OPEN AFRICA

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The web documentary version of this photographic book is available on www.openafrica.it

The sun does not forget a village just because it is small.
African proverb

◀ An Ethiopian girl standing by the Omo river artificial basin, in Southern Ethiopia.

FOREWORD

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Over the past decade our perception of Africa has changed completely: the economy has been growing fast in recent years and this positive trend is gaining momentum: GDP is projected to grow by 4% and the continent has gone from being defined as *'the lost continent'* to *'a land of hope'*. However, Africa is made up of a number of very diverse regions characterized by different income levels, specific economic assets with local features, and varying levels of dependence on commodity exports and of political and social stability, as well as different energy infrastructures development and consequently specific degrees of access to energy. Secure access to modern energy is widely recognized as an important enabler for economic and social development and although Africa is enormously rich in natural energy resources, the continent is poor in energy supply, mainly in the Sub-Saharan area. This region accounts for about 14% of the world's population, but just 4.5% of global primary energy demand, with solid biomass representing over half of primary energy demand. Today about 590 million people in Sub-Saharan Africa live without access to electricity, especially in rural areas and villages not connected to the electricity grid, representing more than half of the global number. For instance, in Sub-Saharan Africa the average electricity consumption is 200 KWh per year, compared to almost 1,600 KWh in the European Union.

The energy access status varies significantly across the continent, from Central Africa, with almost 100 million people living without access – 17% of the total – and the lowest access rate at just 25%, to West Africa, accounting for 30% of those without electricity and with an average access rate of 52%.

However, electrification efforts have accelerated in the last few years, overtaking population growth for the first time in 2014 and leading to an increase in electricity consumption. Since Africa is rich in terms of all renewable energy resources – hydropower, solar, wind, geothermal and biomass – these represent the most effective response to the continent's growing demand for electricity in a fast and flexible way, offering three key advantages. Typically, renewable generation is less concentrated, more decentralized and more easily deployed, with a scalability approach based on current needs. In addition, the time required to build a renewable power plant is much shorter than for other conventional technologies and the cost of renewable energy, if the resource concerned is abundant, is progressively lower.

Having recognized this opportunity, Sub-Saharan Africa is increasingly tapping into its enormous renewable energy potential in order to provide power. Between 2012 and 2015, around 18 million people gained access to renewable energy each year, mostly from hydropower and geothermal, principally in Kenya. Although grid expansion remains crucial, in remote areas where building the grid connection is too expensive, decentralized power generation has huge potential for both household and productive use, such as in agriculture.

Furthermore, an estimated 2 million people gained access through solar home systems in 2016. In some countries in Sub-Saharan Africa, especially in rural areas in Uganda, Tanzania and Nigeria, where mobile phone ownership is higher than the electrification rate, new emerging business models based on pay-as-you-go financing and payment schemes are facilitating access as consumers use their smart phones to pay a regular fee for the energy service or a fixed amount for the solar home system in a rent-to-own plan.

However, given the current policies and measures in place, the number of people without electricity in Sub-Saharan Africa will remain at today's level until 2030, as rapid population growth outpaces electrification progress. Sub-Saharan Africa will be the largest region without access to electricity, accounting for almost 90% of the people in the world without access in 2030. If we do not tackle this situation in an effective manner now, we cannot possibly hope to meet the 2030 United Nations Sustainable Development Goals (SDGs), given that one of them, SDG 7, is to *"ensure access to affordable, reliable, sustainable and modern energy for all"*.

To this end renewable energy, including solar PV and wind power plants connected to the grid, will play an import role, together

with off-grid and mini-grid solutions, a viable solution to bring electricity to rural and remote areas. Renewable solutions – both small and utility scale – are usually accepted by local communities, provide relatively fast investment returns and can easily respond to the needs of the rapidly growing African economies. Access to renewable energy does more than just provide power. When integrated with a sustainability approach, access to renewable energy will accelerate Africa's socioeconomic transformation, enabling poverty reduction, economic growth, environmental protection, action on climate change, improvement in health and living standards, whilst creating opportunities for entrepreneurship, empowering women and improving education. Children are able to remain in school after sunset, women have time to study freed from chores, one can run a business, and gain more easy access to health services and water. This publication, "Open Africa", aims to frame this hopeful potential for growth by visually presenting the tangible impact of sustainable energy access.

As recognised by the United Nations Sustainable Development Goals Agenda 2030, today there is a need for development to be economically, socially and environmentally sustainable in the long-term.

Enel considers sustainability, coupled with innovation, one of the main pillars of its business strategy and, referring to energy access (SDG 7), it is committed to bringing affordable and clean energy to 3 million people by 2020. Based on this strategy, Enel is developing renewable solutions to provide energy access, such as in Zambia where in 2016 Enel Green Power was successfully awarded 34 MW solar PV capacity, as part of the World Bank's "Scaling Solar Program". Enel is also promoting partnerships and pilot projects, aiming to remove regulatory, technical and cultural barriers and to establish a fair economic and policy framework for successfully scaling up renewable energy.

In this context, Enel Foundation plays a central role as a knowledge platform that conducts research and designs multi flag capacity-building programs to forge clean energy leaders in Africa, such as the recently launched flagship-training program *Open Africa Power*. At the same time, Enel is a founding member of RES4MED and RES4Africa (Renewable Energy Solutions for the Mediterranean and Africa), a multi-stakeholder platform that aims to create enabling environments for renewable energy investments in Southern-Mediterranean and Sub-Saharan African countries.

Open Africa aims to demonstrate that progress is being made and, through local photographic testimonies from Uganda, Kenya, Ethiopia and South Africa, it shows the positive impact of sustainable energy access on African livelihoods, from small to large-scale renewable energy solutions. Thanks to these photographs and local stories, this book outlines what happens when people suddenly gain access to energy. In essence, it visually captures what achieving progress looks like in *ensuring access to affordable, reliable, sustainable and modern energy for all* through the deployment of renewable energy, whilst drawing the attention on what is required in order to move forward.

As the world moves ahead to meet the 2030 United Nations Sustainable Development Goals, we hope this book shines a light on the road towards Africa's more sustainable future.

POWERING THE FUTURE OF AFRICA

Africa is often the subject of a one-sided narrative, where the continent is either still presented as a wild, primitive land, or one where wars, poverty and epidemics dominate the social, political and economic life. Energy is no exception to this perspective. To many, the vast African population without access to power (still circa 600 million people) either seems doomed to maintain this unfortunate status, or to slowly overcome it through a traditional, polluting, coal-based generation. A dark economy or no economy at all, appears to be the trade-off for the development of Africa.

Yet, none of this may be true. Sub-Saharan Africa (SSA) is now presented with an unprecedented opportunity to revert a decades-old trend of decreasing access to power, making the dream of achieving universal access by 2030 a closer target. As renewables will represent the core of this dramatic shift, SSA could also experience a *development leap*, surging from an economy with limited or no electricity, to one largely powered by green energy. If achieved, this will be the first case in history of a region electrified without the use of coal. Considering that even countries such as Germany still power 40% of their electricity consumption by coal, such a success would mark an epochal moment. In this sense, SSA would be at the centre of the other revolutionary trend of these years, the sustainable energy transition.

The early signs of this change are already here. International Energy Agency (IEA) data report that in 2014, for the first time in decades, access to power in SSA increased. The same happened in 2015 and 2016. In other words, it was the first time the number of people reached by electricity was greater than the population growth, and where the result was likely not a singular event, but a possible indicator of an inverted trend. Indeed, the change has been matched by a significant surge in renewable energies: according to the IEA, in the 2012-15 period renewables provided power to 18 million people, six times more than in the previous 12 years.

Despite this positive outcome, the path ahead is still long and complicated. Almost 60% of SSA's population has no access to power, and the supply for those who have is often expensive and unstable. The lack of energy has devastating consequences on the region, in relation to the economy, but also to health, education, environment and, finally, migrations. Improving access to power will require massive structural changes in African energy markets and, most of all, tens of billions of euros in investments each year. This is an effort which will require strong and concerted action by all players, actively involving the public and, mostly, private sector, with an egalitarian cooperation between the regional and the international level.

If achieved, this transformation will not only be limited to the energy sector, but will extend to the very economic and social fabric of the African continent. It will impact the economy, where industry and agriculture are constrained by lack of energy, increasing job opportunities and reducing migration. Health will be affected, as hundreds of thousands still die in SSA from the fumes of kerosene lamps and biomass, and so will education, as light will be available for students to do their homework and for illiterate adults to attend night classes. Clean energy will stop the environment from being ravaged by firewood collection, families will have cleaner and easier access to water (fetching water takes as much as 5 to 6 hours a day for women in SSA). It will ultimately set the course for turning the XXI century into the *African Century*.

Between fall and rise

The SSA region is still a divided continent, torn between the sustained growth that several countries in SSA are experiencing, and the looming crisis many are fearing, also in some of the continent's largest economies (such as Nigeria and South Africa).

On the one hand there are positive prospects for growth: according to the 2017 IMF Regional Economic Outlook for Sub-Saharan Africa, a third of SSA countries' GDP is expected to grow by

around 5% in the upcoming years. This confirms the economic trend the region was already benefitting from in the early 2000s when its growth became, for the first time in history, greater than the global average.

On the other hand, with this growth comes an inherent fragility – it is not by chance that in the past two years uncertainty has dominated. There have been many factors behind such troubles, first of all the burden of public debt, which in many SSA countries (particularly those that are oil-rich) accounts for 60% of their public expenditure. Low commodity prices, political instability, and unclear regulatory framework all contributed to the greatest drop in Africa's GDP growth in the past 20 years, reaching as low as 1.4% in 2016.
Furthermore, even the positive economic trends many are experiencing will not be translated into an improvement in the status of the African population. IMF forecasts also highlight that the regional per capita income will scarcely increase, and that it will actually decrease for 40% of SSA's population. In this sense, one of the problems is that the African economy cannot match its population growth: according to UN data, there was an increase of 80 million people from 2015 to 2017 alone, a 2.7% expansion which is expected to continue and raise the population to 1.8 billion in 2035 and 2.5 billion in 2050. By 2035 half the new global population will be born in SSA.

Population growth, weak governance, population dispersion and other issues are part of the explanation for the dramatic situation regarding access to power in SSA, which according to the IEA hosts 14% of the global population, but more than half of those without electricity. Energy consumption is limited, a mere fraction of European levels: according to the Africa Progress Panel, Africa consumed 139 billion kWh in 2015, 57% of Spain's consumption that year. Energy generation does not fare any better: in 2012 Germany had almost twice the total power generation capacity of the region, despite having a population 8% its size. Its grid, inefficient and undermined by vast losses, is limited in coverage, leaving large parts of the population kilometres away from the closest access point. This most severely affects the widely dispersed rural population, 78% of whom are lacking access to power. Even those who have electricity in SSA still face many hurdles: IEA data show an average of 2 hours of blackout a day, with an average consumption of 200 kWh (excluding South Africa). Energy prices in SSA are among the highest in the world, with a marked disparity between the urban areas and those which are farthest from the grid, where electricity can cost even 20 times more.

Heterogeneity is, indeed, another delicate issue for the African energy sector. Many countries have practically no access to energy, as in the case of Burundi, while in only a few does more than half of the population have electricity. Even rapidly growing or large economies suffer from low levels of electrification: in 2016, according to the IEA, only 45% of people in Ethiopia and 33% in Tanzania had access to power.
Such a bleak picture is however in contrast with Africa's resource endowment: according to the 2017 BP Review the continent has 6.8% of global oil reserves, and 6.9% of production. Yet, its consumption is only 2.8% of the total. SSA has been indeed unable to exploit its rich oil and gas reserves to bring access to power to its population; in 2016, one third of the gas the region produced was consumed, one third exported and one third simply flared, a waste that was particularly dangerous for the environment and for human health. Nigeria, which holds SSA's largest hydrocarbon reserves, has yet to bring power to almost half of its population. Countries where such resources have been recently discovered, Angola and Mozambique in particular, have been working hard to develop infrastructure to export their resources, in particular to liquefy natural gas, but are struggling to enhance their electricity generation capacity, with access rates below 35% of the population in both countries.
Yet fossil fuels, and especially coal generation, have successfully managed to deliver access to power in several other regions: China brought electricity to its 1.3 billion people in less than 15 years, and has now virtually achieved universal access to energy. India, which has yet to bring electricity to around 20% of its population, nevertheless managed to double its access rate between 1990 and 2014. Meanwhile, energy access in Africa was decreasing. Why?

One reason has been the astounding population growth rate of SSA, more than double that of India and two to five times that of China in the same period. As the population steadily grew, the number of people who received energy access was simply lower than the number of births. Yet, the situation is more complicated, and is influenced by several peculiarities of the region. SSA countries share a chronic difficulty in developing large infrastructure, due to political instability, inefficient governance, institutional weakness and corruption and the inability both to gather enough domestic resources and to attract foreign investments. Roads, telecommunications, public transport and many other sectors have been victim to the same difficulties faced by the energy sector, which had and still has a tough time in finding the huge funds to develop and run power plants and the corresponding network.

Yet perhaps the greatest challenge is the continent's diversity in conditions and capacities. Africa is very large: three times as big as China, it is in fact almost the same size as China, the USA, India, Japan and most of Europe combined – with less than a third of the population. Its population is dispersed between urban and remote areas which makes delivering energy in SSA much more difficult than in other regions. For example, in many countries, such as Ethiopia or Democratic Republic of Congo (DRC), rural households are often kilometres apart. Grid extension to these remote areas is often impractical and too expensive for the people living there. But, this diversity also represents opportunities for different responses to energy access, such as generation, distribution and connectivity at different scales (grid and off-grid) through a variety of delivery mechanisms, including decentralisation.
This is the mix of factors that together explain the past decreasing trend in access to power in SSA, and which has seemed to doom the region to never-ending energy poverty. This curse was nevertheless perhaps broken in 2014.

A tipping point in energy access for Africa?

According to the IEA, 30 million people have actually gained access to electricity in Africa in only three years (2014-2016). This represented 5% of the total African population without access to power; a radical improvement in a short time, which is the result of an electrification rate three times greater during 2012-2015 than in the previous decade. Meanwhile, some countries were doing even better: Kenya was tripling its electrification rate (from 20% to 65%) in only four years (2012-2016), with Ethiopia more than doubling that indicator (from 20% to 45%).

The change was powered by an astonishing growth in renewables: installed capacity increased by 18% in just three years (2014-2016), according to the International Renewable Energy Agency (IRENA). Even if large hydropower covered the majority of new capacity, the greatest changes in relative terms have been generated by wind and solar energy. In 2014, IRENA reported more than a doubling in solar photovoltaic (PV) installed capacity in SSA: a 900 MW increase in merely one year. Onshore wind grew from 1,157 MW in 2012 to 3,862 MW in 2016 – more than three-fold in five years.
The clean energy revolution in Africa is also set to continue as forecasts from the IEA point out that, if universal access to energy is to be reached, 78% of all electricity generation will have to come from renewables, 58% from solar alone. Coal, which has been the backbone of the electrification of Asia, Europe and North America, will represent a mere 7%.

SSA is leading the way to a clean energy future in Africa due to global trends and regional characteristics. At a global level, solar PV and onshore wind are now the fundamental components of the energy revolution, a process likely to extend and radically transform the global economy: the renewable energy transition. Indeed, the shift from fossil fuels is proceeding at an unprecedented speed, as costs for solar have dropped by 80% in the period 2010-2015, and for onshore wind by 40%, making the sources as cheap as, and often cheaper than gas and coal. Cheaper renewables has led to a great expansion of these resources: in 2015 the renewable network REN21 reported that new installed renewable capacity was greater than all fossil fuels combined for the first time in history. In 2016 it was 9% bigger than the year before.

Technological changes, the expansion in the production and installation of millions of solar panels and thousands of windmills in the US, Europe and China, combined with the technological maturity of solar and wind energy, are the causes for such a momentous change in the past five to ten years. As renewables began providing a cheap and available energy source, SSA immediately benefitted from the global revolution, and tenders to build solar and wind plants registered some of the lowest contract prices in the world. Renewable energy projects in Kenya and South Africa are for instance now competitive with coal plants; in 2010, the World Bank was still stating that its contribution to coal plants in South Africa was justified because of lack of 'feasible alternatives'. Now, the situation has radically changed.
At a regional level, other benefits from renewables help explain why SSA has achieved such remarkable progress. Unlike fossil fuels, which are unevenly distributed among African countries, virtually all of these countries share extensive wind and solar endowment. All major energy agencies agree that the potential of renewable energy sources is several times higher than current consumption. In addition, such resources are mostly destined for local consumption; unlike the situation with fossil fuels, African countries do not have to choose between exporting these resources or using them domestically. Another specificity comes from scale, as solar PV and wind energy have limited scalable economies when compared to coal generation, for instance. As they require smaller, more fractioned investments, this could be a possible transition solution to the chronic challenges faced by African countries in developing large infrastructures.
Above all, the different ways in which renewable generation can be applied represent the greatest advantage for these resources. Indeed, renewables are also expanding in the region as large utility-scale plants, which supply the national grid – this is the case for several provinces in South Africa, for instance, or the massive 310 MW wind project in Lake Turkana, Kenya. It is also changing the structure of several national energy systems; in 2015-2017, thanks to the Last Mile Connectivity Project alone, the Kenyan grid provided electricity to an additional 1.5 million people living in rural areas.

Yet, the breakthrough to achieve universal access to energy in Africa will have to include off-grid solutions, such as mini-grids (small networks including energy generation, storage and distribution, destined to villages or industrial or farming clusters) and solar home systems (stand-alone generation for houses and farms). These offer an alternative to the often insupportable expenses of extending the grid to populations that are too remote or too dispersed to be connected in an economically sustainable way.
Mini-grids and solar home systems had in fact existed years before the recent renewables boom. As solar PV costs fell, and their efficiency increased, mini-grids no longer had to rely on generators, and thus on diesel supply which, in addition to being polluting, was expensive and difficult to ensure. The combination with other, non-intermittent renewables, such as mini-hydro power, or with new energy storage solutions (another technology in great expansion, in particular for batteries), reduced the im-

pact of intermittence and the need for back-up generators. Meanwhile, the development of more efficient solar PV technologies allowed for the spread of solar home systems that even poorer families could afford, and which were also available for other kinds of uses: sewing machines, vaccine refrigeration, water pumps for irrigation and domestic use, and many others. Solar home systems offer a wide range of applications, which explains the dominant role the IEA gives to off-grid generation in Africa in the future: the agency suggests that decentralised renewables represent the majority of new generation required to grant universal access in SSA by 2030. All of this is linked to the mobile revolution in Africa: as in 2016 two-fifths of the SSA population had mobile phones, many providers are experimenting with "pay-as-you-go" systems, in which the cost of energy from mini-grids or solar home systems is paid via mobile phones based on consumption. These solutions make payments automatic, reducing the costs of collection and the risk of non-payment, thus making energy easier to access for poorer consumers.

Unlocking Africa's power

Providing SSA with universal access to energy will radically change the region. Perhaps more: it could be the fundamental enabler for its long-awaited development.

The economy will be the first beneficiary of the shift towards a greater electrification of the continent. Lack of power has been indeed the primary brake to the development of African industry, not only because electricity was not there, but also because of its unreliable supply and high cost. As productive activities could not be diversified, economies became more dependent on the few businesses which could be developed: agriculture, mining and thus export of natural resources. Such activities not only involved a minor fraction of the African population, with rare opportunities for education and improvement, but also took a great toll on the African environment, and ultimately led to the inherent fragility of its economy, which has been widely exposed to the fluctuations of commodity prices worldwide. As cocoa or oil prices fell, so did African economies that were not able to rely on a national industry or on services. Not by chance, this has been one of the main causes behind the recent slowdown of GDP growth in SSA.

Agriculture has been impacted by lack of power as well. Without machinery to process food, and refrigerators to store it, data from Africa Progress Panel show that one third of all African harvests is currently wasted. Mills and wells running on diesel, or human or animal power, are extremely expensive and inefficient in SSA, and this reduces the already low income of farmers throughout the region.

Full, reliable and cheap energy access would help solve this, with a massive impact on Africa's growth. In its Africa Energy Outlook, the IEA indeed estimated that each dollar invested in the African energy sector could boost African GDP by 15 times. The positive impact of such an energy revolution will in addition extend to several other sectors. Healthcare would greatly benefit from full energy access, since less than 30% of the health centres in the region have electricity. Spoilage of vaccines and medicines, lack of diagnostic equipment, and the use of diesel-run refrigerators (dangerous for those affected by tuberculosis and other pulmonary diseases) are all issues that universal, clean access to energy would solve. This shift would also deal with another health problem: that of premature deaths from the use of kerosene and traditional biomass (charcoal, wood, faeces) in indoor environments. Indoor pollution is a serious threat to Africans' health; if we consider also the lack of clean cooking, the number of premature deaths rises to more than 3 million. This is more than deaths due to malaria and, according to WHO forecasts, will be more than deaths due to HIV by 2030, if nothing changes.

These issues also affect gender equality; gathering wood for lighting and cooking takes up to 5 hours per day in countries such as Burkina Faso, and up to 3 hours a day in Kenya – activities that women and children (especially girls) are in charge of. Indeed, according to UN data, if SSA had full access to energy and clean cooking, women would save one entire month per year.

The impacts extend even further. Universal access to energy would also help tackle deforestation, which is also extensively caused by the use of wood for energy purposes. The literacy rate would improve; illiteracy is greater where access to power is lower and schools have no electricity, as in Niger, Mali and Ethiopia (all countries with less than 10% powered schools and an electricity access rate lower than 50%). Children are often busy with gathering wood and water, thus reducing the time available for class attendance. Adults, particularly farmers, cannot attend evening classes because of lack of light, and thus miss the opportunity for further education, or even to simply learn how to read and write.

A powered Africa would thus unlock value in many different ways as electrification would contribute to reducing inequalities and gender disparities, and would put less pressure on the environment. Decentralised generation will have a positive impact on the governance of African countries; it will allow for a greater involvement of local communities, shaping the energy system relative to their specific needs, reducing corruption and political interference which often undermine the functioning of highly centralised energy frameworks in countries with political systems lacking transparency and a solid governance. It will make Africa richer and more equal, in a sustainable way: a change that could impact not only Africa, but Europe as well.

One of the possible solutions to the migration issue is at stake here. Addressing the root causes of the phenomenon is important, particularly regarding political instability and lack of economic opportunities. Energy access can certainly create conditions for economic opportunities, higher productivity and employment thus creating stable conditions for improved livelihoods of populations in their communities and countries of origin. By way of illustration, two and a half million jobs could be provided by the power generation sector alone, according to McKinsey.

The destination is thus clear, both for Africa and for the rest of the world. Yet, the path ahead is still very long.

The way forward

The recent increases in access to power in SSA have indeed shown that reaching full universal access is possible. Yet, it is not certain when this will be achieved.

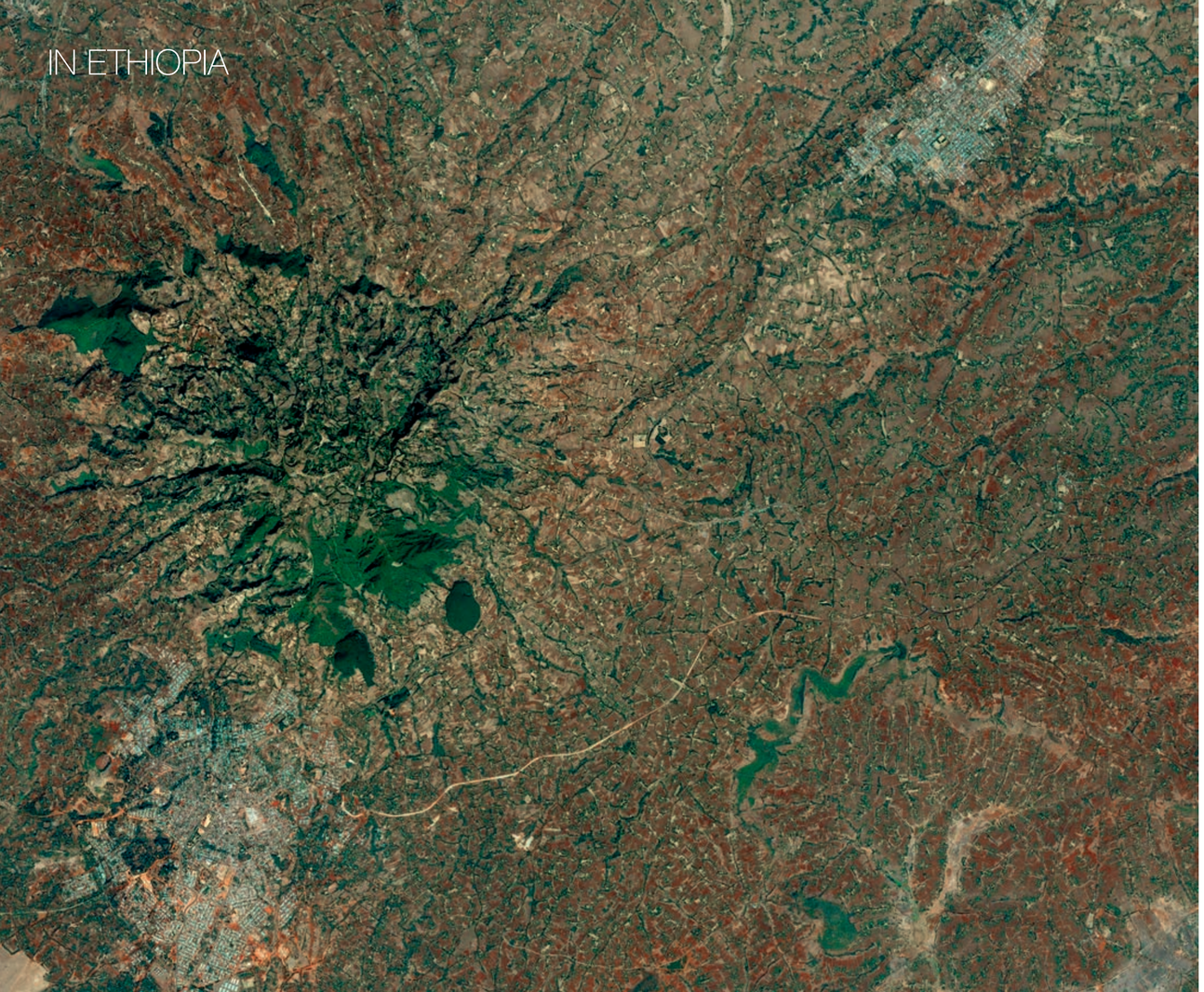
IEA scenarios for the years to come show that the positive trend of electrification of SSA can be short-lasting, if policies and investment flows do not change; in a few years population growth will again overcome the number of people gaining access to power. Furthermore, if renewables are not adequately supported, SSA will lag behind the rest of the world in the energy transition. It will then be easy for many African countries to give in to the temptation of coal, a widely available, apparently cheap and familiar energy source, which already interests several African countries. South Africa is divided between its renewable ambitions and the expansion of its coal capacity to increase stability in the energy supply and reach the 15% of its population still living without electricity – the reason behind massive coal projects in the country, such as the Kusile and the Medupi Power Station. Kenya, one of the African countries focusing on both off-grid and large-scale on-grid renewable generation projects, has been debating the construction of the Lamu coal power station. The 1,050 MW plant would be located just 20 km away from the Lamu UNESCO heritage site.

Assuring a future for SSA's access to power and its role in the energy transition will require a significant but not undoable effort. First, a critical amount of investment will need to be directed towards the power sector of SSA: IRENA's estimate amounts to 70 billion dollars a year from now to 2030 for full development. This is much greater than the 3.8 billion allocated to the sector as a whole by African governments in 2016. Even if such efforts were to receive a significant domestic boost, it will not be enough for a full shift to universal access to power. The collaboration of other players such as institutions and countries already heavily involved in the sector will thus be required: the World Bank, the African Development Bank, the US, the EU and China (which, according to the IEA, accounted for 30% of new capacity additions alone and 13 billion USD of energy investments in the region in the period 2010-2015). Yet, decades of cooperation policies which failed to bring power to Africa have shown that universal access will not be provided by direct public foreign investments – in other words, it will be impossible to depend on the political and economic budgets of the governments of industrialised countries to fully electrify SSA. International financial institutions, donor countries and similar entities will instead have to provide the guarantee for private investments, to reduce the risk perceived (and thus the risk premium paid) by investors to develop renewables in Africa. Such de-risking activities will address factors hampering the development of African countries – corruption, currency risk, political instability and others – as well as renewables themselves, whose novelty still hampers the trust many African governments place in these resources. A shift in the traditional attitude towards development and cooperation will thus be required: from a donor-receiver relationship, to a wider partner-to-partner collaboration, in which international private sector actors do not join the renewables revolution in Africa simply because it is convenient for them. An example of an approach that is already at the core of some international programmes is Obama's 2013 Power Africa Initiative, which aims at using 7 billion dollars in public funding to leverage 54 billion in private investments to the SSA power sector. More recently, the 2017 EU External Investment Plan expects the € 4.1 billion contributed by the European Commission to leverage € 44 billion by 2020, with a significant focus on sustainable energy projects.

Changes will be required also on the domestic side. Indeed, renewables not only work best in countries where there are plenty of natural resources, but where the energy system is the most solid for their integration. On-grid intermittent renewables, such as solar and wind, need to be integrated in the system and compensated by non-intermittent sources (hydro, geothermal, gas), providing flexibility to avoid blackouts when sun and wind are absent – and for this, an expansion of the grid will be necessary. In addition, off-grid solutions should be cheap enough to promote energy consumption in areas where power has always been missing, and thus where people have yet no use for electricity. Energy tariffs should be designed so as to include the social costs of polluting sources, as in the case of coal. Government policies should be stable and fit for renewables, so as to further attract foreign investors. In many cases the regulatory framework will have to be rebuilt. Professionals who run institutions, design and implement policies will need deeper training: from engineers and technicians to economists and energy regulators. International cooperation could be helpful also with this, through extensive capacity building aimed at training the new generation of Africans, who will develop and, most importantly, autonomously run the new African energy sector.

Indeed, the real novelty of the sustainable energy revolution that Sub-Saharan Africa could achieve, is that it could be a truly African phenomenon. It will not be meant to exploit resources destined for export, but to build a new generation of energy consumers, who will use the newly accessed power for their businesses, their education and their health. It will provide the instruments for development to people who now have little choice between subsistence agriculture and migration. It will also make the difference between the constant economic instability looming over Sub-Saharan Africa, perhaps offering a chance for political security through economic prosperity. All of this in a way which will be sustainable from an economic, social and environmental point of view, promoting local employment and the reduction of inequality.

This would be an energy revolution for all; as a famous African proverb says, the sun does not forget a village just because it is small.



A DARK AFRICAN NIGHT

The daily journey of Elias Tesfaye, and that of his fellow researchers at the non-profit Wolayita Development Association (WODA), seems to follow the extension of the electrical network in the region. It starts from the city of Sodo, in Southern Ethiopia, with its shops and lightened asphalt streets, along the dusty roads that lead to the small towns, the provincial centres which are the last outposts of the national grid. Later, here and there the connections manage to reach some villages and schools, but only a few kilometres further along it is dark again. And here Elias' work begins.

Elias is one of the researchers working in the Wolayita region of Ethiopia. His work aims to foster economic development in the area, and a key part of it consists in providing access to power to the population which still has none, the majority in the region. He works in cooperation with Italian and European associations, such as Comitato di Collegamento di Cattolici per la Civiltà dell'Amore (CCCA), and he is thus often accompanied by foreign engineers, like Riccardo Del Citto from the Rome-based University Sapienza. They work together to understand the energy needs of the population living in the region with two purposes: their first aim is to grasp the extent and impact of the lack of access to electricity, and the second is to design a system to generate power which is suited to the specific features of a low-income population, widely scattered on the territory. This is meant not only to offer a solution which fits the local, mostly agricultural economy, but which is also able to survive independently from external support in the years to come.

Their journey thus goes through the different landscapes of the Wolayita region, from the greenish lowlands to the rocky highlands of the Ethiopian plateau, at more than 2000 meters above sea level. The focus groups and individual interviews which Elias and Riccardo lead bring forward a variety of energy needs: farmers complain about the fees they have to pay to grind wheat with diesel-powered mills, families about the cost of kerosene.

Only some of them appear to be aware of the danger posed by the fumes of biomass and kerosene burnt inside small huts and mud houses. Yet, most kitchens have dishes and other houseware soiled by smoke and oil, and the walls are covered in black where the torches are.

As they go from town to town along dry-weather roads or among the giant excavations made by Chinese companies to build major roads in Ethiopia, other energy needs are reported to them: the Gale Wargo health centre complains about lack of electricity to treat patients at night, perform laboratory analysis and even store medicine. Even the community life is hampered by the lack of power: celebrations for children's day at the gospel church of Boke Kalehiwota village took a significant toll on the church's budget due to the rent of a generator and the purchase of fuel to power instruments and amplifiers.

Access to electricity could revolutionise the status of the region. A few farmers, such as the Tantu family, have decided to invest in it mostly through solar home systems. Yet, the main challenge would not be to spread the technology for energy access, but to be able to build a system which replicates itself. Elias' job is thus to start local enterprises which can install and repair solar panels, and to support the businesses growing with access to electricity. Developing a stable demand for electricity – this is going to be the next challenge for Elias, Riccardo and the Tantus' village community.

◀ Wolayita region, Ethiopia.

The Omo river artificial basin, located in Southern Ethiopia. ▲

An Ethiopian girl standing by the Omo river artificial basin. ▶

Three young men on the excavations of new roads, on the hills near the Omo river. Building new roads is the precondition to extend the electric national grid, yet this leaves behind the unconnected villages.

▲ A group of young Ethiopians in the Wolayita lowlands, before the beginning of a focus group with Riccardo Del Citto from Sapienza University.

◀ Ethiopians in a day market in the Wolayita region. These markets are often overcrowded, due to the prohibition of night markets because of the lack of streetlights, which makes these nocturnal gatherings too dangerous for the population.

Riccardo del Citto discusses with the village community the malfunctioning of a small solar panel powering an emergency telephone line. ▲

A focus group under a tree in the main square of a village, in the Ethiopian highlands. ▶

A kerosene lamp used to light up a diesel-powered mill in the Wolayita region. Without electric power, kerosene is the most common fuel, despite the high costs and the dangers it poses to health.

▲ A group of young Ethiopians in front of the Omo river banks.

◀ A young Ethiopian man records a moment of a focus group organised by the Italian and Ethiopian managers in charge of the electrification projects, to understand the energy needs of the area.

A moment of prayer in the Gospel Church of Boke Kalehiwot. On National Children's Day in Ethiopia, the local community had to rent a diesel generator for the special celebration during the mass. ▲

A school in the Wolayita region, at the end of the school day for children. Without electricity, the building cannot be used at night for evening school for adults who work during the day. ▶

An Ethiopian girl in a village in the south of the Wolayita region starts a fire to prepare dinner. ▲
A group of Ethiopians waiting to hold individual meetings about their energy needs with Riccardo del Citto. ▶

A woman from the villages of the Ethiopian highlands, during an individual discussion on the energy needs of her family.

THE CROSSROADS OF THE ENERGY TRANSITION

When it comes to renewable energy transition, Kenya is one of the most advanced and promising countries in Sub-Saharan Africa. It is a story that starts from the chaotic streets of the capital and goes all the way to the furthest regions of a country almost twice the size of Italy.

One of the journey's first stops takes us to a laboratory in Nairobi, more precisely the newly opened research department for renewable energies at Strathmore University. The lab's ongoing work focuses on something that leading European and American research centres are missing: the particular characteristics of Kenya and of Sub-Saharan Africa. This is a large part of the activities of Sarah Anyango Odera, the woman who manages the centre together with other researchers. 'European standards are set on average temperatures which are five to ten degrees below the Kenyan average', she says. Light bulbs and other appliances are designed for a grid which is far above the possibilities of African consumption. 'Here we do research keeping in mind the people who will use the electricity we provide', she adds. This is the added value of developing renewables for Africa, in Africa.

These potential new consumers live in the countryside, but also in Nairobi itself. This is the case for Korogocho, a slum where 200,000 people live in an illegal dump smaller than 2 square kilometres, where toxic fumes constantly arise from burning waste. Electricity also plays an important role here: Michael Otieno and his sister Martha tell us that the neighbourhood has changed since street lights and electricity appeared. 'Korogocho's nights are less dangerous than they used to be five or six years ago', they say, and people can now open small businesses, have hope for improvement, in a slum which had been ravaged by crime and unemployment for decades. Yet, more has to be done, since poverty still pushes people to steal electricity and share it (for a fee) with the neighbours: this is 'mulikamwizi', meaning 'stealing to share' in Nairobi slang. This is an issue which cheaper electricity can solve, and here transitioning to renewables could be the solution.

Yet, the most evident progress delivered by the renewable energy transition lies in the borderlands of Kenya. Talek, for example, is a town located a few kilometres away from Tanzania. It is Masai land, belonging to a people of breeders who refuse to cultivate crops and who have always had a transitional idea of property – they stay in a place for a few years, perhaps a generation, and then they simply leave. Talek Town is a crossing point which looks like an African Far West. A series of oddly named hotels, like the Deep Cooked or the Jamaica Hotel, welcome coach drivers, while the tourists arrive by car and go to the luxury lodges. They come by the hundreds during the migration period and represent a significant source of income for many people in town. Yet, tourism alone is insufficient to keep the town's local economy running.
Thanks to a local mini-grid recently installed by GIZ, the German agency for cooperation, the economic situation here is changing. There are new small shops and businesses that now stay open late, as well as workshops for plumbers and electricians. Meanwhile, hotels have already started buying a few television sets and lights, brightly coloured for outside and white for inside.
With the mini-grid, access to electricity has pushed the town's economic growth forward, a process which would have otherwise taken longer through grid-extension. Even if tempted by the desire to move, many Masai people are still living on the borders of Talek, in farms often without electricity, and going to town for the market or to charge the phones they use to pay for all sorts of services. It is a life halfway between the old nomadism and the stability of the town. In such conditions, a typical Masai like Dee Tome, who is also the chairman of the committee running the mini-grid, is still teaching his son how to kill a lion or how to handle a spear, because 'those are things you need to know'.

Yet, change is already at the gates of Talek, and of Kenya.

◀ Talek Town, Kenya.

The highlands of the Masai Mara park. ▲

A technician working on the connection to GIZ's mini-grid for one of the many mechanics of Talek. ▲
Children playing at the gates of Talek, close to the repeater which gives a 4G coverage to the area. ▶

▲ The inside of the Seventh Wonder, one of the many bars which use the connection to the mini-grid to power fridges, lights and TV sets.

◀ The Jamaica Hotel, a small hostel for the drivers who often go back and forth from Nairobi to the Masai Mara park, enlightened thanks to Talek's mini-grid.

The sons and daughters of Dee Tome, a young Masai and chairman of the committee managing the mini-grid.

A routine control of the solar power plant's batteries in Talek. ▲
A technician working on the poles of the photovoltaic power supply system of GIZ's mini-grid. ▶

A young driver and tourist guide to the nearby Masai Mara's park, in Talek. ▲
A young Masai girl outside her shop selling electric supplies to connect to the mini-grid. ▶

An overview of the Korogocho slum from the opposite side of the dump. ▲

Kevin Omondi and Emmanuel Omondi, two inhabitants of Korogocho, putting on a light saving bulb, as requested by their landlord.

◀ Sarah Anyango Odera, researcher at Strathmore University, and her colleague, testing innovative light bulbs at the Energy Research Centre's laboratory.

LAKE VICTORIA'S OWN TORTUGA

Reaching the Ssese Islands takes three and a half hours of navigation through Lake Victoria on rough boats made of old Congolese wood. One of the most prominent islands is Kitobo, where the first impression is of lush vegetation: visitors are welcomed by palms and avocados echoing with toucans and monkeys. Upon landing, however, the islands show a different face: unexpected activity and the constant movement of both fishermen and new inhabitants, arriving to open small businesses and shops. Musoke Livingstone, the owner of all of Kitobo, says that upon returning from a two-week trip, he has already noticed ten new houses.

The reason behind this dynamic transformation is a solar mini-grid plant which was built by the Italian company Absolute Energy. The plant has allowed for a stable and cheap electrical connection: electricity now costs one-third what it did when it was supplied by the diesel generator formerly powering the town, and which was operational only at certain times of the day. This mini-grid is considered one of the most advanced in all Sub-Saharan Africa, and is composed of 880 solar panels of 250Wp each, four vanadium battery packs (each as big as a container) and a back-up generator. All of this provides the stability needed by the population of the island, of whom 90% (circa two thousand people) are now connected to the mini-grid.

Life in Kitobo is now linked to energy. The small streets among the metal and wooden shacks resound with the noise of drills and electric saws working at all hours, and the Ugandan reggae music issuing from the bars. The small shops shine with the lights, stereos and popcorn machines they proudly display. Soon ice cream machines will arrive, too.

Electricity is a novelty which is changing the shape of the island. It represents a fundamental aid to the development of the fishing industry, traditionally Kitobo's main activity. Boats can be repaired even at night and be ready to leave before dawn.

A stable connection will also enable the functioning of the much desired ice machines.

In addition to this, electricity is also key to diversifying the activities of the island, providing an alternative solution to the drastic decrease in fish, an unsolvable problem for many communities on Lake Victoria. Additional job opportunities also reduce the seasonality of work, which used to empty out Kitobo as the fish migrations changed. Investments in food processing machinery are increasing, as well as infrastructure to provide services to other islands in the archipelago, all without electricity with the exception of Bugala, the largest. Oscar Omdia, a local businessman, had long since planned to leave the islands because of the scarcity of fish and the hardship in developing new activities. Electricity arrived right before he packed, and now he has great plans for his life in Kitobo. Many are following Oscar's path.

As a consequence, in a few years Kitobo could become significantly different from the pirate-style fishing cove that it is today. Many are considering constructing permanent buildings, and there is talk of building a central hospital also serving other islands. Yet already today, the lights of the two cinemas shine brightly from inside their metal shacks, the town radio blares out across Kitobo, while people come and go on the pier crowded with white herons. All of this tells a story of change that has started and has no intention of stopping, using only renewable energy sources.

◀ Ssese Islands, Lake Victoria, Uganda.

Kitobo at dawn, seen from the neighbouring Island of Banda. ▲

Ronald Bogere, a young fisherman of Kitobo, and his partner setting hooks ready for the morning fishing. ▶

A typical household of Kitobo, seen from the windows of one of the four churches of the town. ▲

Francis Ekapoloni, technician responsible for the connections between the mini-grid of Absolute Energy and the houses of Kitobo, working on one of the town's poles. ▶

Kitobo's people in front of a shop selling MTM Mobile Money top-ups, the payment method via cell phone also used to pay electricity bills. ▲

Kitobo's residents waiting for the opening of one of the several shops offering phone charging and DVD rental, and which opened shortly after the mini-grid started functioning. ▶

Ndalike Kamhati, a customer service employee of Absolute Energy, during an evening check. ▲
One of Kitobo's main streets at night. ▶

▲ A fisherman from Kitobo heading off-shore for night fishing.

◀ One of the mechanics of Absolute Energy working at night, thanks to the electricity supply of the mini-grid.

Ronald Bogere having lunch in a cafe of the island, ▲
while waiting to get back the nets he had released at dawn.

One of the two cinemas in Kitobo broadcasting the European Champions League. ▶

◀ Geoffrey Mangali, a technician of Absolute Energy's power plant, heading towards the panels for a last check.

Geoffrey Mangali and Jonathan Makanga, technicians of the mini-grid ▲
of Absolute Energy, performing the routine cleaning of panels.

THE FACES OF AFRICA

Landing in South Africa reveals a renewable energy transition that appears quite different than in the rest of Sub-Saharan Africa. Cities are lighted up and 86% of the population has access to electricity. Here, as well as providing access to those still without power, renewables are augmenting a system that is still unstable, when compared to Western countries. Unlike the mini-grids or solar home systems being implemented elsewhere in Sub-Saharan Africa, however, massive on-grid solar and wind power is a real possibility in South Africa, where the electricity network is far more developed than on the rest of the continent.

The Northern Cape province, for instance, is an immense dry region whose few towns are scattered around the red-soil landscape, and which until a few years ago was served only by a couple of hydro plants. Now, landing in the small airport of Kathu, right below the Serengeti desert, provides a panorama of wilderness studded with shiny flats of solar panels: from above, the new solar plants look like small lakes, while from the ground they seem endless. The panels require the attention of engineers, who are often trained abroad in Germany, Italy or Spain, as is the case for Maxwell Sibayoni, an engineer at Enel Green Power's Adams solar plant. While the maintenance work necessary for renewable plants is much simpler than it is for coal, it can be trickier for windmills than for solar plants. Repairing the 90-meter-high white towers on the windy shores and grasslands of the Eastern Cape, for instance, requires special technicians. Brian Galvin has quite a spectacular job: he started as a mountain climber, and now he travels the world to repair windmills and train local technicians – in this case Anwar Collins, a South African man from the province. They go up, fix their ropes, and then slowly float down to the blades. 'After a few times it stops being scary and it becomes like driving a car', Brian says.

In South Africa, solar and wind power are combating the temptation to use coal, which just four or five years ago was seen as the only option to extend the power supply and avoid costly blackouts for cities, mines and industries. And, besides their role in the energy mix, renewables are contributing to the difficult social transition that South Africa is still fighting from the apartheid period.

'South Africa is still a pyramid', says Keabetswe Dichabe, a young black entrepreneuse from the Northern Cape region. She explains that everyone at the top has got more than everyone else at the bottom, even though these represent the majority. 'This is true for all resources in our country', she adds, 'including energy'. Cities, where mostly white people live, have streetlights and power; in townships, where black people are, the electricity supply is less stable and they often live in the dark. In the countryside there is simply no electricity. Yet, power is needed for the development of businesses and agriculture, and thus for the emancipation of these areas hit by high rates of criminality and unemployment. This need could be satisfied by renewable plants, which are smaller than those powered by coal or gas, and thus can be delocalised to reach distant communities. As the supply of electricity from renewable energy sources becomes more abundant and cheaper, this could help even out the strong social differences in the country.

The rise of renewables is part of a greater phenomenon, which could truly change Africa, and which is coming from Africans themselves. Keabetswe had almost fully qualified as a lawyer in Johannesburg while her business partner, Phenyo Nkoi, was already working as an engineer in a multinational pharmaceutical company. They both quit their job and came back to their townships near Kuruman, to start local enterprises and give something back to their community: hydroponic solar-powered farms, for instance, or alternatively, shiny bars in the townships to attract both white and black people. They are not alone, they say, and feel they are part of a movement bringing electricity, jobs and health services to the forgotten regions of Africa. 'A movement', Keabetswe says, 'which in twenty or thirty years will change the face of South Africa, of Africa, and the world'.

◀ Gibson Bay, South Africa.

Brian Galvin, rope access technician on a wind turbine at Enel Green Power's ▲
wind farm in Gibson Bay, in the Eastern Cape region of South Africa.

Wind farms between Gibson and Oyster Bay, Eastern Cape. ▲

Farms near the town of Hankey, Eastern Cape. ▲

A fully electrified township near Port Elizabeth, Eastern Cape. ▲

Lungile Kato, alias DJ Champ, in his house in Hankey, Eastern Cape. ▲

A farmer working in a social farm sponsored by Enel Green Power's Adams solar plant, providing food to the nearby Vergenoeg village, near Kuruman Town, Northern Cape. ▶

Sibahle Jessica Blouw and her friends and fellow singers. They live in the town of Hankey and often connect to the internet through the “Free Wi-Fi Connectivity” project sponsored by Enel Green Power’s Gibson Bay Wind Farm. ▲

A young South African outside the library of Hankey, using one of the free Wi-Fi spot sets in the town. ▶

◀ Performers during a community celebration in the Gantatelang village, in Gasegonyana local municipality of the Northern Cape.

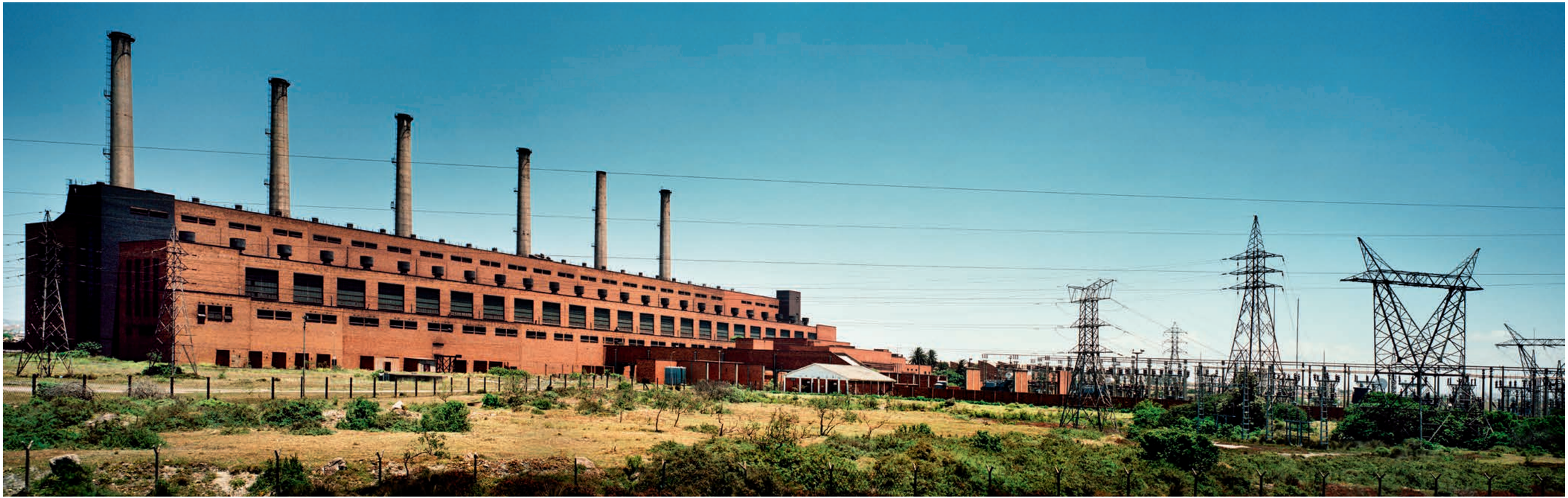
Phenyo Nkoi, a young South African entrepreneur, with his collaborators in his hydroponic farm in the south of Kuruman Town, Northern Cape. ▲

One of the staff members of Enel Green Power's "Free Wi-Fi Connectivity" project in Hankey, Northern Cape. ▶

The Workshop Ko Kasi at night, an alternative bar opened by Phenyo Nkoi near the town of Kuruman, Northern Cape.

▲ Workers substituting a solar panel in Adams solar plant in Kathu, Northern Cape.

◀ Brian Galvin descending from a wind turbine that he had just repaired in Gibson Bay, Eastern Cape.



A decommissioned coal plant near Port Elizabeth, Eastern Cape. ▲

▲ A young man working at a car wash service in Kimberley, Northern Cape.
◀ A diamond mine near Kimberley, Northern Cape.

The upper part of the town of Hankey, Eastern Cape. ▲

A view of Port Elizabeth, Eastern Cape, from the old lighthouse. ▲

2030: THE TANGIBLE DREAM OF UNIVERSAL ACCESS TO ELECTRICITY

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1. Central Africa refers to Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea and Gabon.
2. East Africa refers to Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan and Uganda.
3. West Africa refers to Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, São Tomé and Principe, Senegal, Sierra Leone and Togo.
4. Southern Africa refers to Angola, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.

The vision for 2030 – universal access to electricity

Envision a future not far from now, in which all 1.4 billion people living in the region of Sub-Saharan Africa in the year of 2030 have access to electricity. In this vision, every person has access to reliable and affordable electricity that powers everything from personal devices and household appliances, to public buildings and shared spaces. Access to electricity is undeniably transforming people's lifestyles. Lighting in homes lengthens productive hours into the evenings, allowing children to complete schoolwork. Women living with electricity achieve household tasks with greater efficiency and safety, gaining the time to seek further employment. The option to charge phones, listen to the radio, and watch television more regularly strengthens communication networks and multiplies people's access to information. Fans ease immense heat, and refrigerators enable cold storage of vital food, drink and vaccinations. Hospitals, schools, and other public buildings are better able to provide essential services for citizens as steady access to electricity offers a baseline of operational consistency. Businesses also thrive upon this baseline, avoiding financial and material losses caused by unexpected power cuts. In countless more ways, access to electricity transforms society radically. It serves as a cornerstone of economic development.

This exact vision has been formalized on a global scale as United Nations' Sustainable Development Goal (SDG) 7.1. Ratified by 192 member countries in November 2015, the goal dictates: "By 2030, ensure universal access to affordable, reliable and modern energy services." SDG 7.1.1 in particular addresses access to electricity. For the first time, the international community has acknowledged on paper the importance of access to energy for sustainable development, generating political momentum to address the situation.

This goal is significant for the world, but especially for Sub-Saharan Africa, the region with the highest proportion of people lacking access to electricity, but also a region which has demonstrated promise to progress towards universal access in leaps and bounds. This SDG is aptly timed, as the region is poised for economic growth in the coming decades; gross domestic product is projected to grow at an annual average rate of 4.8% between now and 2030. Energy access is one of many puzzle pieces that must fall into place in order to unleash the region's economic potential. Furthermore, Sub-Saharan Africa is now positioned to pursue energy access with a new paradigm. The region has the chance to bypass historic trajectory of first relying on polluting fuels and inefficient technologies, and move straight to deploying clean renewable supply and energy-efficient technologies.

The reality of 2017 – signs of promise and room for improvement

This is a story of both impressive progress and immense work left to be done. In 2013, for the first time, Sub-Saharan African people gained access to electricity at a rate faster than the rate of population growth, meaning that the number of people without access to electricity in Sub-Saharan Africa has stopped increasing and since declined. This was brought about by an impressive tripling of the pace of electrification in 2012 onwards, relative to the rate between 2000 and 2012. Since 2000, at least 260 million people have gained access to electricity. Despite this turn-around, 590 million people – roughly 57% of the population – remain without access in Sub-Saharan Africa, such that it remains the largest concentration of people in the world without electricity access.

It has been argued that just as there is a two-speed Africa in terms of economic growth there is also a two-speed Africa when it comes to electricity access. While the number of people in Sub-Saharan Africa gaining access has increased in recent years, progress has been uneven across the continent. The first disparity lies between the urban and the rural. Over 80% of those without electricity live in rural areas, where the electrification rate is less than 25%, compared with 71% in urban ar-

eas. This only makes sense given the myriad challenges of reaching communities living far away from the existing grid. There are also stark differences in the electrification rate between countries, even neighboring countries with similar geographic conditions. In 2016, eight countries had an access rate above 80% – Gabon, Mauritius, Reunion, Seychelles, Swaziland, South Africa, Cabo Verde and Ghana – countries lying all over the continent. Most other countries had a rate below 50% while others persistently see a rate below 25%.

Studying Sub-Saharan Africa by sub-region elucidates the conversation about this disparity. For instance, Central[1] and East[2] Africa both had an electrification rate of 10%, which remained roughly in parallel from 2000 until about 2012. The two regions' paths diverge between 2012 and 2016, when six times more people gained access in East Africa than in Central Africa. While each sub-region is endowed with indigenous energy resources, a more stable investment climate and better regional interconnections made it easier for electrification efforts to advance in East Africa. Thus, East Africa is the sub-region which has seen the fastest progress in electrification in recent years. The access rate is now 40%. Since 2000, however, the electrification rate in East Africa has increased by roughly 30 percentage points: each year, over 85 million people have gained access over this period.

Kenya and Ethiopia have shown notable progress as a result of government initiatives, private-public partnerships and international support. The Last Mile Connectivity Project in 2015-17 expanded the national grid to 1.5 million Kenyans in rural areas. The number of connected customers has more than tripled in Kenya since 2012 and the access rate increased from 20% to 65% in 2016. In Ethiopia, the electrification rate improved from just over 20% in 2012 to 45% in 2016. Both Kenya and Ethiopia have flourishing off-grid markets providing access in rural areas. Kenya in particular is now the largest market for off-grid solar home systems (consisting of a solar module with a battery and small appliances like LED bulbs and mobile phone chargers) and solar lanterns in Africa, partly due to measures to remove value-added tax for solar imports, to regulate their quality, and to implement an Off-Grid Solar Access Project. Other renewable sources have also played an important role: Kenya plans to double its total geothermal capacity to more than 4 gigawatts (GW) by 2022 while 6.5 GW of capacity from the Grand Renaissance dam has been under construction in Ethiopia. However, there is still a long way to go to achieve universal access to electricity: there are 56 million people in Ethiopia and 17 million people in Kenya without access, and reliability can be a problem even when grid connections are in place.

Meanwhile, West Africa[3] accounts for 30% of those without electricity in Sub-Saharan Africa. The average access rate in this sub-region is 52%, and the number of people without access has been stable since 2010 despite population growth. Ghana has been one of the most successful countries in the sub-region in expanding access. Between 2000 and 2016, its electricity access rate increased from 45% to 84%, supported by the roadmap for universal electrification by 2020 set out in the 1989 National Electrification Scheme and policies focused on rural communities, though reliability of supply remains an issue. Senegal also has successfully provided access to 5 million people since 2000; its electrification rate increased by over 30 percentage points to reach 64% in 2016. Nigeria has an electricity access rate of about 61%, meaning that some 113 million people have access. However, due to concerns about reliability, 80% of those with connections also use an alternative source of electricity supply, mostly diesel generation. Nigeria is the largest African importer of diesel generators, and back-up diesel generation in Nigeria costs households and business almost $22 billion per year in fuel cost alone.

Central Africa has almost 100 million people without access, 17% of the total in Sub-Saharan Africa. While electrification rates vary widely by country, as a whole its rate is the lowest of all the sub-regions, at just 25% of the total population in 2016, and just 5% of the rural population. Gabon has made spectacular progress, increasing its access rate from roughly 30% in 2000 to 90% today, despite having a relatively low population density. In 2014, the Gabon government announced a policy that seeks to make use of a wide range of approaches to achieve universal access by the 2030s, including the development of small-scale renewable energy projects. Cameroon has also made good progress, with its access rate reaching 63% in 2016, up from 20% in 2000. Democratic Republic of Congo (DR Congo), which has more than half of the population of Central Africa, also has one of the lowest electrification rates – 15%. This means that roughly 68 million people are without access in DR Congo, though it is now planning to tap its hydropower potential, which could speed up the pace of electrification.

Finally, Southern Africa[4] accounts for nearly a quarter of the people without access to electricity in Sub-Saharan Africa. Excluding South Africa, which has an access rate of 86%, the access rate for the Southern Africa sub-region is 31%, roughly double what it was in 2000. Tanzania has seen its access rate increase from 11% to 33% over the last 15 years, having had particular success in creating an enabling environment for off-grid access. A quarter of all households who have electricity access obtain it from off-grid solar photovoltaics (PV): this reflects thriving solar home system and mini-grid markets. Recently there has been a sharp increase in businesses entering the mini-grid market, which serve enterprises as well as households. Namibia is scaling up electrification very rapidly, with electricity now reaching 56% of the population, up from 30% in 2012. Given the disparity between urban (78%) and rural (34%) electrification rates the government's targets focus on rural electrification, aiming for 50% of rural households to have access to reliable electricity by 2020, and 100% by 2030. It is doing so through centralized spatial planning, feed-in tariffs for renewables-based generation, and action to shield the country's supply from fluctuations in the price of imports from the South Africa Power Pool.

Realizing the vision

What strategic choices about infrastructure, business models, investment and policy will be needed to bridge today's reality and our vision for Sub-Saharan Africa of 2030?

The infrastructural expansion will include both grid extensions and decentralized renewable energy sources. Grid expansion remains the primary means of bringing about electrification in the region, as the least-cost pathway to electrification in many locations. Approximately 280 million people are most likely to gain energy access via grid extensions by 2030. However, an accelerated deployment of mini-grid and off-grid electricity sources will be essential to achieving the goal of universal access, especially in service of the rural population. Spatial analysis (conducted by the Royal Institute of Technology in Stockholm and the International Energy Agency) shows that mini-grids and stand-alone systems will together form the source of three-quarters of additional connections, reaching 513 million people – mostly rural dwellers – between 2017 and 2030. The resulting cumulative capacity additions would be 87 GW, comprising 40 GW of mini-grids, 32 GW of off-grid systems as well as 15 GW of additional centralized generation capacity. This means that by 2030, we would see a Sub-Saharan Africa where just under half of the population retrieves their electricity from the grid, while 30% relies on mini-grids and 24% relies on off-grid generation.

Solar PV, mostly off-grid solar cells, will be the most important fuel source. Off-grid solar PV is particularly well-suited for delivering access to rural areas where grid access is impractical or very expensive, and takes advantage of the region's relatively abundant sunshine. By 2030, almost 82% of the rural population of Sub-Saharan Africa who do not currently have electricity would most likely gain access through decentralized solar photovoltaic systems. The second largest fuel source by 2030 would be hydropower, already seeing capacity expansions in many countries. Market trends suggest that Sub-Saharan Africa is poised to leapfrog to an economic development paradigm based on affordable renewables, which could meet almost two-thirds of demand growth over the period to 2020, similarly to how the continent leapfrogged traditional fixed lines and desktops for mobile phones.

This growth of decentralized renewables would be largely enabled by creative business models suited to local conditions, especially those which take advantage of the capabilities offered by widespread mobile ownership. Recently, private sector actors have been stepping in with business models that utilize mobile phones and pay-as-you-go schemes to lower the barriers associated with high upfront costs that have impeded many households from acquiring decentralized systems. The future of decentralized renewables depends not only on a thriving market for solar home systems, but also an increase in the number of businesses entering the mini-grid market. In some countries in Sub-Saharan Africa, more households have mobile phones than have access to electricity. The most popular combination so far has been the pairing of pay-as-you-go with solar home systems. On average, these systems provide customers low levels of power but bundling them with super energy-efficient appliances can enhance their effectiveness and offer more energy services at lower cost schemes. Companies have already started and will continue to utilize mobile networks to provide energy services through pay-as-you-go financing and payment.

Investment patterns would need to reflect the distributions of needed connection types and fuel mixes. Cumulative investment for providing electricity access in Sub-Saharan Africa is estimated to total $454 billion over the period to 2030, averaging $35 billion per year. This would be equivalent to less than 2% of the cumulative investment in the energy sector globally over this time frame. Investment need is roughly evenly split between finance for new power plants and finance for new infrastructure for transmission and distribution. Two-thirds of the investments would need to be allocated towards decentralized options: mini-grids attract 43% while off-grid solutions attract 24%. This corresponds to annual investment of approximately $12 billion for on-grid connections, $15 billion for mini-grid connections, and $8 billion for off-grid connections, in order to reach 800 million more people by 2030.

Finally, policy can play an essential role in supporting new business models, encouraging investment, and integrating forward-thinking planning which will help to optimize the usefulness of the infrastructure built between now and 2030. While some business models are competitive without aid or subsidy, they would have a much greater effect if government policies provide clarity related to grid expansion plans, set appropriate tariff structures, and simplify the permitting and licensing processes. Policy adjustments to provide incentives, such as the elimination of value-added tax on solar panels as was done in Kenya and Tanzania, and better clarity and transparency of policies and programs can encourage investment. Unifying channels for financial grants and subsidies from international donors and multilateral development banks can help to ensure that all potential flows of investment are used optimally, including social capital, grants, impact investing, as well as commercial lenders. For example, the International Solar Alliance, for which the International Energy Agency is a signatory, has undertaken efforts to mobilize over $1 trillion of investments needed for the massive deployment of solar energy by 2030, creating aggregated demand for solar PV and mitigating investment risk.

Policy planning will need to be comprehensive: it will be essential for energy efficiency to be treated as an integral part of energy access policies. For energy to have an impact, it must be affordable and reliable. This is particularly challenging in areas that are sparsely populated and far from an existing grid. Energy efficiency has the potential to improve not only the economics of energy access, but also the reliability and performance of a system. However, too often, developing countries are the recipients of second-hand, inefficient appliances, which

while affordable, limit the level of energy services a consumer can attain. Pairing off-grid systems with super-efficient appliances allows consumers to maximize each kilowatt-hour of electricity and improves the affordability of energy access.

Policy planning will also need to be forward-thinking: decentralized off-grid systems have proven to be effective in many countries at providing access to areas that are too expensive to electrify via the grid in the short or medium term. However, moving beyond a basic level of consumption is likely to require more energy than off-grid systems can provide, and therefore require either mini-grids or grid connection, which also can usually offer less expensive electricity. Mini-grids themselves can be integrated into large networks, if they use compatible equipment. This underlines the need to recognize the dynamic and integrated nature of energy access development, and for coordinated planning which takes account of ways to upgrade existing systems and integrate decentralized systems into the grid if and when the need arises, as is being done in Tanzania and Namibia. Adequate policy planning will enable Sub-Saharan Africa to harness the full benefits of building out electricity access.

Success stories of today blaze the trail for our pathway to realizing universal access to electricity in Sub-Saharan Africa. The region must capitalize on the current political momentum and international attention garnered by SDG 7.1.1, to strengthen and redouble its initiatives. Both grid extensions and decentralized renewable power will need to be constructed, with off-grid solar PV playing an essential role in reaching rural communities. Business models which help to enhance the affordability and reliability of electricity will be essential, including pay-as-you-go models which capitalize on mobile phones as the means for paying electricity bills. Approximately $35 billion of investment per year will make the pathway possible, a small sum in comparison to global energy sector investment. Policymakers will take up an essential role in ensuring the longevity and usefulness of new energy infrastructure, supporting business models, as well as encouraging the necessary investment. With these essential elements, Sub-Saharan Africa has the opportunity to create a new paradigm for energy access over the next decade or so, laying a cornerstone of the foundation for sustainable development.

ENGAGING THE PRIVATE SECTOR TO REVERSE THE COOPERATION PARADIGM AND FINANCE AFRICAN ELECTRIFICATION: ON-GRID SOLUTIONS AND GRID DEVELOPMENT

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1. This relates to annual residential electricity consumption per capita (for those with access). (IEA: Energy Access Outlook).
2. IMF and IEA Energy Access Outlook.
3. South Africa, Cape Verde, Kenya, Morocco, Nigeria, Sudan, Tunisia, Ethiopia, Gambia, Madagascar, Malawi, Niger, Ruanda, Senegal, Tanzania revised their RES target; Burkina Faso launched its first RES Plan; Ethiopia, Zambia, Senegal and Madagascar joined the World Bank's "Scaling Solar" Initiative
4. WEO 2017 Special Report: IEA Energy Access Outlook.
5. WB: Linking Up: Public-Private Partnerships in Power Transmission in Africa.
6. WB: Linking Up: Public-Private Partnerships in Power Transmission in Africa.

Africa's main energy challenge: energy poverty

In almost the entire Northern hemisphere, electricity access is largely a solved issue but it is still one of the most crucial challenges for Africa. It is worth to recall that electricity access is the foundational layer for improving health, education and socio-economic standards. Indeed, the correlation between adequate access to electricity and real economic development is very significant. Industrialized countries such as the United States, Australia, Italy and Germany present high numbers in both variables, whereas all Sub-Saharan countries – except from South Africa – are fairly low.

Sub-Saharan Africa's electricity consumption is far below that of other emerging markets. Average residential electricity consumption per capita for people living in that region – excluding South Africa – is only about 200 kilowatt-hours (kWh) per year, compared to almost 1600 kWh in the European Union[1]. The electricity gap that Africa has to fill is impressive. Electricity consumption per capita is the main driver to unlock the massive improvement of quality of life for millions of people living both in urbanized and remote rural areas.

Today Sub-Saharan Africa hosts 14% of the world's population, but 60% of people without access to electricity: as of 2016, over 1 billion people have no access to electricity at a global level, of which about 600 million live in Sub-Saharan Africa. Only 10 African countries have electricity access rates exceeding 50%, while the remaining ones have an average grid-access rate of barely over 25%.

The continent's energy development lags behind the growth of its population and socio-economic needs: energy is in fact an instrumental right, as a condition for access to clean water, health systems, education and productive activities in developing countries. In other words, energy is a key tool to guarantee fundamental human rights.

Even though the electrification efforts in Sub-Saharan Africa are accelerating and population without access to electricity decreased for the first time in 2014, these efforts will be overshadowed by population growth in the next years. By 2022, Africa's population is expected to grow by 200 million people reaching 1.5 billion people living in the continent. Most of this population growth will take place in Sub-Saharan African countries. Over the next 5 years, the expected African GDP growth rate is 8%, with electricity demand expected to soar by 25% hitting around 800 TWh[2].

Forecasts on Africa's future electrification rate differ when compared with other developing regions such as Asia and Latin America, where it is predicted to reach circa 99% by 2030. In fact, the expected electrification rate of Sub-Saharan Africa will only reach 59%; by then, 90% of the 700 million people lacking access to electricity will live in this part of the world, according to current trends and policies.

These figures call for concrete actions and urgent measures to be implemented in order to meet this rapid increase of power demand. Setting the final goal to the actual delivery of electricity requires a remarkable effort for a holistic strategy and planning definition of generation, transmission and distribution infrastructure to be also matched with the growing urbanization trends.

In terms of generation, the technology mix will be the result of the energy sourcing strategy that different governments will implement taking into consideration the legacy generation mix on the one hand and the infrastructure and generation investment opportunities unlocked by the technology evolution on the other hand.

In fact, even though electricity in Africa is mostly produced from fossil fuels, over the last five years renewables have started to gain ground. Since the Paris Agreement in 2015, many countries have launched or reviewed their renewables development programs[3]. The reasons behind this choice are both economical and strategic. Declining technology costs, resource abundance, and stronger support from international financing institutions are driving the roll-out of renewable power in Africa. Moreover, the benefits of sustainable energy development would help African

governments to strengthen energy security, reduce energy import bills and diversify the energy mix, acting as a basis for long-term prosperity. In addition, access to clean and sustainable electricity would result in the creation of social and economic development opportunities for the continent, such as industrial growth, local jobs creation, entrepreneurship promotion, circular economy and gender equality.

The answer: renewables deployment

There is a vast untapped potential for renewable energy all over the African continent: from hydro resources concentrated in the central regions, to the widely spread intense solar irradiation and abundant geothermal reservoirs in East Africa. In terms of potential for electricity supply, the continent can take advantage of the fast deployment of renewable technologies to address electricity access and security issues.

Moreover, nowadays building a new renewable plant is cheaper than building a conventional one, making renewables the perfect combination between competitiveness and low environmental impact.

Time is of the essence to succeed in such a plan. Coupling Africa's ongoing macroeconomic trends such as soaring population growth and among the world's most rapid urbanization rates with the strengths of renewable energy such as fast time-to-market, cost competitiveness, scalability, modularity, and sustainability, make utility-scale and grid-connected renewables energy plants among the most suitable solutions to electrify the continent. Nevertheless, an enabling environment with appropriate regulation, governance, access to financial markets and finally enabling infrastructures such as transmission and distribution lines is required.

It is just a matter of time for renewables to play a leading role in the energy industry in Africa as well. Governments have the unique opportunity to start and facilitate this process, eventually supported by international organizations and institutions willing to promote sustainable and virtuous business models. The time is coming: according to the latest scenarios by the International Energy Agency (IEA), we can expect more than 100 GW of newly installed renewable energy capacity on the continent by 2030, almost half of which (47%) will be solar and the rest coming from hydro and wind, with respectively 36% and 11% of the total capacity installed.

The role of the grid

IEA analysis revealed that from 2000 to 2016 nearly all of the people who gained access to electricity worldwide did so through new grid connections, mostly with power generation from fossil fuels. However, the technologies used to provide access started to shift, with renewables providing 34% of new connections since 2012, out of which off-grid and mini-grid systems accounting for 6%[4]. Upgrading the national grids is a mandatory step for IEA's scenarios to come true, bringing electricity to over half of those that gain access before 2030.

The success story of India is a good example to be highlighted. Thanks to investments on grid and new connections realized by the government over the last two decades, the country's electrification rate recorded a significant growth doubling the number of people with granted access to electricity from half a billion to one billion. The concrete commitment of political institutions made possible to improve massively the quality of life of the population and to start a virtuous path that will lead India to reach universal electricity access in the early 2020s, with renewables providing energy to 60% of the population that gains access.

Even though the Indian and the African contexts present some differences such as population density, the strong urbanization trend in Africa will make grid-connected power plants the main solution to provide electricity access.

Indeed, investments in transmission and distribution networks are generally cost-effective and secure when built to serve an area with high demand, while investments in rural areas are less attractive. However, decentralized systems will play a fundamental role where scattered population and remote locations make investment in construction and maintenance of grids more complicated, or to fill the gap waiting for the grids to come.

The kinds of intervention on the electric grid required in developing countries are mainly three: i) connecting remote regions to the national grid, ii) replacing ageing infrastructure and iii) upgrading existing infrastructure to support the integration of renewables. The upgrade of existing infrastructure and the access to the most advanced technologies is extremely relevant in Africa, since a mere connection of villages to the grid does not necessarily secure a reliable electricity supply given the poor efficiency of the existing lines.

Considering that Sub-Saharan Africa has less than 250 km of transmission lines per million of people – less than a third of the ratio in the United-States of America[5] – it provides a clear overview of the impellent investment needs to connect generation capacity and distribution networks. Such investments require abundant source of financing: public finance will not be sufficient, new business and financing schemes have to be promoted in order to attract private foreign investors.

Internationally, between 1998 and 2015 nearly 100.000 km of transmission lines have been financed through private investments in Brazil, Peru, Chile and India[6]. However, developing policies to build an attractive environment to expand transmission infrastructures in Africa would require a large consensus among stakeholders, including governments, regulators and utilities. The approach to do so should be led by the experience acquired in the generation sector through the Independent Power Producer model.

Enablers for a green revolution in Africa

To attract investors in the energy sector, both to develop renewable energy projects and to invest in network infrastructures, national governments, with the support of international actors and associations, should take initiative and make significant changes in a few key aspects.

One of the main obstacles for energy players to invest in Africa is the financial viability and availability of proper project funding schemes. Increasing the availability of financing at reduced costs and risks in the region could lead to the right risk-return profile and catalyze private investment. Sometimes over-estimated risks related to project completion, revenue generation and operating costs undermine the project viability or profitability. There are several international and local development and financing institutions that could help to de-risk private investments.

In particular, these actors can: i) directly provide guarantees for large infrastructure projects to cover key non-commercial risks; ii) indirectly mitigate risks creating a platform that gathers interest and creates a new market for institutional investors willing to invest in infrastructure.

Credit tranche and *bundling* are other useful credit enhancement techniques. Project financing instruments may be sliced into tranches to match the different appetite for risk of different investors. Furthermore, multiple projects can be re-bundled into a portfolio that aims at mitigating risk for investors with low risk appetite, such as pension funds and a central bank to effectively deliver new capacity. To attract the private sector, it is necessary to provide clear and consistent regulations, allocate risks to the parties best suited to carry them, ensure that a credible buyer (off-taker) exists and seek support from external institutions to guarantee for risks.

Moreover, it is important for governments to demonstrate political will. They should prioritize and plan efforts, while keeping an eye on the long term and focusing on the regulations and capabilities needed for the sector to thrive, not just on the plants and associated infrastructure.

The adoption of sound regulatory frameworks is necessary to overcome several investment challenges. Indeed, despite significant progress in cutting costs and improving procedures, regulatory uncertainty remains one of the biggest risks for investors in Africa. Non-transparent policy-making processes and inconsistent implementation of the regulatory rules generate unpredictability for investors, raising investment risk as well as uncertainty on expected project returns. As a result, many investments, even if commercially profitable and economically attractive, do not reach the execution phase.

Governments can reduce risks for private investors through policy and institutional frameworks that support a favorable business climate. Establishing a coherent set of rules for investments should be a priority – inclusive of all investment-related policy areas, such as tax, trade, environmental and labor market policies. Finally, governments should adopt measures to protect investors providing them with a high level of certainty, predictability and stability, such as:

- fair and equal treatment, ensuring due processes, transparency, non-discrimination and proportionality in government action;
- free transfer of payments related to investments in freely convertible currency, without undue delay and according to market rates of exchange;
- access to neutral and effective dispute resolution mechanisms.

As a promising sign of things to come, on the generation side, several African countries are on the right path in responding to these regulatory and financial challenges, but still many efforts need to be made in order to improve the timing of programs put in place and to enhance risk mitigation. As an example, the World Bank's Scaling Solar program, which was implemented for the first time in Zambia in 2016, represents a best practice that is being replicated in other African countries. The tender program offers clear rules, shortened timeframes and standardized phases.

The International Finance Corporation (IFC) offers a one-stop-shop solution and package of advisory services, template of contracts for financing, guarantees and insurance drawn from across the World Bank Group to help governments and utilities procure solar power transparently, competitively and at the lowest possible cost. The World Bank is currently engaged with this program also in Senegal, Madagascar, Ethiopia and in a second round in Zambia. The program recognizes that the lack of clear regulatory frameworks is the real brake on investment in the area. Addressing the problem is already a good result: if we succeed in raising awareness of governments, then we will have made another important step forward.

As for the generation sector, also on the transmission side the solution is to have recourse to private funding. This will allow the state-owned utility, or the government, to pay competitive and cost-reflective transmission prices. As the private sector invests in financially viable transmission projects, this can also have spillover effects: with higher transmission capacity, utilities can increase electricity sales and reduce generation costs. Moreover, private sector involvement can bring managerial skills, technical know-how and performance incentives.

Going forward

The expected economic and social evolution in Sub-Saharan Africa for the next decades has to be underpinned by a great effort in the development of power generation and transmission infrastructures. With the large renewable resources and plummeting prices in solar and wind generation, the opportunity for sustainable development is real and is now beginning to take shape. Still, going forward relevant efforts are required: such as the development and execution of grid infrastructure without which the expected improvement and growth of Africa will not occur. The experience gained with the Independent Power Producer model and the success of the Scaling Solar program of the World Bank, show that an attractive framework for private investors in Sub-Saharan Africa is possible, and would be the fastest and more financially secure way to electrify the continent. Even though there are still important hurdles that have to be overcome, governments have to show their clear involvement and commitment to lead the change by implementing the necessary rules to support business and investment.

ONE SIZE DOES NOT FIT ALL: NEW BUSINESS MODELS FOR UNIVERSAL ELECTRICITY ACCESS

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The complexity of the challenge

Sub-Saharan Africa has seen significant progress on electricity access in the last few years. However, population growth is currently outpacing the continent's electrification. The International Energy Agency estimates that if we maintain business as usual, nearly 600 million Africans will still live in the dark by 2030. It is necessary to come up with approaches that are commensurate with the actual dimension of the problem.

Making substantial progress on electrification in Sub-Saharan Africa is a very complex issue. It involves a range of public and private actors with potentially conflicting interests. It is tightly interrelated with the social, technological, financial and regulatory challenges that have hampered Africa's development for a long time. Any effective measures have to be implemented and maintained over long time spans that exceed the typical time range of political action.

Finding the right balance between orthodox and well-proven electrification approaches and the necessity of contextualized strategies represents an exceptional challenge for decision-makers. Governance and regulatory arrangements will have to leverage the lessons derived from past experiences, while adapting to the fast-changing technological, economic, financial, social and institutional environments in each country.

While the difficulty of the challenge might be daunting, we believe that universal electricity access can be achieved within one decade, provided that adequate business models are implemented.

Learning from fifty years of electrification attempts

The analysis of past electrification attempts on the African continent can provide decision-makers with unprecedented insight into idiosyncrasies warranting the design of African-specific frameworks for universal electricity access, as well as the key features of future appropriate governance and regulatory models.

Until the 1960s, the low priority given by colonial administrations to electrification led to overall energy access rates as low as a handful of percent at the time of independence. Newly independent African States faced an acute lack of basic power infrastructures. Power grids remained undersized for national consumption and their extension limited to major cities, industrial centers and mining installations.

Following the idea that the success model of electrification in industrialized countries could be transposed as such in developing countries – the "one-size-fits-all" approach – African states quickly engaged after independence into large-scale projects based on the extension of the national grid in urban zones and the deployment of some mini-grids in rural areas. These initiatives were the first attempts to address the issue of electrification and extended energy access to secondary cities and, to a lesser extent, to large villages.

However, rural electrification remained at an embryonic stage. The application of the grid-based electrification model proved ill-suited to African contexts characterized by a low and sparse demand – expensive to electrify by conventional means – and the inability to pay of rural households. Moreover, the large proportion of non-electrified population relative to national population proved to be a major obstacle to the implementation of balanced cross-subsidization. In the absence of any credible alternative and based on the experience of industrialized countries, grid extension remained the only electrification strategy in Sub-Saharan Africa until the late 1960s.

A decade later, the oil shocks of the 1970s created a momentum in favor of off-grid renewable technologies. Solar energy emerged as a potentially viable alternative for the electrification of small urban centers and remote rural regions. However, solar products had not yet reached high levels of reliability and cost efficiency. Most solar kits proved to be too costly for African households and reliability issues led to distrust towards what was perceived as deceptive "high-price for low-quality" electrification solutions. Lastly, projects suffered from unsustainable financing models based on public grants from development banks. Diesel-based "captive" generation remained the most common form of energy source in peri-urban areas as back-up of unreliable grid supply and for some off-grid solutions.

The 1980s and 1990s played a decisive role in the structuring of modern electrification policies. Innovative strategies then emerged with the objective of providing electricity in little quantity, everywhere and right now, in contrast to traditional models that aimed at delivering large quantities of electricity, but only here and there and in the long term. These strategies relied on a number of organization innovations, such as (i) the realization of extensive preliminary analyses of the services that electrification should provide, before ultimately choosing the appropriate electrification technology for each household, and (ii) the search for large-scale synergies between the national grid, local mini-grids and individual solar kits. Often praised as Africa's success story in energy access, Morocco's emblematic national electrification strategy launched in the early 1990s boosted energy access rates up from 15% to 95% thanks to careful preliminary planning, sound governance and stringent regulation. However, the success of these strategies remained limited to countries with solid institutional, financial and technical frameworks for electrification. Most state-led attempts remained at an embryonic stage, as projects suffered from strong short-term political interference and the lack of clearly-defined and inclusive technical, economic, financial and institutional framework for electrification. Electrification rates stagnated at low levels and grid extension projects remained the norm in most Sub-Saharan African countries.

Sub-Saharan Africa also chose its own path during the power sector liberalization reform that swept most of the world during the two decades starting in the early 1990s and established a market-based model that has predominated mostly in Europe, America and Australia, but that has not fully taken root in most developing countries. Instead, diverse hybrid power markets have emerged, combining traditional and liberalized features. In Sub-Saharan Africa, few countries have unbundled their power utilities, and wholesale and retail competitive markets have not been implemented. Vertically integrated state-owned utilities are still the norm. In some countries there is competition at wholesale generation level to become Independent Power Producers (IPPs). This has implications on the investment mechanisms for generation and transmission network infrastructures, which are vital for the provision of electricity by grid extension, that until recently have practically been the only electricity delivery mode in most countries.

In practice, it is not until the 2010s that a conjunction of technological innovations has reinvigorated the declining sector of rural electricity access in Sub-Saharan Africa. Taking advantage of improvements in the price and efficiency of solar panels, the emergence of smart metering and the spread of mobile phones use and mobile payment, a new generation of digitally financed off-grid solar kits – so-called "pay-as-you-go" (PAYG) solar home systems – is now accelerating and reshaping the dynamics of off-grid electricity access by providing financing and increasing connectivity throughout the solar value chain. Well-suited to challenging African contexts, digitally prepaid off-grid solar has transitioned from pilot scale to a diverse and substantial subsector of the global off-grid energy market. Operating independently from national electrification plans, privately-owned PAYG solar companies integrating technical maintenance, local distribution and micro-financing functions are driving an unprecedented diffusion of solar systems on market terms, in contrast to the traditional donor and government-driven model of electrification. Mini-grids also benefit from cost reduction and higher technological performance, although to a lesser extent. While their economic viability remains a major obstacle and is still subject to the presence of local anchor loads, mini and micro-grids both hold the potential of providing higher level of electricity service and allow for productive uses of electricity among rural populations.

Lastly, attracted by the new dynamism of the energy access sector and the potential of vast untapped Sub-Saharan African markets, energy multinationals have recently started exploring possible business models for electrification in developing countries. These new players may now act as catalyzers of energy access and have a leading role in the development of much-needed disruptive business models for electrification.

The key role of contextualized governance and regulatory arrangements

Fifty years of electrification attempts in Sub-Saharan Africa have revealed the critical importance of pursuing tailor-made energy access strategies. Rethinking governance and regulatory arrangements in the light of this lesson will be fundamental in the development of idiosyncratic African electrification paths coalescing a wide range of stakeholders, technologies and business models.

Most importantly, past electrification attempts have shown the critical role *of contextualized, integrated, inclusive and financially sustainable strategies* in any successful energy access program.

Contextualized, since universal energy access will not be achieved without the design of adequate *African* business models. Some relevant features of the power sector that are taken for granted in the regulation of electricity in industrialized countries simply do not hold in the least developed ones, such as universal grid connection, reliable supply, cost reflective tariffs, or insignificant amount of theft and non-paid bills. As a consequence, the electrification process in least developing countries – and more specifically in rural areas, where the majority of people lacking access live – has to be redesigned starting with a different set of assumptions, which should strongly condition the regulatory approach.

Integrated in several respects: by combining public and private participation, avoiding dogmatic approaches, exploiting the synergies between all possible electricity delivery modes – grid extension, micro-grid or solar kits – and lastly by harnessing the full potential for cross-subsidization between different types of loads and rural and urban areas.

1. universalaccess.mit.edu

Inclusive: since any new governance and regulatory framework, and the resulting business models, must safeguard the objective of truly *universal* energy access, acknowledging varying levels of demand for electricity and ability to pay while simultaneously bringing together the most capable stakeholders able to best meet local demand.
Financially sustainable: obviously a hard requirement for any viable electrification business that must adopt long-term financial schemes that ensure both affordability for local population and profitability for electricity providers. While strong political and social pressures have maintained electricity prices at low levels, usually far below what is necessary for cost recovery, it clearly appears that sustainable electricity access will not be achieved without a disruptive change that integrates an electrification plan at national scale, brings managerial and technical innovations that improve the quality of service, reduces total energy and collection losses to an efficient level, promotes productive uses of electricity and demand growth, and engages customers in a positive relationship of cooperation.

Thinking the "Electricity Company of the Future" (ECoF)

Traditionally, the entire supply chain of electricity – large generation plants, the transmission network, distribution networks at several voltage levels, and commercialization – has been necessary to provide electricity to all end consumers. For the most part, this will be also the case in the future, although off-grid solutions in the form of mini-grids and stand-alone systems – might be for some time the preferred option for a sizeable percentage of those to be electrified.
Providing universal access to electricity in countries with low levels of electrification will need massive investments in generation and transmission infrastructures, given that the generation capacity and kilometers of lines per capita in these countries are much lower than in the rest of the world.
The current approach to large generation investment is quite standard, but for the fact that a substantial amount of new investment opportunities will be on renewable technologies. This model has worked so far, and it will continue to do so under the standard practices of risk management that have become common during the last two decades.
Some large generation investments are only economically justified if there is enough transmission capacity shared under sound trading rules among countries within a geographical region. However, the lack of institutional strength and flaws in the market rules and transmission regulation under which they operate continue to hamper investment in generation and, most significantly, in the transmission networks. International experience with regional electricity markets suggests that necessary transmission network investments will not take place without sound regional rules for network planning, cost sharing and management. But, again, as with large generation plants, the mechanisms for financing, contracting and cost recovery of these infrastructures are well-known and proven.
Distribution is a whole other story. Inadequate distribution business models have remained a major obstacle in the development of successful electrification strategies in developing countries and there is no demonstrated solution available. Incumbent distributors devote most of their efforts to grid extension, struggling with deteriorating assets and quality of service, theft and unpaid bills, poor reputation among consumers, and financial survival, while paying little attention to actual consumer needs. In most cases, there is no overall strategy to move consumers from the lower access tiers to full access, either on or off-grid, nor to coordinate electrification planning with overall economic planning to ensure an economic return on electrification investments, with associated growth in demand.
Despite the many difficulties experienced today, distribution intended in its broadest rendering, including network assets and commercial activities, encompassing all forms of electricity supply (i.e. grid connection, mini-grids and stand-alone systems), and due to its present weaknesses, offers multiple possibilities for innovation in management, technology, regulation and consumer engagement. This is particularly the case for the last mile, where the direct interaction with the end consumers takes place.
The Electricity Company of the Future, or ECoF, designed with the objective of overcoming the major limitations of the electrification models present in most developing countries, should be built around the concept of an enhanced distribution utility that we shall term the "Integrated Distribution Company" (IDC). The ECoF is the IDC, plus other activities that might be added depending on the circumstances. As necessary, investment in large-scale generation to guarantee supply to the distribution activity, or in the transmission network to facilitate access to competitive electricity sources can be considered. Sound, traditional and well-established businesses already exist for these segments of the electricity supply chain, as indicated before.
The distribution activity would be understood here as a territorial concession, that meaning a company with an obligation of electricity supply in the assigned territory, using whatever delivery model is most convenient for the purpose.
The ECoF will be consumer-centered and it will make use of advanced technologies for that purpose, making a difference with the current incumbent distribution companies, whose level of engagement with the customer is very unsatisfactory in general.
The managerial, financial and operational changes that will be necessary in the incumbent distribution company will most likely require a substantial private sector participation in both its ownership and management. A significant private ownership and full management responsibilities in the incumbent (typically publicly-owned) distribution company can only be possible with a large private energy firm with sufficient financial resources. The private firm, by itself or in consortium with one or more local companies, must have the technical expertise to deal with last mile distribution issues and the capability of effective consumer engagement. Partial or total public ownership might be a political requirement in many countries, and also presents advantages regarding the public perception of the company and some additional guarantee of customer protection.
Rather than caring only for the grid-connected consumers as most incumbent distribution companies in the considered countries do, the new distribution company would be responsible for the supply to all consumers in the concession territory via any delivery mode (grid connection, mini-grids or stand-alone systems) and even battery charging. Off-grid solutions could either be provided by the distribution company, outsourced to franchised developers or left to independent developers under the supervision of the regulatory agency and the distribution company. The scarcity of funding may impede the investments that would make possible an immediate implementation of universal electrification. However, an integral plan that "leaves no customer behind" – although with diverse electrification modes and timing, as needed – must exist, and its implementation should commence from the outset.
The ECoF will benefit from the application of sound regulatory practices. In particular, it is important that the remuneration of the distribution activity recognizes the different nature (risk profile and capability requirements of the staff) of the two business models that in most developing countries come together under the name of "distribution": the mostly infrastructure-centered and the mostly consumer-centered business models. The differences between the activities of distribution (i.e. installation and operation of network assets) and retail or commercialization (i.e. purchasing wholesale electricity and selling it to end consumers, serving as the only interface) is magnified in the context of rural electrification. While the former should be treated as a regulated monopoly, an activity of low financial risk and mostly related to physical assets, the latter has several important sources of risk and its success mostly depends on its interaction with the consumers, and on how it is perceived by them. The "infrastructure" side of the distribution company would be accountable for the quality of the physical service provided to the end consumers and the technical losses in its networks. The retail side would be responsible for metering, billing for the reduction of electricity theft, and for all activities related to commercialization of the electricity product and consumer engagement, including the search for anchor loads, the development of productive uses of electricity and the design and utilization of an adequate system of tariffs that could facilitate the viability of the company.
The ECoF must exploit all existing opportunities to improve the efficiency of the distribution company, by increasing its revenues and reducing its costs. The opportunities for cost reduction and increasing revenue collection are multiple, and they can jointly reduce significantly the existing difference between costs and revenues (the "viability gap"), which unquestionably is the major roadblock to achieving the economic viability of the ECoF.
The financial viability of the company will be enhanced by exploiting the synergies with productive uses of electricity. On the one hand by focusing on and giving priority to electrification projects associated with productive uses. On the other hand, by engaging with the communities and encouraging the adoption of those productive uses.

LOCAL CAPACITY BUILDING TO TACKLE THE SUSTAINABLE ENERGY TRANSITION

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Energy access started to be recognized as an important driver for development and growth, gathering particular attention in the second half of the twentieth century. Post 1950, many newly independent countries were trying to understand the challenges that lay ahead (Bandung Conference, Non-Aligned Movement, Afro-Asian Solidarity) and what to make of the new world order. On the other hand, by the 1950s countries such as the United States were already benefitting from electrification through growth in productivity and were rapidly ensuring access even to the sparsely populated mid-west. For brevity, we refer to the former group of countries as "The South" here to distinguish from "The North", the wealthier countries.

Referring to the period leading up to the 1950s, economists Petra Moser and Tom Nicholas (2004) note that 'electricity made it possible for workflows in the factory to be restructured away from traditional energy sources such as water power'. They also note the role of other advancements, especially those in automobiles and trucks, which we equally well recognize as part of the energy system today. While labor and capital are widely accepted as two key drivers of economic growth, Ayres and Warr (2010) go further to claim the efficient thermodynamic conversion of heat into useful work, is a third important driver.

Some countries of The South such as Indonesia, Tunisia, and Vietnam made rapid progress with electricity access reaching well in excess of 50% by 1990. Access rates were however below 25% in Sub-Saharan Africa and below 50% in South Asia at that time. At the UN Summit in 2000, the Millennium Development Goals (MDGs) for the year 2015 were adopted. The focus was primarily on health, education, hunger, without specific mention of water and energy access. Yet, soon it was recognized that energy was indeed the enabler for many of those goals. This point was brought to the fore in a seminal report, *Energy services for the Millennium Development Goals (2005).* The report placed equal emphasis on the importance of moving away from cooking with solid biomass fuels in rudimentary fires, process heat and mechanical for industrialization.

Immediately following the UN General Assembly resolution 65/151, which passed on 20 December 2010 and designated 2012 as the International Year of Sustainable Energy for All, the UN Secretary General charged a high-level group to come up with a process for convening dialogue as well as energy-specific recommendations. As a result "Sustainable Energy for All" was launched in 2012. On the first day of 2016, at a historic UN Summit world leaders adopted 17 Sustainable Development Goals (SDGs), which included Goal 7 that aims to *Ensure access to affordable, reliable, sustainable and modern energy for all.* While the unfinished task of ensuring access for all was still at hand, the gravity of climate change came to the fore and COP 21 reached a global consensus in the Paris Agreement of 2015, to limit global warming to below 2 degrees. It was clear that not all countries in Sub-Saharan Africa had the resources to achieve those goals, let alone the fact they were just as vulnerable if not more to the impacts of climate change, something that was primarily the responsibility of the North. The Addis Ababa Action Agenda in 2016 was a historic agreement to generate finance for the sustainable development agenda. Yet the reality is that it takes time for such finance to flow and to materialize.

These political processes are important for national leaders and their energy ministers to set their agenda and to create policy and regulatory frameworks and incentive programs for energy access. The role of the private sector at all levels, from small to large entrepreneurs is singularly important in bringing innovations to market, in financing and execution for scale, and in turn for scale to drive down costs. The role of global innovation systems in driving cost reductions through scale is equally important. Three singular developments can be cited as examples: the lowered cost of LED lighting, solar photovoltaics, and mobile telephony are beginning to provide dividends and are enabling essential services.

What is perhaps less recognized but equally important is the role of local innovations such as in business models, in service delivery, in adapting innovations to the needs of farmers, craftsmen and women, to the needs of health and education, and to the needs of cooking. Some constraints to be overcome are technical, some operational and some financial. We can see entrepreneurs, some emerging from The North, start-ups with skills to raise global capital, and engagement by larger companies. However, we have yet to see larger scaled models for growth in businesses and entrepreneurship that start locally. We also see constraints to the development of public-private models that are needed when it comes to developing core infrastructure for business development. But most importantly we also recognize that without early support for entrepreneurs, without risk capital, without experimentation, without learning by doing, without the kind of skill and knowledge development that is specific to the new energy systems, we will not be able to achieve scale. This is one element of capacity building and is key to effectively support the emergence of new technologies and their rapid spread. Such new business models will also need trained local staff. Pilot demonstrations, educational programs that develop skills in microprocessor-based control, battery management, implementation that rely on the Internet of Things (IoT), power electronics and newer smart or prepaid meters, knowledge-sharing and hands-on practical training will be the second element of capacity building.

There has been a dramatic increase in the scale of manufacturing solar photovoltaic modules, initially receiving an impetus from feed-in-tariffs that led to their rapid decline in costs. Being a downwardly (and upwardly) scalable technology, small solar systems initially became affordable for those with somewhat higher incomes than the poorest, who used it for access or as a back-up to the grid. The last decade also saw the pervasive spread of mobile technology and the financial innovations around "pay-as-you-go" schemes. The convergence of these innovations made it possible to develop business models that could allow scale, reductions in transaction costs and access to lower cost financing. While such small solar-powered battery-based systems or lanterns provide limited capabilities, they nevertheless meet an important early need when compared to a reliable grid connection. The next challenge is to provide the flexibility and potential consumption growth that a reliable grid connection foresees but without the grid's heavy generation and transmission infrastructure. Early deployments of micro-grids are beginning to demonstrate some of these features. My group's early work through a pilot demonstration project in Uganda and Mali, which we called *Sharedsolar,* showed how such consumption flexibility enabled new business and growth. Our installations in Senegal, called *Acacia*, provide low-cost daytime solar power that directly services irrigation loads through smart scheduling without battery storage, and show the potential for leveraging the low cost of photovoltaics through demand-side flexibility.

The role of capacity building has become critical since these innovations rely on digitization of the energy delivery mechanisms. These digital and increasingly decentralized systems working synergistically or independently from larger systems need a different kind of expertise than running a large coal-fired power plant or diesel generator. They no longer rely on someone who is skilled at maintaining an engine, but instead need someone who can detect digital or communication failures and fix them, someone who can upgrade firmware, someone who can download data and carry out basic analytics.
This transition in how access is being enabled is mirroring what the larger electric utilities are experiencing. A high anticipated penetration of renewables in the grid will be accompanied by a high degree of localization since both wind and solar are intermittent and very geographic in nature. Heating and transportation will also increasingly become electric. How will intrinsic weather, climate driven supply, and demand variability be managed in different settings? A diversity of measures on the demand side will provide flexibility to the grid. In fact, the smaller decentralized innovators can teach the big entrenched players some new tricks. A transition on the demand and appliance side is beginning to take place, to keep up with the new market mechanisms that will be unleashed with large-scale penetration of renewable power into the electric grid. Electrification of cooling occurred with electric motors out-competing the delivery of large hunks of ice. Now, electricity from renewables is poised to out-compete heating fuels and transport fuels.

There are new ways in which even the rural poor are already facing the challenges of verifying uniqueness of identity, requirements that come with digital records and payment systems. Ensuring that they are not left behind and that the process ensures equity and dignity regardless of whether one is able to read or write is just as important. Ensuring privacy and misuse of data will be just as important to The South as we now learn important lessons from the new social media platforms in The North. For the youth, we will also need a kind of convergence in developing people skills, combining secondary school education with basic core competencies in digitally controlled hardware and the digital commercial infrastructure. It is important that the revolution in energy access and the transition to renewable energies is not stalled by the lack of human competences. But a whole generation of young people is coming of age without ever having heard of a landline phone or fax machine. Hence, I am hopeful we can achieve this. There is no time to wait and we need all the institutions, the entrepreneurs, the universities, the civil society and the support of the international partners to ensure success.

DECENTRALIZED RENEWABLE ENERGY SOLUTIONS AND INNOVATIVE BUSINESS MODELS TO FOSTER LOCAL AND SUSTAINABLE DEVELOPMENT IN SUB-SAHARAN AFRICA

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Africa holds a significant potential for development, which is strongly connected to energy access. Today the continent counts 1.2 billion people, with 600 million of them living without access to energy or relying on biomass such as charcoal, and isolated fossil fuel gen-sets to satisfy basic energy needs. As the African population is expected to grow by 40% reaching 1.7 billion people by 2030, energy poverty rates would rise consequently, resulting in the same number of people projected to be lacking energy access by that time. Renewable energy (RE) plays a key role in this issue, and is predicted to make up about two-thirds of total capacity additions being responsible for three quarters of the population gaining access by 2030. As illustrated by the United Nations Sustainable Development Goals (SDGs), access to clean, affordable and reliable energy (or SDG 7) has a bouncing impact on many other aspects of development, from health services to education, to economic growth and gender equality. This is particularly true for Sub-Saharan African (SSA) rural populations, which today represent the vast majority of people living without access to electricity. In these contexts, decentralised renewable energy solutions are able to effectively respond to the immediate energy needs and – if adopted within an integrated innovative business model that allows for the productive use of energy- can foster the sustainable development of local rural communities.

Mini-grids for better access

Decentralised renewable energy solutions are instrumental to provide households electricity access to independent villages and are a key element to kick-start local development. Given Sub-Saharan Africa's vast geographic expansion and relatively underdeveloped grid infrastructure, off-grid systems are one of the most viable means to electrify rural and remote places, where communities are generally too distant to be economically connected to the main grid, but are still densely populated enough to offer economies of scale in power delivery. Stand-alone and mini-grid solutions are expected to meet 70% of the demand of newly connected customers over the next 25 years. Renewable mini-grids specifically are defined as integrated systems with one or more renewable generation solutions such as small wind, photovoltaic or mini-hydro power generators. These systems usually include an energy storage component such as an electrochemical battery, a diesel backup generator and a distribution network to connect each single user.

Due to their inherent characteristics, renewable mini-grids and distributed generation not only make possible the electrification of households but also play a key role in enabling energy access for productive uses. Firstly, in most remote areas, renewables can generate power through mini-grids at a significantly lower cost than through diesel generation or grid extension, making them more accessible and affordable. They are also faster to put up and thus promptly respond to the population's immediate energy needs: the installation of a mini-grid, for example, can be completed in less than one year. Given that mini-grid plants are directly related to the local necessities and usage conditions, they also result to be socially and environmentally sustainable.

However, it is their modularity and flexibility feature that makes mini-grid technologies particularly suitable when it comes to designing an effective and financially sustainable model for development. This means that the power of a mini-grid plant can be easily increased according to the growth of energy demand in the community.

Main barriers to mini-grids deployment

Scaling up the deployment of mini-grids still faces significant barriers, such as the lack of an adequate regulatory framework, permitting processes and low energy demand in rural areas.
A clear regulation system is needed in order to allow ESCOs (Energy Service Companies) or IPPs (Independent Power Producers) to sell energy to final users, and to easily define a tariff that covers long term investment costs. Since – as is the case for many countries – the energy market is state-owned and managed, ESCOs and IPPs are excluded from entering the market. Moreover, the Levelised Cost of Energy (LCOE) produced through decentralised systems in rural areas is higher than the national grid tariff, but lower than providing energy through grid-expansion or diesel generation. The difficulty lies in establishing a tariff that effectively reflects the production costs of the mini-grid plant itself, allowing to gain a return and even out investment costs. In addition, authorization and permitting processes are often undefined both in the general terms and in timing.
There is also a great deal of uncertainty in the eventuality of the national grid reaching the site where the mini-grid has been installed. Low energy demand and little willingness to pay for people living in remote areas also creates uncertainty for private sector and financial institution investments: the potential customer that mini-grids are directed to is used to live without access to energy and therefore would consume very little of it once provided, representing a high-risk investment.
Though not completely effective, there have been attempts to mitigate the problem of a lacking regulatory framework through grants and funds provided by external donors, thus reducing the upfront capital investment costs requested to private investors and consequently lowering the tariff of the energy sold. However, this scheme is not scalable and can only be sustained until the donor money runs out. On the contrary, local governments should decide in favour of cross-subsidisation of mini-grids, to cover the gap between the national tariff and the cost of the energy generated by the specific mini-grid, for example through a subsidised-tariff or a RAB (Regulated Asset Base) scheme.
In the case of potential arrival of the national grid to the mini-grid site, the plant should be connected to the main grid. It would sell energy to the community, at the same price as prior to the grid connection arrival, and to the grid operator at a price that remunerates the generation part of the investment. Another option is that the mini-grid operator sells the asset to the grid operator at a price related to the residual value of the asset.

To face the barriers to mini-grid implementation, lower risks and foster investments, mini-grid technologies should be paired with an anchor load or with elements to grow the local agri-food business and services, such as irrigation or food treatment and conservation. These productive uses of energy would increase the creation of value through a multi-stakeholder business model that actively involves the local community as partner in the initiative instead of as client.

Providing extensive capacity building activities is also instrumental to ensure the full inclusivity of the community, support the roll-out of new technologies and enable the local ownership of sustainable projects in the long run. RES4Africa is very active on this matter: with the Micro-Grid Academy it set up a regional capacity building platform that provides theoretical and practical training on energy access and decentralised renewable energy solutions to young East-African and international technicians and engineers.

An inclusive multi-stakeholder business model to foster rural development

We need to move beyond a basic level of consumption and deliver energy access for productive uses across local economies. Productive uses refer to activities that create goods or services or that enhance income potential or value. This includes income generation in agriculture, commercial activity, industry and mining, but also in education and health services, which can improve the potential to make economic gains and help achieve the SDG goals on poverty, employment and economic growth, industry and infrastructure at the same time.
Agriculture in particular is of paramount importance for economic development in SSA, accounting for 18% of the region's GDP and representing 70% of the working population. GDP figures often underestimate the importance of agriculture because of the difficulty of capturing the informal economy and thus taking into account the contribution of small shareholder farming. Access to renewable and modern energy is important for food production and it can improve every phase of the agri-food chain, from production to preparation. Studies by the UN Food and Agriculture Organization (FAO) on the nexus between water, energy and food provide a clear representation of the interlinkages existing between these three elements and local development.

In order to attract investments and truly drive the sustainable development of African rural communities through energy access, a comprehensive, innovative and inclusive business model needs to be adopted. This should aim to connect energy supply with the agri-food chain, industry and services in such a way that it enables energy access via an overall sustainable and scalable cycle through the use of energy for productivity. The model should be designed and implemented with the joint efforts of different stakeholders across the energy value chain: from NGOs to international organisations and regulatory agencies, public and private sector actors, investors and the communities themselves. Engaging a wide array of stakeholders would align all players' perspectives and objectives allowing for the development of a functional system that simultaneously fits with the local needs, makes use of varied expertise and fulfils investments' requirements. The local communities play a vital role in the functioning of such a model and must be included from the design phase up to the whole implementation process. With an inclusive and bottom-up approach, local communities shift from being the client to becoming a key stakeholder that participates in the model and thus creates shared value. This plurilateral involvement would also concretise in a multi-faceted process, involving, besides the mini-grid, a series of facilities and other inputs necessary to boost local economic development. For what concerns agricultural productivity, these would be for example a water pump and irriga-

tion, mills for food processing, or devices for food conservation and mechanised production. In the services sector this would translate into the development of key facilities, such as hospitals, schools, internet access and commercial activities. Lastly, growing industrial businesses could also play an important role as they serve as anchor loads ensuring a constant revenue stream and reducing investment risk. In addition to these elements, the modularity and flexibility of mini-grid technologies would help to gradually follow the economic and social growth pathway of communities watering down the capex expenditure and reducing the financial exposure of high-risk projects.

Other than modular mini-grids, this type of innovative and non business-as-usual model would in itself leverage the regulatory system and break barriers to RE investments, by generating widespread value from a variety of sources other than selling energy. With the opening of this type of new market there also needs to be a "multi-utility company" capable of managing the entire expanded value chain (comprising the energy, water and agri-food sector). This new entity would be able to scale, diversify and focus its investment according to the most fruitful activities, thus dramatically reducing risk.

Conclusion

The shift to approaching development from a more integrated point of view, influenced in part by the SDGs, is changing the view of energy's role in development and the provision of energy services. Access to sustainable energy plays a key role in unlocking Sub-Saharan Africa's vast potential for economic development, and impacts many aspects related to it. Strategies to deliver clean energy access in the continent should be diverse and tailored to local conditions and practices. Renewable hybrid mini-grid technologies with their modularity feature, and new inclusive business models offer scope for achieving faster and more affordable rural electrification in the region, as well as local sustainable economic development. In this new integrated perspective of sustainable development, actions, initiatives and projects need to be thought out to impact multiple aspects of sustainability, instead of focusing on one isolated sector only. Partnerships and collaboration are fundamental to achieve the SDGs, and a multi-stakeholder inclusive approach can leverage the existing barriers to RE decentralised investments by generating value from different sources. Broadening the focus beyond energy supply towards productive uses of energy, including water and food, can create a stronger business model for investors and a greater impetus for policy-makers to improve access to electricity and foster economic growth.

THE WAY FORWARD

Roberto Vigotti
Secretary General, RES4Africa

This book, a RES4Africa project in collaboration with Enel Foundation, aims to increase the engagement of stakeholders from continental and regional organizations, to governments, civil society, the private sector and academia on the African continent and beyond, in order to drive effective and long-lasting progress on advancing sustainable energy in Africa.
The continent's transition to sustainable energy requires four essential pillars: policy and regulation, financial mechanisms, innovation and, last but not least, human development. The international community should aim to empower and activate these levels in order to advance sustainable energy access in Africa.

Supporting the creation of a favorable business environment through appropriate policy and regulation and multi-stakeholder cooperation will help bring about innovative and sustainable, locally-grown solutions. Strong financial de-risking mechanisms for grid-connected and off-grid projects should also be recognized as pivotal to promoting medium and long-term investments.
Off-grid renewable energy solutions can be deployed in many areas faster and cheaper compared to grid-extension. They provide leapfrogging opportunities for energy access, and can significantly improve African livelihoods.

It is imperative to showcase innovative African solutions, business models, and players to help scale up investments in projects and initiatives that bring energy to hundreds of millions of Africans. The objective should be to strengthen multi-stakeholder collaborations among private sector actors, African institutions, innovative local start-ups and civil society to ensure the continuation of Africa's innovative development.

The Open Africa project is inspired by the outcomes of the G7 Energy Ministerial side event *"Africa 2030: Empowering the continent through innovation, green tech solutions and capacity building"* organized in Rome in spring 2017, in cooperation with Enel Foundation. Both initiatives reflect Enel Foundation's long-confirmed commitment to local capacity building, with educational programs directed to young professionals at the Advanced Training Course and the Micro-Grid Academy, and to PhD students at Open Africa Power. Knowledge sharing plays an essential role in supporting the ongoing African sustainable energy transition that is visually represented in this book.

With this printed version and the parallel web documentary we hope to broaden the awareness and the commitment of policy makers, stakeholders and investors to help achieve universal energy access, strengthen energy security, consolidate resilient growth, trigger socio-economic benefits such as job creation and inclusive development, and improve prosperity and stability in Africa.

RES4Africa

Renewable Energy Solutions for Africa (RES4Africa) promotes the deployment of large-scale and decentralized renewable energy solutions in Sub-Saharan African countries to meet local energy needs. RES4Africa's mission is to create enabling environments for renewable energy investments in emerging markets. The association gathers the perspectives of a member network from across the sustainable energy value chain. RES4Africa functions as a platform for members and partners of emerging markets to foster dialogue and partnerships, share knowledge, and build capacity to advance sustainable energy investments in emerging markets.

res4africa.org

Enel Foundation

Enel Foundation is a knowledge platform that focuses on the crucial role of clean energy to ensure a sustainable future for all. By envisioning a sustainable future – resilient and equal – boosted by quality education and an enlightened self-interest by the business community. The future we want is powered by affordable, reliable, sustainable and modern electricity for all. We focus on research and education. By developing partnerships with pre-eminent experts and institutions across the globe, leveraging on the vast knowledge of our Founders, we conduct research to explore the implications of global challenges in the energy domain. We develop scenario analysis, define policy and regulation opportunities and design capacity-building programs to the benefit of scientific and institutional realms. We operate at the intersection of business and society. By engaging institutions and governmental bodies, thought leaders and civil society representatives, industry experts and academia. We are a non-profit organization seeking to converge with likeminded actors determined to solve global challenges ensuring a sustainable future for all.

enelfoundation.org

Akronos

The aim of the association "Akronos" is to bring together institutions, private companies and the general public through art and culture. Its specific targets are to design and realize high quality multimedia projects, through which the partners of the association can tell their stories and approach a wider audience. Akronos produces photographic and journalistic books, exhibitions, video projects, workshops, concerts and events, with specific attention to the web documentary as a new and innovative form of journalistic communication.

akronos.it

The project

This book and its complimentary web documentary are a RES4Africa initiative in partnership with Enel Foundation and Akronos, that aims to visually illustrate how access to sustainable energy in Africa positively impacts African livelihoods. The book's narrative is recounted through a series of local stories captured in Ethiopia, Kenya, Uganda and South Africa, as well as testimonies from international experts in the field of sustainable energy. The objective is to portray a continent with a vast potential for growth, on the path to achieving sustainable development through renewable energy.

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The complimentary web documentary version of this photographic book is available on www.openafrica.it.

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