa's Development (NEPAD), the African Development Bank and the multi-agency Programme for Infrastructure Development in Africa (PIDA), as well as the leaderships of Nigeria, South Africa and the Democratic Republic of the Congo.

The substantial capital outlays necessary, US$80 billion-$100 billion, with a lot more needed to deploy transmission and distribution networks, make Grand Inga one of the world's most costly projects. China's growing interest in Africa's infrastructure development could provide a significant boost.

The first phase, Inga III, with generating capacity of 4.5GW, is expected to cost US$5 billion to US$12 billion, with financing structured as a public-private partnership. In August 2016, a Chinese consortium of China Three Gorges Corporation and Sinohydro was competing against a Spanish consortium of Actividades de Construccion y Servicios and Eurofinsa. If expected financing comes from China's Exim Bank and state-owned banks, Grand Inga could become the largest Chinese-funded infrastructure project.

The risks are too high for most international investors. One way to mitigate the risks is to build adequate demand for generated electricity. The Democratic Republic of the Congo and South Africa have signed an agreement on the off-take of 2.5GW of electricity by 2020[234] and the construction of transmission lines. (continued)

Agreements are being reached with Egypt and Nigeria. However, supplying a large volume of electricity to regional markets without developing the domestic market could heighten the country's political risks. To build domestic demand, the mineral-rich country could develop energy-intensive industries such as aluminium and copper refining. Investors would need to be convinced that they have sufficient risk-adjusted return, especially with regard to certainty of power delivery.

The Grand Inga project will be executed in multiple phases over a span of many years, so only a portion of the total capital will be required each year and cash-flow from earlier phases should be able to inject a meaningful amount of capital for later phases, with the likelihood that the project would eventually become "self-financed".

Cross-border coordination is vital, as the execution of Grand Inga will entail building and managing a matrix of grid systems across several countries. There should be comprehensive planning at national and regional levels, inter-regional rule-setting and close coordination among partner countries throughout the project's lifetime. NEPAD can serve as the credible authority, working through political consensus to manage cross-border issues and ensure mutual benefits for all partners.

Domestic political uncertainty had threatened the viability, but seems to be ebbing with the recent agreement on a political transition in late 2017. Strengthening national governance systems and finding solutions to shared problems using continental platforms could prove critical to ensure execution and protection of Grand Inga as a common African public good.

Concerns have been raised over the environmental, social and economic costs. The diversion of the Congo River will affect natural habitats, agricultural land, communities and livelihoods, and could displace 30,000 people. The World Bank has assessed the impacts as minimal, however the concerns are legitimate and taking them into account will maximize the project's benefits. The World Bank later suspended technical assistance funding in July 2016[235] citing "a different strategic direction".

It is urgent to secure financing for a comprehensive environmental and social impact assessment, expected from the NEPAD Infrastructure Project Preparation Facility (IPPF) and the African Development Bank.

The Grand Inga initiative is achievable, provided that it is well structured and risks are mitigated. Strong political impetus at the national and regional levels can mobilize financing, structure and build the project, and transform Africa's power landscape.

REGIONAL POWER TRADE COULD TRANSFORM AFRICA

Cross-border power trade is needed to ensure Africa can provide affordable energy and that new energy-generation and transmission projects can be viable, as well as accelerating the continent's wider integration agenda. Cost-effective generation and trade of electricity at the regional level would help to resolve the African energy trilemma of affordability, reliability and sustainability[236]. Yet less than 8 per cent of power is currently traded across borders in Africa.

The ultimate goal should be to bring together and interlink Africa's numerous and fragmented power initiatives to create a single pan-African power superhighway. To achieve this goal, African countries will have to commit to a much deeper level of cooperation and overcome the lack of financing for supranational interconnection projects.

Power trade provides the opportunity to export surplus electricity from countries in excess to those experiencing power deficits, within and across regions. The pooling and optimization of resources promises US$50 billion[237] savings in generation expenditure. Similarly, levelized costs of energy are expected to drop by 6 per cent in Southern Africa and 10 per cent in East Africa, making cross-border electricity cost-competitive.

Over the years, various cross-border initiatives have been implemented in a bid to improve regional interconnection and power trade. As a result, Africa's power-interconnection capacity nearly doubled between 2005 and 2011, from 5.4GW to 9.3GW[238]. Most recently, major regional power projects under way are likely to boost the continent's interconnection capacity significantly in the near future once they come online.

A continental framework for power trade already exists

Massive power projects have the potential to unlock economies of scale and make business sense only when shared among countries. Cross-border power initiatives therefore stand to benefit from effective regional power-sharing arrangements and cooperation. This is true for Africa's flagship power projects such as the Grand Inga Dam **(Box 7)** and the Grand Renaissance Dam in Ethiopia (6GW), but also holds true for initiatives such as the Manantali Dam in Mali and the Rusizi III hydropower project straddling Burundi and Rwanda.

The Programme for Infrastructure Development for Africa, which was endorsed in 2012 by the summit of the Assembly of African Union Heads of State and Government, provides the strategic underpinning to guide the development of cross-border power infrastructure and drive investments in Africa. It is a collaboration between the African Union Commission, the NEPAD Secretariat and the African Development Bank, the latter acting as the executing agency of the programme.

The programme serves to accelerate regional power projects, particularly those for regional interconnections. Under this framework, 15 energy projects, including 9 hydropower projects, 4 transmission corridors and 2 pipelines (one gas, one oil) with a total price tag of US$40.5 billion, have been prioritized for implementation between 2012 and 2020[239].

Many of Africa's energy resources are shared (for example, water resources) and persisting weaknesses exist at regional levels, especially in terms of cooperation and financing. There is an increasingly glaring need to adopt a continental approach to power infrastructure

development and management. The objective is to build and strengthen strategic infrastructure, increase the flow of cross-border power trade and shield continental public goods from uncertainties and risks[240].

The leading Pan-African institutions have particular roles to play in increasing cross-border power trade[241]. These are the African Union, the African Development Bank and the Economic Commission for Africa, as well as the eight continental regional economic communities that are recognized as the building blocks of the African Union.

Regional power trade has yet to overtake bilateral deals

There are currently five regional power pools, set up on the basis of existing regional economic communities[242].

- Southern African Power Pool (SAPP), to which all mainland countries in the Southern African Development Community (SADC) are connected, with the exception of Angola, Malawi and Tanzania
- West African Power Pool (WAPP) connects 14 countries in the Economic Community of West African States (ECOWAS)
- Central African Power Pool (CAPP) links 11 countries in the Economic Community of Central African States (ECCAS)
- East African Power Pool (EAPP) connects countries in the Common Market for Eastern and Southern Africa (COMESA) and Nile Basin Initiative member states (including Egypt and Tanzania)
- North African Power Pool (NAPP) links countries in the Arab Maghreb Union (AMU).

By and large, these power pools are in a developmental state, which explains the limited power flows within regions. Most of them are in the process of developing their respective master plan, which will be their guiding tool for coordinating regional interconnection and integration efforts. Furthermore, there are very limited links between the power pools[243].

Accordingly, only 8 per cent of power flows across borders in Africa. The bulk of regional power trade (7.5 per cent) takes place almost exclusively within the Southern Africa Power Pool, which traded close to 5.3 TWh of electricity in 2012-13. As the main producer, South Africa exports power to Botswana and Namibia and it imports electricity from the Cahora Bassa Dam in Mozambique to re-export it to provide power to the mining sector in southern Mozambique. Elsewhere, less than 1 per cent of power flows within the Central African and East African power pools. There are few interconnections between countries in the North African Power Pool.

Regional power integration and trade has been constrained by the lack of an efficient infrastructure network for transmission and distribution. Much of the power flows between neighbouring countries on the basis of bilateral agreements. In many cases, this has proved to be a successful arrangement in lieu of weak regional connectivity. In West Africa, this is the case with the long-standing two-way power trade flows between Ghana and Côte d'Ivoire. Additional examples include the one-way bilateral agreements between South Africa and Namibia and South Africa and Botswana, as well as Kenya's power import from Uganda[244].

In recent times, Ethiopia is emerging as a major player in power trading in East Africa. Interconnection lines include the region's first power connector with Djibouti in 2012[245] and the roll-out of transmission lines to connect with Kenya, with further big expansion plans.

Recent developments

In a bid to address weaknesses and accelerate regional power integration, African countries have agreed to strengthen existing and prospective interconnections within and across power pools. They call for greater regional coordination in planning initiatives and harmonizing policies, procedures, standards, systems and market frameworks, among others[246]. A range of concrete measures have been put in place in order to create and improve interconnections and high-voltage transmission backbones.

Power corridors: The Programme for Infrastructure Development in Africa has prioritized the development of four corridors[247]:

- The North-South transmission link from Egypt to South Africa
- The central corridor from Angola to South Africa
- The North African transmission link from Egypt to Morocco
- The West African power transmission corridor from Ghana to Senegal

The aim of these corridors, with branches extending in each of the regions, is to strengthen interconnections across the various power pools.

Power interconnections: Africa is moving towards greater regional power connectivity and launched several interconnection initiatives in recent years. Examples include the 2GW capacity, 500kV transmission line linking Ethiopia to Kenya, expected to become operational this year, and the 400KV transmission line underway to link Kenya, Uganda and Rwanda, with capacity to accommodate 500MW of cross-border power trade[248].

Prospects for increased regional power integration look bright for East Africa. Projects planned for development between now and 2020 are Sudan-Ethiopia, Egypt-Sudan, Rwanda-Tanzania, Uganda-South Sudan, Libya-Egypt and Kenya-Uganda interconnectors[249]. Supply agreements have been reached and work on grid codes is already underway.

In West Africa, the 225kV transmission line linking Côte d'Ivoire, Liberia, Sierra Leone and Gambia (CLSG) is one of the priority projects of the West African Power Pool and will connect to the existing Côte d'Ivoire-Benin-Togo-Nigeria interconnection. It will cost US$500 million and is expected to come online in 2017. Projects in the next three years include the 225kV interconnector spanning Guinea and the subregion, which has a transfer capacity of 800MW and a price tag of close to US$900 million, as well as plans to connect Ghana's grid to those of Burkina Faso and Côte d'Ivoire.

AFRICA IS MOVING TOWARDS GREATER REGIONAL POWER CONNECTIVITY.

In Northern Africa, a 400MW one-way interconnector already links Morocco to Spain[250]. A further 4.5GW of interconnection will be added through the North Africa power transmission corridor linking Egypt, Libya, Tunisia, Algeria and Morocco. Other proposed projects include 400KV interconnection project with a capacity of 4GW, which will link the southern part of the Mediterranean Basin (Algeria and Tunisia) to the northern part (Italy and Spain), partly in the context of the DESERTEC power project[251].

The Southern African Power Pool uses many existing interconnectors. The Southern African Development Community (SADC) is building the first power interconnector between regions, linking Zambia, Tanzania and Kenya. The first phase was due to start operations at the end of 2016[252]. The US$1.4 billion project was

implemented on the basis of a tripartite cooperation among three regional groupings – the Common Market for Eastern and Southern Africa (COMESA), East African Community (EAC) and Southern African Development Community (SADC). Under the agreement, each country is required to build infrastructure within its borders, with Zambia as the lead coordinator, and to establish trading mechanisms.

Another flagship project under construction is the Zizabona interconnector, linking Zimbabwe, Zambia, Botswana and Namibia, which is expected to accommodate the flow of 600MW of electricity generated by existing and prospective hydropower plants in Zambia and Zimbabwe[253]. Given the high financial costs involved (US$5 billion), SADC is urging its member states to transition to cost-reflective tariffs by 2019 in order to stimulate private investors' interest in the project. Nine other priority transmission projects with a price tag of US$4 billion are in the pipeline. South Africa's agreement to purchase 2,500MW of generated electricity from the Grand Inga dam has given the project a much-needed boost. What remains now are decisions concerning the best route for transmission lines between the two countries. Interconnectors could also be set up to link the dam to Nigeria and Egypt.

Current initiatives

Transmission lines: East Africa is investing heavily in the roll-out of high voltage lines in an effort to integrate regional power markets[254]. It is expected that between 2016 and 2018, a number of transmission lines will be completed, linking Kenya to Uganda, Ethiopia to Kenya and Tanzania to Kenya. Some of the financing will come from Chinese sources, as in the case of the Ethiopia-Kenya power connection project. A major complaint has been that projects have been consistently falling behind schedule for lack of proper planning and coordination, adequate financing and other issues such as land disputes.

Generation capacity: In East Africa, the Rusizi III hydropower plant recently secured US$138 million in financing (out of the total of US$625 million) from the African Development Bank, as a priority project[255] of the Programme for Infrastructure Development in Africa. The regional initiative, which straddles the Democratic Republic of the Congo and Rwanda and feeds into the East African Power Pool, will add 147MW to the regional power-generation capacity. This project is the first in the region to be built under a public-private partnership arrangement, with the Great Lakes Energy Organization responsible for overseeing the project development.

Power projects underway in Southern Africa were to add 3GW of new capacity to the regional grid[256] in 2016. South Africa was expected to contribute the largest share with the commissioning of at least three power plants with a combined output of over 1.5GW. Other significant contributions to the Southern African Power Pool come from Zambia (300MW) and the Democratic Republic of the Congo (430MW). Angola has announced massive investments in power projects at a time when it is hard hit by plunging oil prices. It was expected to increase the region's generation capacity by 780MW in 2016, although it was not not yet connected to the regional power pool.

Trends in power trading

Some experts contend that electricity will become the most traded commodity in the near future, particularly in the Southern Africa market[257]. Power trading has increased within the Southern African Power Pool: trading was valued at US$50 million between April 2014 and March 2015[258]. The traded volume exceeded 900,000MWh, up from 508,000MWh a year before, as a result of short-term power trading by power-pool countries in order to reduce black-outs and load-shedding. Investment in regional interconnectivity will be sustained.

Hydropower will continue to dominate regional power trade, especially in East Africa. Its share in the energy mix is likely to rise in the Southern African power market with 430MW generated by the Democratic Republic of the Congo to be added to the Southern African Power Pool during 2016. Gas is fast emerging as a major commodity, particularly in Southern Africa, with plans to implement the African Renaissance Gas Pipeline (ARPG) linking Mozambique to South Africa[259]. Tanzania, itself a major gas producer, is making preparations to commence work on a gas pipeline connection with Uganda. A portion of the generated power will cater for the electricity needs in both countries.

When it comes to regional gas pipeline initiatives, Ghana's experience offers warnings. Following the completion of the 680 km West African Gas Pipeline (WAGP) in 2005, gas supply reached Ghana only in 2008. Even then, supply has been intermittent with incidents of vandalism further upstream in Nigeria, coupled with damages and irregularities elsewhere. The situation soon became dire and regular gas shortages forced Ghana to ration power[260]. But, with recent discoveries of offshore gas fields, Ghana is exploring alternative ways to resolve its gas issues. As the West African pipeline dried up, the country is seeking to develop its own gas fields and commission new gas-power plants to offset the lack of regional gas supply[261].

A novelty in regional power trading is the commercialization of power generated by Kenya's Olkaria Geothermal Plant, which will feed into the Eastern African Power Pool. The initial agreement signed was a 30MW power sale by Kenya to Rwanda, transiting through Uganda by July 2015. This year, Kenya, Uganda and Rwanda will start trading 15MW of power, in spite of delays in the execution of the 400kV transmission line, which has a transfer capacity of over 500MW between the three countries[262].

Diversifying the energy mix and reducing dependence on hydropower in the context of climate change and recurrent drought will go a long way towards strengthening regional power pools and flows. However, experts in the SAPP region caution against an increase in clean energy uptake by regional power pools, because of rising load and back-up problems, as was the case for Cape Verde for instance.

Challenges

Despite encouraging progress, the road leading towards Africa's power superhighway is fraught with challenges. A number of bottlenecks and weaknesses are constraining the development of regional power initiatives. A different approach is required to mitigate and reduce risks when dynamics emerge that are beyond the competence of regional power pools.

Power infrastructure and markets: Lack of infrastructure is often cited as a primary constraint to regional power cooperation. An efficient and reliable cross-border transmission network is a pre-requisite for the integration of energy markets. One muted issue is that individual countries adopt a protectionist stance with regards to their national power plans and are uneasy about relying on power imports, for fear of becoming energy-dependent. Another cause for concern is the limited size of regional power markets, as this tends to raise the costs of electricity generation instead of driving them down. There is a need to develop demand for power when developing large-scale projects and large anchor projects are deemed necessary to justify the scale and cost of large infrastructure developments[263].

Regional cooperation: Strong regional cooperation is essential to the success of large-scale regional projects and should be governed by a robust regulatory framework. Countries must coordinate all activities pertaining to the project throughout its lifetime and address issues as they arise, in particular related to energy security[264]. A typical example of failed cooperation is Egypt's recent pull out from the East African Power Pool over the use of the Nile waters[265]. The master plan signed by all member states with the exception of Egypt will go ahead as planned, but Egypt's announcement is likely to delay the delivery of the Libya-Egypt and Egypt-Sudan interconnections.

Governance: Governance arrangements should be determined for clarity and expediency of regional power initiatives[266]. These include whether it is privately or state-owned or a public-private partnership, defining the collaboration among various regional blocs and groupings, explaining the auction systems, and clarifying the number of entities to be involved and the sharing of benefits from power-purchase agreements.

Financing: Regional projects require substantial investments and financing is a persistent challenge. Multilateral banks, and in particular the African Development Bank, provide a portion of the financing usually complemented with other sources, such as the United States of America, China and the European Union. Although revenues derived from power exports help, African countries have to look for alternative ways to mobilize financing, often in the form of budgetary allocations.

Developing a viable business model: One study on interconnections in the Mediterranean Basin argues it is crucial to develop the right business model for regional interconnections[267]. It suggests that the key features for a successful business model include:

- Incentives for investment and efficient operation
- Management of risk and uncertainties
- Coordinated planning and governance

Since African regional power pools have varying levels of interconnection and market structures, it is not straightforward to choose between a regulated system and a market-based system.

GETTING THE FINANCES RIGHT: MAKING POWER SUSTAINABLE

Many African countries are working to ensure universal access to energy for all by 2030, in line with Sustainable Development Goal 7, despite their severe budget constraints. How do planners decide which option – including stand-alone or off-grid, mini-grid and national grid – offers the best value for money, given circumstances such as location, power sources and consumers' incomes and power usage? Financial assessment is a vital tool that enables planners to compare, select, finance, execute and maintain power projects across generation, transmission and distribution.

Location-specific costs: Four key parameters are considered in each location: i) how much and what quality of energy is required, ii) what is the population density, iii) is there a grid connection nearby, and iv) what other local resources are available and what is the cost of the technology to make them supply electricity?[268] Assessing how much and what quality of energy is required involves the six-tier framework **(Figure 15)**, from Tier 0 (only torch and radio or less than 3kWh per household per year), up to Tier 5 (heavy or continuous appliances such as air conditioning, in addition to heating water,

ironing, pumping, cooking rice and refrigeration, which uses more than 2,121kWh per year). Lower population densities mean higher cost per household connected and influences transmission and distribution choices. Distance to the nearest grid influences both connection cost and transmission losses, and the cost of grid electricity is also important. Alternative local power sources could include a nearby good location for wind, solar, hydropower, or biomass resources. The cost and availability of diesel also needs to be considered.

Using these parameters can determine the best technology and connection in each case, based on two measures: the total cost per household connected between 2015 and 2030, and the levelized cost of electricity (LCOE), which determines whether a project could break even over its lifetime.

It is possible to use geographic information systems (GIS) or other geo-referencing software both to explore local solutions and to build complex regional studies. Researchers have produced maps of different connection types for different parts of Nigeria and Ethiopia, based on anticipated expansion of main transmission lines and the power plants operating, being built, planned or under consideration. They suggest that grid-based power is the least-cost solution for 85 per cent of newly electrified households in Nigeria and 93 per cent in Ethiopia, but that mini-grid and standalone are both significant in areas with low population density, which in Ethiopia means large areas of the country.

Affordability: One-third of all people in 22 surveyed Sub-Saharan African countries use electricity and they are disproportionately urban and rich[269], although two-thirds of households are in rural areas. Even in communities where there is a connection, lack of affordability is the main reason why other households cannot access electricity. Only six of the countries offered very low prices for low usage (30kWh a month or less), and affordability is exacerbated by sharing meters between households and high connection costs.

Electricity was defined as affordable if households that use 30kWh or less a month, spend less than 5 per cent of their monthly consumption spending on electricity. Grid electricity even at the subsistence level is out of reach for the poor in 11 countries, and this was worse after connection charges were considered. Some households pay too little or nothing, through fraud (tampering with meters), stealing (illegal connections), billing irregularities and not paying their bills. Steps identified to help the poor access electricity include individual meters, subsidizing installation, encouraging prepaid metering, reformulating minimum usage ("lifeline") rates, and stamping out corruption to eliminate bribes. Prepaid meters encourage small frequent transactions, which are more suited to poor households than a monthly billing cycle, remove reconnection costs and discourage unpaid bills.

Similarly an earlier study[270] showed that two-thirds of 27 African countries used increasing block tariffs, and some added extra subsidies for the poor, although some had relatively high fixed charges of US$1-$3 a month. Average effective tariffs were affordable for 90 per cent of the existing customers but would be affordable to only 25 per cent of households that were not yet connected. Nearly 80 per cent of countries fully recovered their operating costs, but only 30 per cent fully recovered capital costs.

Connection costs are particularly significant for off-grid renewable energy supplies, such as household solar. Low income customers usually do not have the capital for these and rolling them out depends on innovative[271] business models.

Financing gap: Nearly half the US$8 billion spent in 2013 on financing Africa's energy infrastructure is thought[272] to have come from domestic public financing, with the rest coming from private participation in infrastructure, official development finance and Chinese investments. As mentioned in the Africa Progress Panel's 2015 report Power, People, Planet, the total cost of financing energy infrastructure needs was US$63 billion in 2013 alone, leaving a US$55 billion gap.

Official development finance was the main source of external infrastructure finance in the 1990s and remained significant at nearly 35 per cent of all finance in 2012, when US$3.5 billion was invested in energy projects. Private participation in infrastructure is growing fast, but electricity financing was only 19 per cent of the total in 2005-2013. Generation attracted most of the private and Chinese finance, while transmission and distribution were mostly financed by governments and China. Over 2010-2015, China financed US$13 billion or a fifth of all investments in power in Africa. Renewable energy accounted for 56 per cent and of the generation capacity (including 49 per cent on hydropower). The Power Africa initiative of the United States committed US$7 billion over four years and acted as a focal point for a range of US agencies and the private sector. The European Union is deepening its energy cooperation with Africa through the Africa-EU Energy Partnership.

Initial costs to set up large-scale renewable energy projects are usually higher than for carbon-intensive projects, including where generators are built for coal or other supplies. Appropriate incentives need to be devised if the mix is to take a longer-term and global approach, including benefiting the world through lower carbon impact.

Governments can improve the efficiency of their investment processes, for instance up to 40 per cent of public investment in low-income countries[273] is lost through delays, cost overruns and inadequate maintenance. Domestic capital markets can be a useful channel for raising local-currency long-term infrastructure finance, either through bonds or other investments. Effective domestic capital markets would also encourage long-term institutional saving, such as pension and insurance funds, and foreign investors using local-currency instruments.The African Development Bank and the International Finance Corporation are boosting local-currency financing.

A bigger pipeline of bankable feasibility studies can encourage the flow of investment. These can be created by national governments, regional economic communities, financiers and multilaterals, experts and specialist project-preparation units. Established risk-mitigation mechanisms, including the World Bank's Multilateral Investment Guarantee Agency (MIGA) and its International Development Association Partial Risk Guarantees, are key to launching many projects and to reducing their costs.

Investment and development banks can specialize in developing and building projects and handing them over, once cash-flows are more predictable, to other institutions such as pension funds[274]. At the same time, having a partner such as the African Development Bank or the World Bank in a consortium encourages private investors who believe these can apply soft pressure to governments to honour commitments.

Challenges to be addressed to attract more private and international investors include reducing political and country risk, ensuring the profitability of projects is commensurate with the risks, and the legal and regulatory environment[275]. The framework for investing into energy projects can be more favourable through: predictable tariff regimes, simplified licensing procedures, standardized "technology-based" power-purchase agreements and realistic energy-planning tools[276]. Key to feasible generation projects are power-purchase or off-take agreements. Investments in transmission and distribution also require creditworthy and effectively managed power utilities that can afford to meet their obligations, and effective grids that do not waste much money through losses and breakdowns.

Financing industry: Inadequate electricity imposes crippling costs on businesses. Business leaders say power supply is the top obstacle to the region's growth. African businesses are estimated[277] to lose 5 per cent of annual sales due to power outages. Already, privately owned diesel generators supply more than 5 per cent of total electricity, mostly to businesses, and the costs of running back-up generators are equivalent to between 1 and 4 per cent of gross domestic product (GDP). For example, Nigerian manufacturers spend four to eight times as much of their manufacturing costs on power generation as their competitors in similar economies.

Instead businesses can create "captive" power-generation units[278] strategically located in areas with high demand, as outlined in Part II above. These mini-grids can improve reliability and quality of power supply – which is essential for competitive manufacturing – reduce losses on transmission and significantly cut time, planning and investment capital for new projects. Users can add or take away generation units as demand changes, and may also be able to sell excess power back into the national grid. Power-supply companies can choose customers based on their creditworthiness, instead of relying on a single buyer like a distribution company or state-owned utility. They can also provider cleaner and more efficient generation than the individually owned diesel generators on which many businesses currently depend. Making captive mini-grid power work requires a favourable policy and regulatory environment, established local industries, reliable fuel supplies (including gas), technical knowhow and business skills. It offers a scalable, bankable investment option for tackling the power deficit that is crippling businesses.

Africa's lack of power is holding back development across the continent. It hampers the businesses that already provide economic growth and jobs. Their competitors have cheaper and more reliable power, hindering their growth. The power gap also blocks development, education and health at household level.

This paper shows that many options are available to African policymakers, including reforming regulation, restructuring utilities, holistic planning and encouraging the wide range of solutions appropriate to different settings, including off-grid, mini-grid and renewable energy inputs into the national grid while expanding access. It outlines the step and reforms necessary to achieve this and discusses experience and potential in financing these projects as well as in making power systems more efficient and sustainable.

The paper highlights where success stories are already working in Africa, demonstrating solutions that can be scaled up and replicated by other countries.