African Development Bank Group
Groupe de la Banque africaine de développement

Estimating Investment Needs for the Power Sector in Africa 2016-2025

Africa Infrastructure Knowledge Program

September 2019

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Preface

Despite the progress made over the years, about 60 percent of sub-Saharan Africa's population – or more than half a billion people - remain without access to electricity. In rural areas, the situation is worse, with only one in four Africans having access to electricity. In addition, per capita consumption of energy in sub-Saharan Africa (excluding South Africa) is still extremely low at 180 kWh, compared to 13,000 kWh per capita in the United States, 6,500 kWh in Europe and 2,000 kWh in other developing countries.

As part of its efforts to address this situation, the Bank in 2016 launched the New Deal on Energy for Africa that has the aspirational goal of achieving universal access to electricity by 2025 – 100 percent access in urban areas, 95 percent in rural areas, by promoting on- and off-grid solutions, as well as related technical advances. The New Deal on Energy for Africa is a partnership-driven effort that facilitates the Bank's collaboration with governments, the private sector, bilateral and multilateral energy sector initiatives to develop a Transformative Partnership on Energy for Africa.

A key aspect of the Bank's work on infrastructure development is its Africa Infrastructure Knowledge Program (AIKP) that aims to improve the availability of statistical information on infrastructure development across Africa. The AIKP program is intended to provide an effective and sustainable platform for data collection and analysis on Africa's infrastructure sectors, namely: (i) electricity; (ii) transport; (iii) ICT; and (iv) water and sanitation. One unique feature of the AIKP is the estimation of investment needs in all the infrastructure sectors using mathematical programming models. These models seek to catalyze a more active and informed engagement of stakeholders in the development of infrastructure investment strategies in Africa.

The current study titled: "Estimating Investment Needs for the Power Sector in Africa 2016-2025", focuses only on the energy sector. It has three main objectives: (i) to generate individual country energy investment needs using mathematical programming models, (ii) to provide information about the state of the energy sector in Africa as a whole and in its five regions individually, and (iii) to provide information that helps African countries and regional institutions in determining the optimal set of investments needed to meet the demand in their respective countries and regions by 2020, 2025 and 2030.

This report was prepared by the Statistics Department in close collaboration with the Energy Policy, Regulations and Statistics Department. It includes optimization accounts for country-specific daily demand profiles and solar and wind resource profiles. The report is based on information provided by the 48 African countries that have been participating in the AIKP data collection and analysis exercises undertaken by the bank over the years as part of its statistical capacity building program (SCB) for Africa. The success of this task is therefore entirely due to the commitment of the AIKP country teams based in the National Statistics Offices, national infrastructure ministries and other national and sub-regional institutions in Africa. On behalf of the AfDB Statistics Team, I would therefore like to express our profound gratitude to all those involved for their enduring commitment to the successful implementation of the AIKP work program in general, and for their active participation in the data collection and analysis in particular, which has helped to make this exercise a great success.

My appreciation also goes to the AIKP Team in the Statistics Department, comprising Louis Koua Kouakou, Maurice Mubila, Yassine Jmal, and Desire Lakpa who oversaw the implementation of this AIKP task and ensured its successful conclusion.

The Statistics Team is also grateful for the productive collaboration with colleagues in the Energy Financial Solutions, Policy and Regulation Department, Nirina Letsara and Callixte Kambanda, who provided critical inputs for this task under the guidance of Wale Shonibare, the Director of their Department and currently serving as Acting Vice President for Power, Energy, Climate and Green Growth.

Charles Leyeka Lufumpa
Director, Statistics Department
African Development Bank Group
helped to make this exercise a great success.

Objectives and approach of the study

Annex IV presents a complete description of the methodology and sources utilized in this study. This section offers a narrative summary to the reader in order to better understand how the various estimates have been arrived at and how they should be interpreted. Specifically:

- **Investment needs to meet growing demand and access targets.** All work regarding data collection, assumptions, modelling activities and optimization are designed so as to estimate optimal investment needs in the sector, within a reasonable set of restrictions.
- **Optimization using the Balmorel model. The Balmorel model is the primary tool utilized in the analysis.** It applies a wide range of technology and geographic specific data and assumptions pertaining to costs, production, resources (water, solar and wind), fuels, distances, etc. to determine the optimal set of investments in order to meet demand in each country and region by 2020, 2025 and 2030. Importantly, the optimization accounts for country-specific daily demand profiles and solar and wind resource profiles.
- **Restrictions to the optimization to reflect reality.** Because the optimization model is designed to minimize total system costs, it does not inherently reflect certain technical or practical restrictions that may exist. For example, most countries prefer to develop a diversified generation mix, and are not willing to rely entirely on power imports to meet demand. Thus, a key aspect of the analysis has been that of introducing reasonable restrictions to the model, while maintaining significant opportunity for it to determine optimal investment paths.
- **Interpreting the results of optimization.** The results of the modeling are a combination of optimization and a set of restrictions, and must be interpreted as such. The results do not predict what will happen in the future, but rather what the team has deemed as an optimal yet plausible sector development path. By optimal is meant the set of investments that minimize total system costs (including capital, fuel and O&M) for the region as a whole.
- **Access expansion.** An access expansion model has been developed in order to ensure that country specific access expansion paths reflect; i) consistency with the overall targets of the AfDB for the continent, ii) the fact that each country has a different starting point in terms of rapidly expanding access, and iii) the various access options – on-grid (rural and urban), mini-grid and off-grid.
- **Demand growth and investments access expansion.** Demand grows as a result of; i) economic growth and electricity consumptions elasticity, and ii) access expansion. Projections for both sources of growth are made for each country. In addition to generating additional demand, access expansion generates investment needs - directly. Thus, in order to complete investment needs projections for the sector, updated per-connection assumptions are made for on-, mini- and off-grid.

Estimation and uncertainty.

Making projections 14 years into the future in a market influenced by technology change, political turmoil, cross-border relations, economic growth and human behavior is fraught with uncertainty. Several of the methods utilized in this analysis rely on prior statistical analyses. The team has very diligently and carefully selected the sources for all data and projections for each input. However, whether based on statistical analysis or market research, all projections have uncertainties tied to them. Nonetheless, in utilizing our modeling tools, the analyses necessarily arrive at specific investment needs estimates – rather than intervals, as this is not a statistical analysis. This does not imply that we believe that our estimates will turn out to be exactly correct or accurate. Instead, these are our best estimates and there is no reasonable manner in which to assign probabilities or intervals.

The scenarios and sensitivity analyses presented in Chapter 3 illuminate this uncertainty – but also the power that policy – can have on the future of Africa.

Executive Summary

How much investment is needed to realize the African Development Bank´s (AfDB) New Deal on Energy for Africa (the New Deal)? This is the overriding question that is thoroughly analyzed from the bottom-up for 54 countries in Africa, covering generation, inter-connectors, transmission and distribution (T&D), mini-grids and off-grid access options. Underlying the analysis is an unprecedented collection of data, high-resolution regional power investment optimization and a tailor-made access expansion model for the continent. The answer to this question is an average annual investment of 29-39 billion USD until 2025, depending on the continent's ambition as to avoided greenhouse gas (GHG) emissions. In total, 230-310 billion USD is required until 2025, while an additional 190-215 billion USD is required for the period 2026-2030. The total average annual investment from 2018 to 2030 is estimated at 32-40 billion USD, as depicted in the figure below.

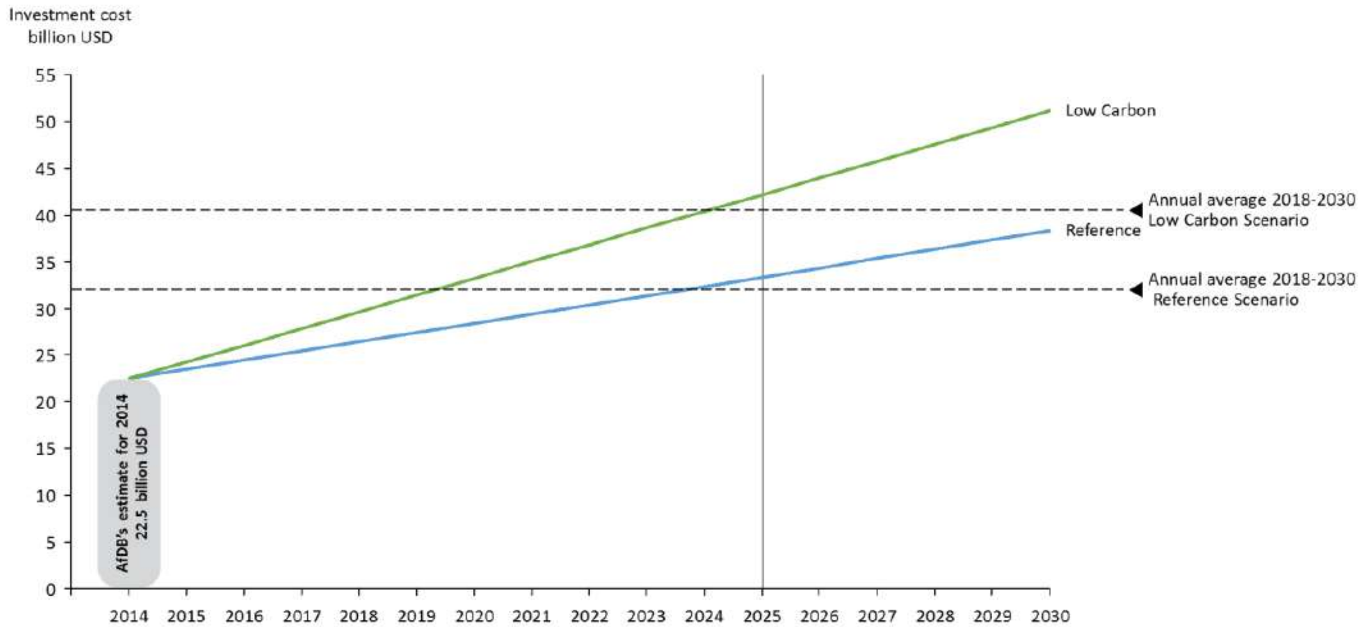


Figure 0.1 Depiction of required investment ramp-up to achieve universal access targets of the New Deal and beyond into 2030 (the figure draws on the analysis results but is for illustrative purposes only).

Achieving the New Deal's Universal Access Vision

AfDB's New Deal on Energy for Africa 2016-2025. The starting point for this analysis is the AfDB's "aspirational vision to achieve universal access to electricity by 2025 – 100% access in urban areas and 95% access in rural areas." The Strategy goes further in terms of establishing "strategic building blocks to achieve universal access", which by 2025 include 130 million new grid connections and 75 million end-users benefiting from off-grid solutions.

If the New Deal's aspirational vision is realized, it is estimated that about one billion Africans will gain access modern energy services by 2025. Such a rate of access expansion would be unprecedented for Africa and would require a major policy and financing push, as well as favorable macro-economic conditions. However, the analyses presented in this report confirms that an emerging "continuum" of access levels and decentralized power systems coupled with rapidly evolving business models, plummeting renewables costs and blossoming energy efficiency options likely means that the AfDB´s vision of universal access can be realized at a lower cost than previously expected.

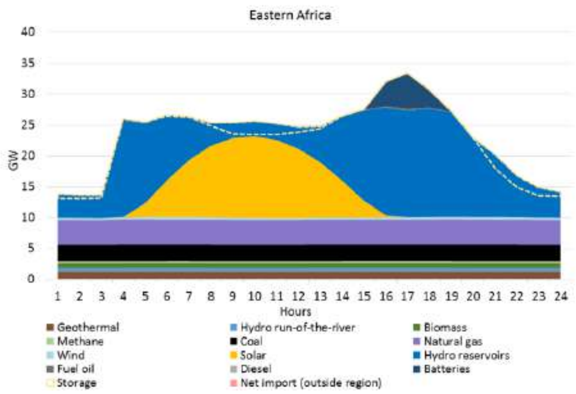
It is important to recognize that every country has a unique starting point, and efforts and investments will have to be tailored to these conditions. Accordingly, for the sake of this analysis, a tailor-made model has been developed to project access expansion paths across countries and access types in line with AfDB's New Deal targets. Specifically, each of the 54 countries have different starting points and they will all follow unique paths (and pace) to universal access. Nonetheless, the AfDB targets are so ambitious that most countries must see rapid access expansion and some form of "convergence" if these targets are to be met. The model developed for this study takes account of, among others, the current access rates, population density, poverty, and investment climates for each country to determine the pace and relative importance of grid, mini-grid and off-grid. Ultimately, the analysis does not take a view on the realism of these targets but quantifies the requirements.

Regional optimization of investments and system operations

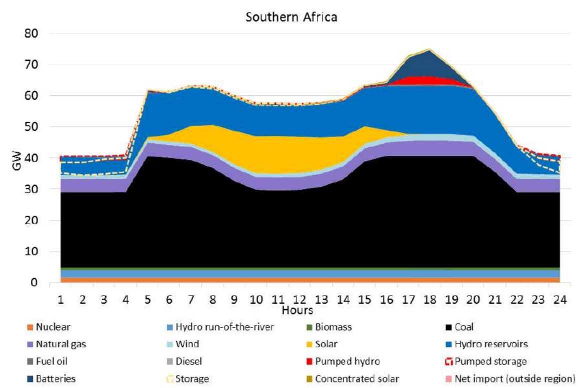
When it comes to optimization, network integration and (implied) system operations at the regional level, each region has a unique starting point and optimal development path. For this study, a tailored Balmorel Model is deployed in order to optimize technology choices and supply options for each country and region. Among other features, the model accounts for the cost and physical characteristics of wide range of generation technologies, inter-connection options and costs, country-specific daily demand profile estimates and actual daily variable renewable resource profiles and inter-action between supply options in meeting peak demand. While several modelling restraints have been introduced so as to reflect real-world constraints, such complex optimizations often yield unexpected results.

Africa currently has an unprecedented 80 GW of new capacity under construction. This limits the need for additional investments until 2025, and even introduces likely surpluses in Eastern and Southern Africa. About 49 percent (39 GW) of this new capacity is added in Northern Africa, which also is set to retire 19 GW during the period. Central Africa, on the other hand, has a mere one GW under construction compared to East Africa's 12 GW. At the continent level, these numbers should offer hope, as they indicate that there already is a certain level of momentum in terms of achieving the New Deal's targets.

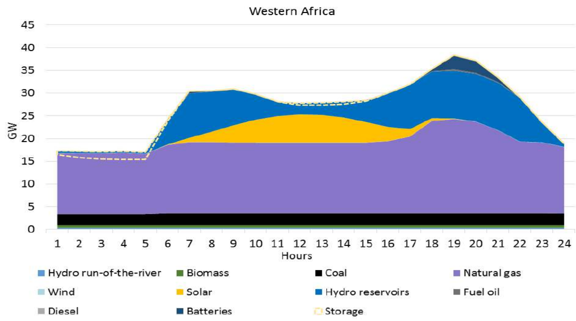
In East Africa, a forecasted near-term power supply surplus eventually evolves into a more than quadrupling of installed capacity by 2030, with the inter-play between large reservoirs and solar power a key feature particularly towards 2030. The region is forecasted to undergo significant system integration over the period with some unexpected evolutions in exports and imports, as countries look to meet growing demand and utilize comparative resource advantages. As can be seen from the figure to the right, the East-African region is expected to develop a diverse generation mix, with solar and batteries making up the lion's share of investment by 2030 in several countries.



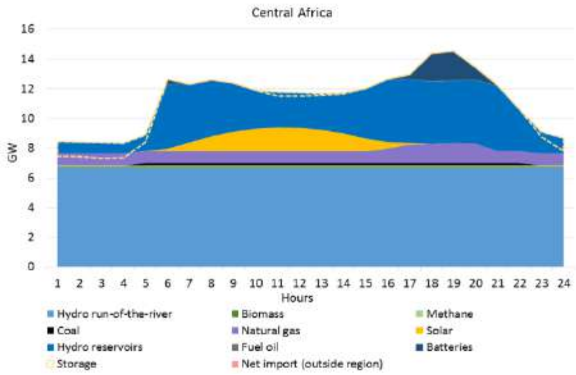
In Southern Africa, the expectations of continued sluggish growth and decreasing energy intensity in South Africa dampens forecasted demand growth and new investment requirements, especially until 2025. With no dedicated emission reduction efforts or policies in the Reference Scenario, coal power in South Africa continues to dominate the generation mix, although large reservoir hydropower and, towards the end of the period, solar power make important contributions. The power system is already highly integrated and the region, particularly some smaller countries, are set to reap significant benefits from this integration. Only limited additional investments in new inter-connectors are deemed optimal.



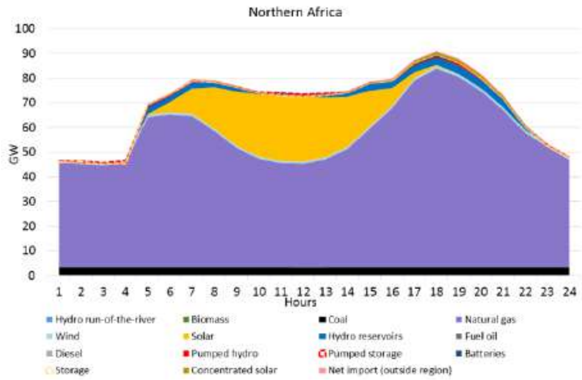
In Western Africa, growing energy demand is met through significant investments in natural gas power plants, solar and reservoir hydropower, resulting in more than a tripling of installed capacity by 2030. Investments in generation are complemented by a number of new inter-connectors, allowing the region to fully utilize its potential and develop a diverse generation mix. The projected energy mix is dominated by solar, hydro power with reservoirs and natural gas, with the latter playing a particularly important role.



In Central Africa, few generation projects are currently under construction, and significant new investments are required already by 2025 in order to meet the forecasted demand increase. Furthermore, because few of the power markets in the region are meaningfully connected at present, investments in new inter-connectors are crucial for the development of an integrated and well-functioning power system. By 2030, installed capacity in the region is expected to quadruple, primarily as a result of investments in large run-of-river hydropower projects in the Democratic Republic of Congo and Cameroon as well as solar power complemented by utility-scale batteries and reservoir hydro.

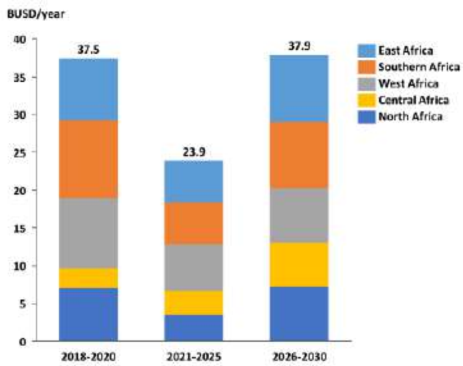


In Northern Africa, most countries are already at or near full access. Electricity demand growth is therefore primarily driven by the forecasted economic growth in the region and particularly in Egypt. By 2030, installed capacity is forecast to be near double, with substantial investments made in solar and natural gas power plants. Some renewable energy projects and a significant number of natural gas power plants are already under construction, considerably reducing the required additional investment in generation by 2025. Furthermore, it is found optimal to invest in new inter-connectors for all countries except Egypt, although the amount of tradable power within the region is modest compared to its total electricity demand.



Continent-wide investment needs to achieve New Deal

It is estimated that a minimum of 32 billion USD per year must be invested on average up until 2030 to realize the New Deal. This estimate is based on regional system-wide optimizations. Deviations from a pure region-wide cost-minimization strategy will lead to higher costs and likely higher investment needs. The scenario analyses in this study explore the implications of deviations from pure system cost minimization.



The introduction of dedicated emission reduction ambitions and/or carbon pricing (a Low Carbon Scenario) has dramatic impacts on the optimal generation mix, investment requirements and system cost levels. In order to simulate the implications of global efforts to reduce emissions in the African power sector, a carbon price was introduced to the optimization in a separate Low Carbon Scenario. In terms of system cost, the carbon price has the most prominent effect on the power system in Southern Africa, reducing the reliance on coal power plants in favor of wind, solar and hydro. This effect is also considerable for Eastern and Western Africa, since these regions rely on natural gas and partially coal in the Reference Scenario. Greenhouse gas emissions in the Low Carbon Scenario are forecasted to be nearly 35 percent lower than the Reference Scenario in 2025 and about 40 percent lower in 2030. 2030 emission reductions as compared to the Reference Scenario amount to 235 million ton of CO2-equivalent per year, equal to half the 2016 emissions of South Africa . Such a green shift, in accordance with the Nationally Determined Contributions set forth by all African countries during the 2015 COP 21 in Paris, would imply an increase of total system costs in 2030 by approximately five percent and an increase of annual investment needs over the forecasted period by 30 percent. Specifically, the Low Carbon Scenario would imply an increase in total system costs for Africa of 5.8 billion USD per year from 2030. As this amount would represent the cost to the African power system of a low carbon development path, it could be treated as a reference amount when considering climate financing from developing countries, as envisioned under the Paris Agreement.

A separate Trade Stagnation Scenario where inter-connector investments are severely limited reveals that while regional integration has surprisingly limited aggregate impacts on the continental level, it is nonetheless critical for several smaller countries that stand to benefit significantly from lower cost imports. The limited aggregate impact is primarily driven by the dominant role of the larger power systems and the fact that a number of major inter-connectors already are under construction. However, Burundi, Eritrea, Swaziland, Lesotho, Benin, Togo, Chad, Gabon and Mauritania among other will reap significant benefits from increased integration. The relative benefits of trade also differ between regions due to the countries' different levels of dependency on cross-border power trade. While it is found optimal to trade significant amount of power for countries in Central, Eastern and Western Africa, countries in Southern and Northern Africa trade lower amount of power relative to the total electricity demand in the regions. However, while total investment in inter-connectors by 2030 is a mere 8.9 billion USD, this increased integration results in an estimated 3.4 billion USD reduction in annual system costs across the continent.

Compared with the less ambitious Business-as-Usual Scenario (BaU), the New Deal access expansion vision implies a ramping up of investment by approximately 45 percent, or about 130 billion USD over the next 13 years. This is equal to an average increase of USD 10 billion per year. While the lion's share of this increase is related to T&D investments, the New Deal Scenario also impacts generation, as it implies an additional 38 GW of installed capacity compared with the BaU Expansion Scenario. The additional capacity consists mainly of natural gas and hydropower plants as well as solar and utility-scale batteries. Notably, the New Deal Scenario only results in a marginal increase of the total investment cost for Northern Africa because the region already has near universal access.

Implications of analysis for AfDB and its New Deal on Energy

The AfDB has embarked on its New Deal agenda in the midst of an exciting transition for the global energy sector. Renewable energy sources are already the most competitive sources of power in most markets and costs continue to fall. Energy efficient solutions are becoming wide-spread and we are witnessing a general weakening of the coupling between economic growth and demand for electricity which is likely to dampen

[1] Based on the team's review of a range of estimates including World Energy Outlook 2016 and Bloomberg New Energy Finance 2017, and is set equal to USD 20 per ton of CO2-equivalent emitted in 2020, USD 30 in 2025, and USD 40 in 2030.

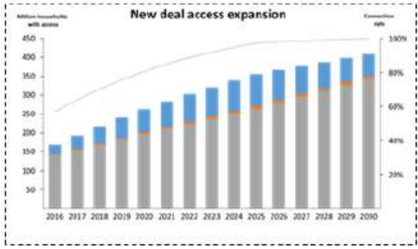
[2] Available at: http://www.globalcarbonatlas.org/en/CO2-emissions

future demand growth while also increasing the economic value of every kWh delivered. Low cost variable renewables will put national and regional power systems to the test, while utility-scale battery solutions likely will come into full maturity during the New Deal timeframe. Finally, off-grid solutions are now offering a more complex understanding of what constitutes access. Mini-grids will likely contribute to more decentralized generation, which will also dampen transmission investment needs.
For the most part, these developments are foreseen and incorporated in this analysis and drive much of the results and estimates. All in all, these developments contribute to making the ambitions of the New Deal less overwhelming and more achievable. AfDB will need to be at the forefront of anticipating and leveraging on these developments.

Achieving universal access is possible and perhaps requires less additional funding than previously thought, but progress is already lagging. The estimates presented in this study indicate an investment requirement of some 29-39 billion USD per year in order to achieve universal access, if an optimal investment plan is realized. This implies that with good regional planning and wise investment decisions, Africa can achieve its high ambitions within a reasonable investment window. This analysis would indicate that the AfDB can champion the view that with good and coordinated investment decisions by public, private, and multilateral investors the New Deal is possible. However, when it comes to access expansion, the indication is that the pace is already too slow when comparing the base year of 2016 with what must be achieved by 2025.

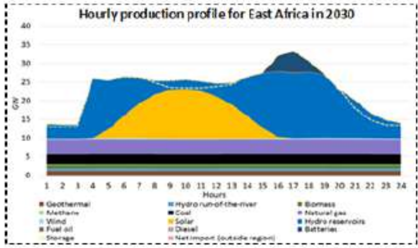
The additional costs for Africa in pursuing a low carbon development path are laid out in this report and provide AfDB with an opportunity to front the case for these costs being covered by the global community. The global policy agenda already points in this direction. The global community wants to see a “clean development path” for Africa, and most international funders are no longer willing to finance fossil-fuel based generation sources. Specifically, the Low Carbon Scenario implies 10 billion USD in additional annual investment and 5.8 billion USD in additional annual system costs from 2030 compared to the reference scenario. While the costs are not astronomical, they are real and ultimately put an estimated price tag on the annual cost for the continent pursuing such a development path. Surely, AfDB is in a position to front Africa´s case for the international community to cover these costs.

Road Map to the New Deal on Energy for Africa



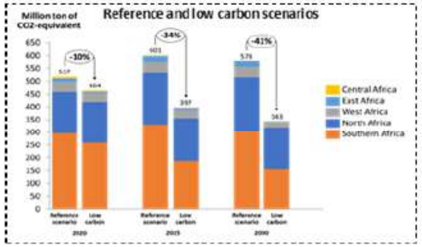
Universal Access by 2025

- Universal access to electricity by 2025
- 190 million new off-grid, mini-grid, and on-grid connections across Africa between 2016 and 2025
- 10 BUSD/year in investment in distribution, mini-grids & off-grid by 2025



Power Systems of the Future

- Falling costs for solar and batteries ensure their prominent roles in the new investments
- By 2030, renewables make up 46% of total installed capacity, up from 20% in 2016, accounting for nearly 65% of total investment in new generation.
- 22 GWs of batteries are to be installed by 2030
- Regional integration and technology diversification allow for integrated regional power system management

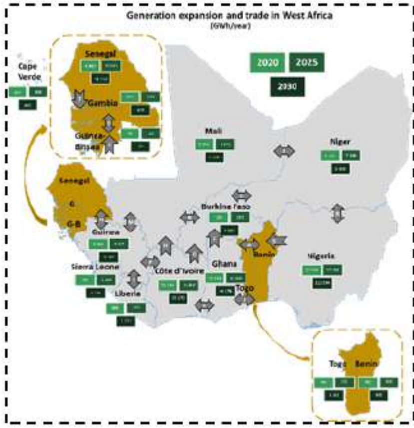


Low Carbon Development

- An additional 10 BUSD/year in investments by 2030 and 5.8 BUSD/year in system costs from 2030
- Result in avoidance of 235 mTCO2/year from 2030
- Africa needs partners in financing the green transition

Regional Integration

- Regional integration allows for optimization of resources
- Low-cost imports critical for several small countries
- 8.9 BUSD in investments in inter-connectors results in 3.4 BUSD in annual system cost reductions



Investments within Reach

- Annual investment of 29-39 BUSD is needed to realize the New Deal on Energy for Africa, depending on the continent's ambition as to avoided greenhouse gas emissions
- The continent already has an unprecedented 80GWs completed or under construction since 2016
- A total of 136GWs of new generation and storage by 2025.

Multiconsult

The New Deal on Energy for Africa

A transformative partnership to light up and power Africa by 2025

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
BaU	Business as Usual
CAGR	Compound Annual Growth Rate
DRC	Democratic Republic of Congo
EAPP	East African Power Pool
GDP	Gross Domestic Product
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt hour
IEA	International Energy Agency
MUSD	Million United States Dollar
MW	Megawatt
MWh	Megawatt hour
USD	United States Dollar
T&D	Transmission and Distribution
TW	Terawatt
TWh	Terawatt hour

1 Electricity access and demand

Underlying the AfDB´s New Deal on Energy for Africa[3] is the recognition that access to modern energy services is a prerequisite for development. Notably, the demand for electricity services and access rates in Africa are no longer tied to grid expansion by a 1:1 ratio. Increasingly, these services are being provided by a continuum of on-grid, mini-grid and off-grid services. As economic growth persists, technology costs fall and business/financing models improve, the unserved population will obtain access through one of several service options and levels. The African Development Bank (AfDB) Strategy incorporates this reality, as does the analysis found in Section 1.1.

Section 1.2 forecasts the demand to be served by grid-connected infrastructure, as a function of economic growth and industrialization , as well as increasing household and service access. As the analysis below illustrates, the combination of economic growth and rapid access expansion implies a Compound Annual Growth Rate (CAGR) in demand of nearly 5.7 percent until 2030.

1.1 Electricity access projections

The AfDB's New Deal on Energy for Africa has as its "aspirational vision" to "achieve universal access to electricity by 2025 – 100% access in urban areas and 95% access in rural areas." This is admittedly highly ambitious, yet also comes at a time of transition, or even revolution, in the way we both measure access and the way in which the power sector of the future is expected to be built out. It also comes at a time when utility-scale solar power has become fully competitive with all other sources and prices continue to fall. It also comes at a time when the global community has committed itself to pursuing universal access electricity and a clean development path for Africa.

Rather than take a view as to the feasibility of this "aspirational vision", this analysis sets out to assess the costs and investments required to achieve it. A tailor-made model has been developed to project access expansion paths across countries and access types in line with AfDB's New Deal targets. Each of the 54 countries have different starting points, and they will all follow unique paths to universal access. Nonetheless, the AfDB targets are so ambitious that most countries must see rapid access expansion and some form of "convergence" if these targets are to be met. The model developed for this study takes account of, among others, the current access rates, population density, poverty, and investment climates for each country to determine the pace and relative importance of grid, mini-grid and off-grid expansion. Please refer to Part A of Annex IV for a more detailed description of the model.

As presented in the figure below, nearly 190 million new on-grid, mini-grid, and off-grid connections will have to be added across Africa between 2016 and 2025, in order to achieve AfDB's vision for Africa. By 2030 the number of new connections is forecast to exceed 240 million. This ambitious expansion program would provide all the 408 million households in Africa with access to electricity by 2030. Off-grid solutions play an important role in terms of achieving the 2025 targets, with the number of such connections peaking at around 85 million in 2025. After 2025, the number of off-grid connections are expected to decline year-on-year, as national and mini-grids expand.

[3] Available at: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Bank_s_strategy_for_New_Energy_on_Energy_for_Africa_EN.pdf

[4] Please refer to Part B of Annex IV for a more detailed description of the methodology and assumptions underpinning the demand projections.

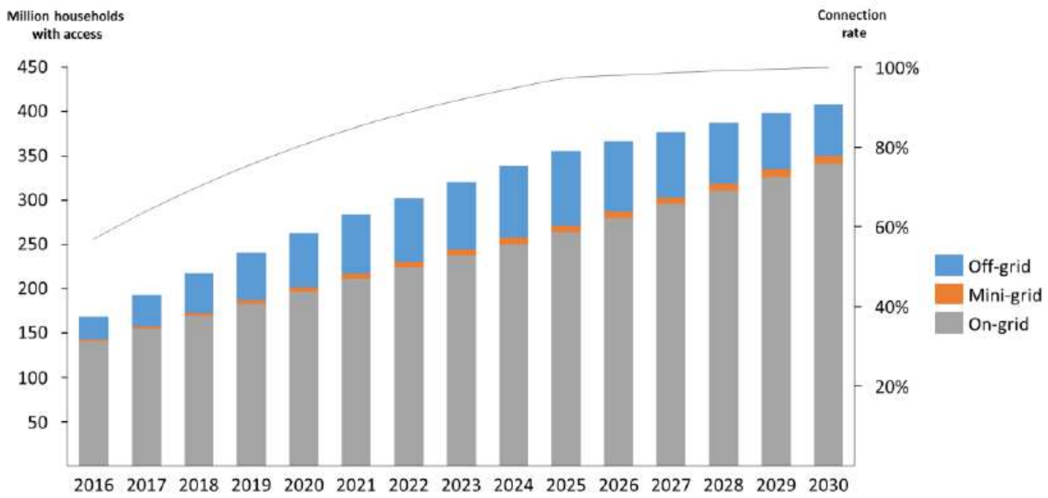


Figure 1-1. Access expansion projections under the New Deal

The resulting urban, rural, and total connection rates are found in the figure below. While all urban households are forecast to have access to electricity by 2025, a lower starting point and higher cost per connection means that full rural access only is realized in 2030.

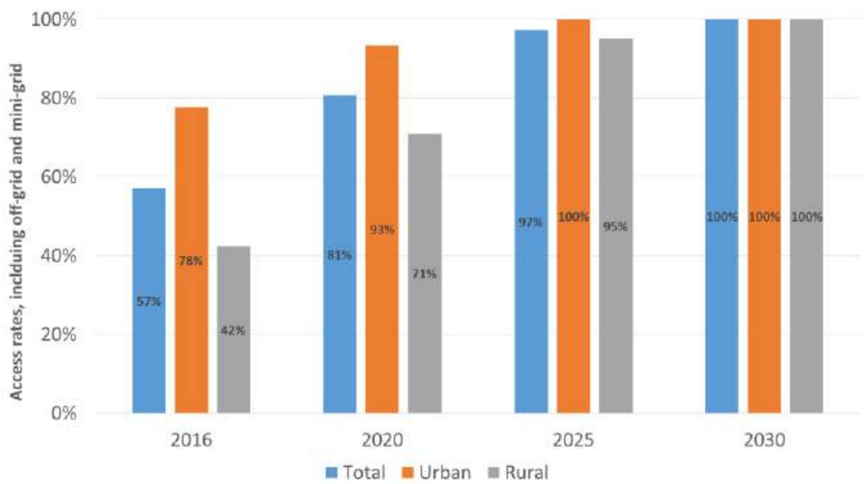
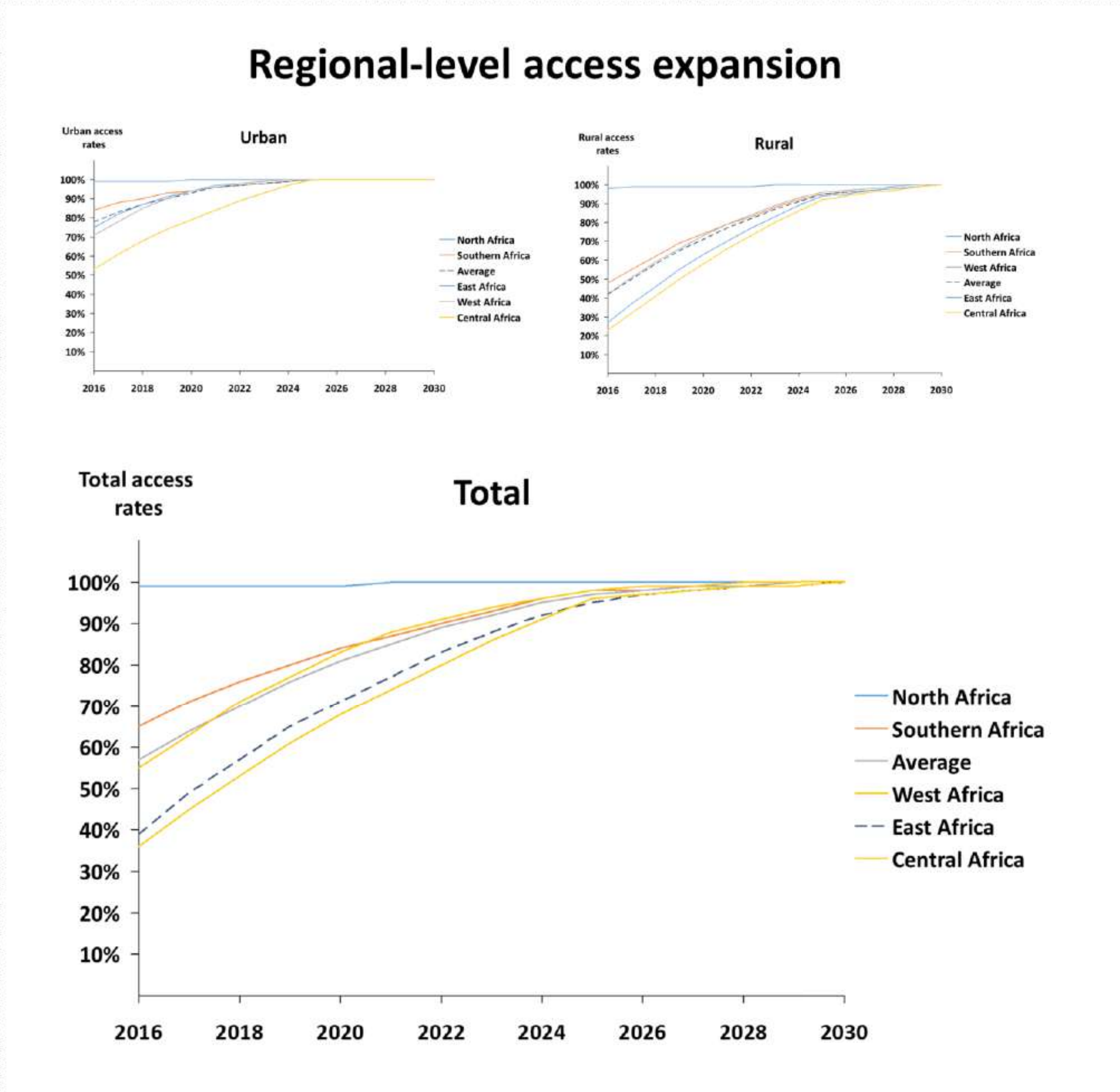


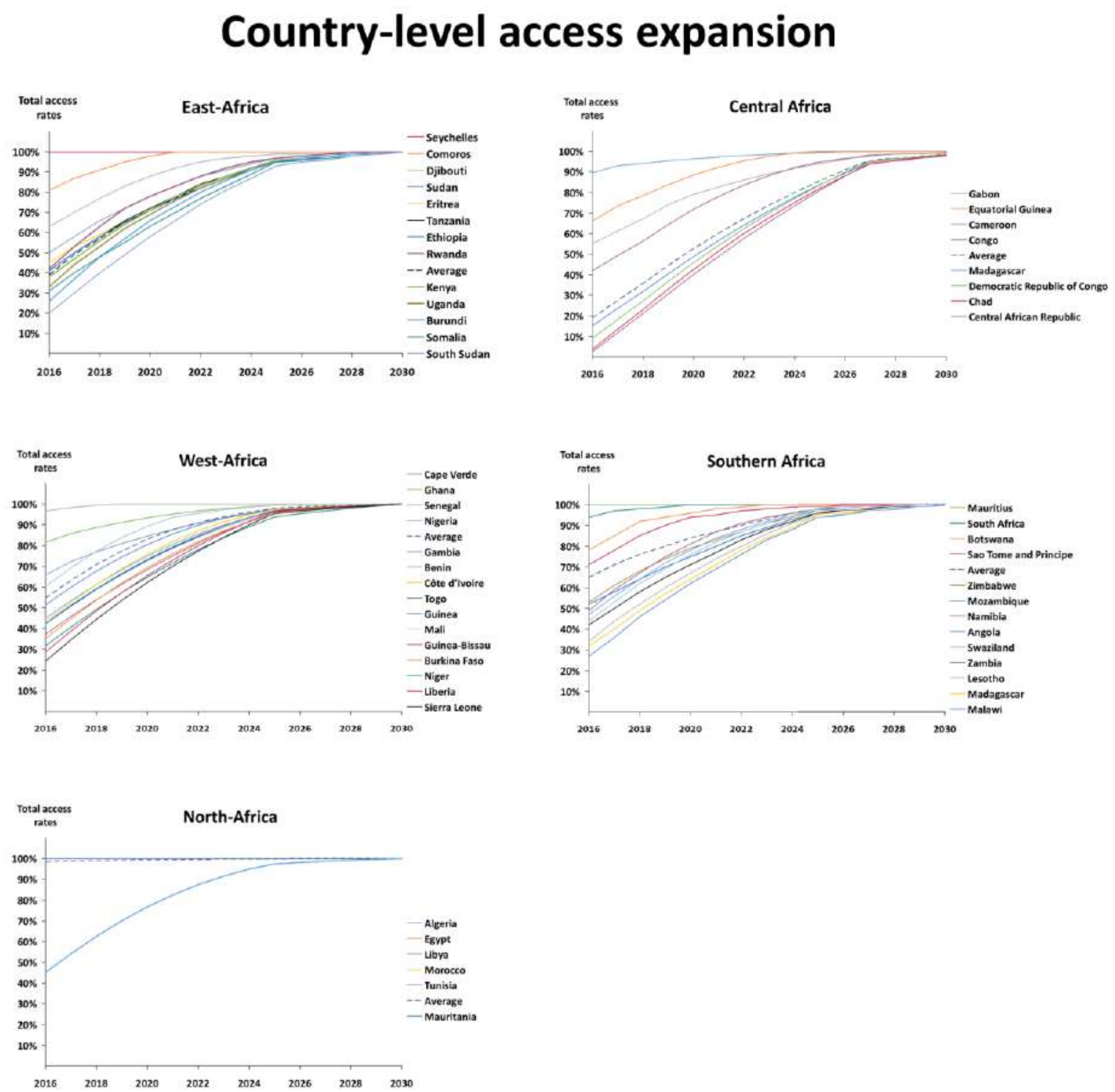
Figure 1-2. Urban and rural access rates (2016, 2020, 2025, 2030)

As outlined above, unique urban and rural access expansion paths are modelled for each country . Box 1 below visualizes these, aggregated for the five regions. Total access paths for individual countries are found in Box 2. There are striking differences in the challenges facing the different groups of countries. Many African countries will be confronting major funding and institutional capacity constraints in lifting access rates significantly and at a rapid pace.

[5] Please refer to Part A of Annex IV for a more detailed description of the methodology and assumptions underpinning the access projections.



Box 1 Forecasted access expansion paths, aggregated by region



Box 2 Forecasted access expansion paths, by country

1.2 Electricity demand projections

The forecasted electricity demand aggregates the organic demand growth following from increased economic activity (GDP growth) and the effects of the unprecedented access expansion program presented in the previous section to forecast net on-grid electricity demand for each country.

The total net electricity consumption in Africa for 2016 is estimated to 652 terawatt-hours (TWh). As seen in the figure below, net consumption is forecast to reach 1,080 TWh/year by 2025, and around 1,400 TWh/year in 2030. This implies a CAGR of 5.7 percent between 2016 and 2030, marking a noticeable break from the 3.7 percent CAGR over the past 10 years estimated by the International Energy Agency (IEA) in their 2016 World Energy Outlook .

The methodology and assumptions underpinning the demand projections are described in detail in Part B of Annex IV, while tabulated year-by-year net demand numbers for each country are found in Annex III.

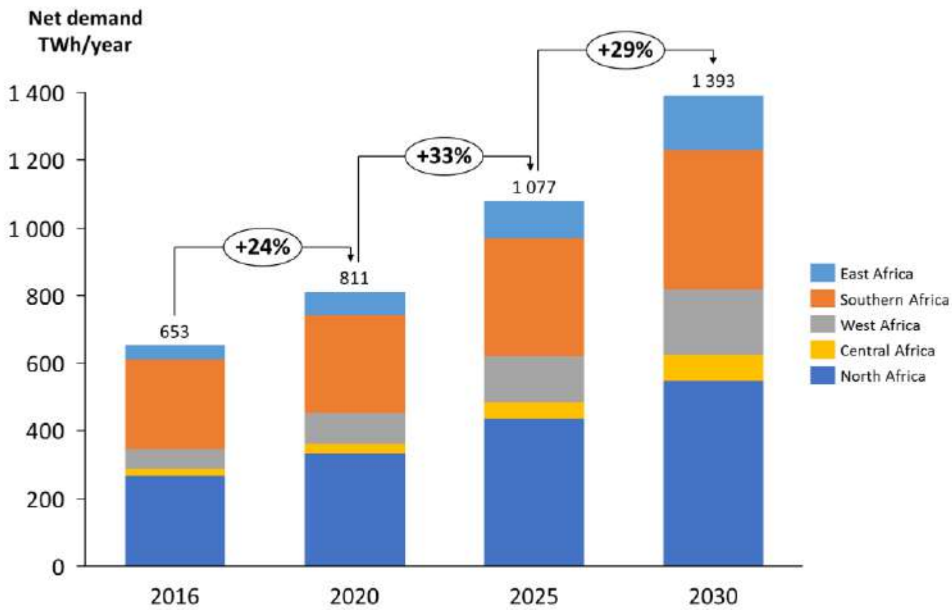


Figure 1-3. Forecasted net electricity demand by region (2016, 2020, 2025, and 2030)

To allow a closer look at the forecasted 2025 net demand numbers for each region, these are presented separately in the figure below.

[6] Available at: https://www.iea.org/newsroom/news/2016/november/world-energy-outlook-2016.html

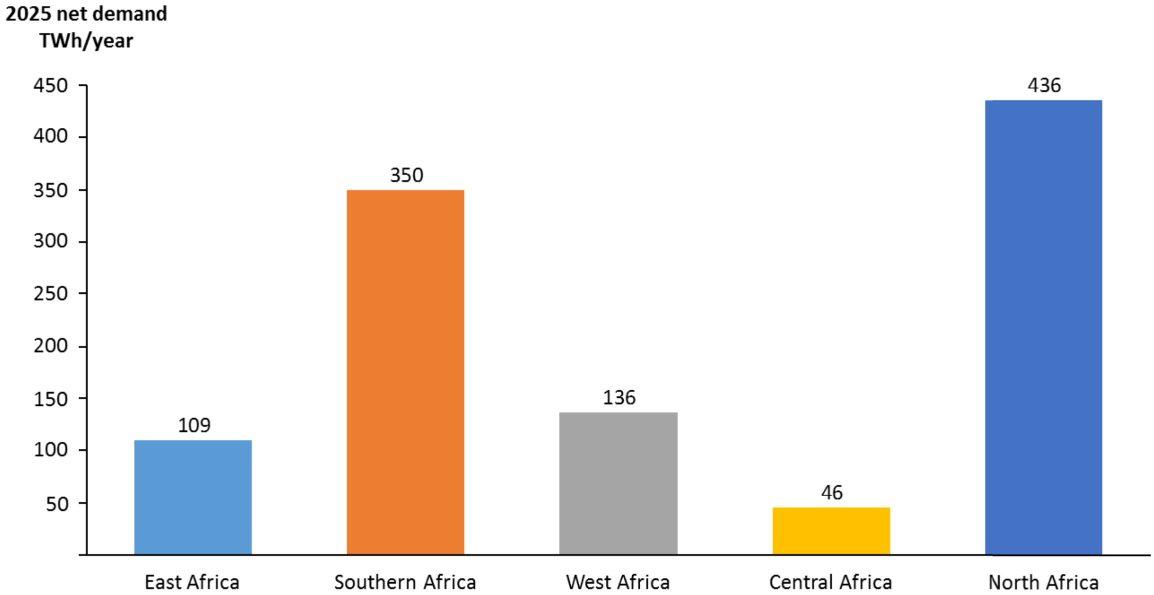


Figure 1-4. 2025 net electricity demand projections

Each of the five regions have their own growth stories. It is notable that despite strong demand growth in Central, Western, and Eastern Africa, their combined 2025 demand is still forecast to be lower than that of Southern Africa.

- **Eastern Africa.** Driven by strong forecasted GDP growth in the economic engines of Ethiopia and Kenya combined with the second most ambitious grid expansion on the continent, the region is expected to see the highest demand growth of all the five regions up to 2025, with a CAGR of 11.1 percent.
- **Southern Africa.** Due to low forecasted GDP growth and high base-year electrification rates in South Africa, the Southern region is forecast to have the lowest relative growth rate leading up to 2025 at a CAGR of 3.2 percent. As a result, demand in Northern Africa is expected to overtake Southern Africa by 2020. Likewise, Egypt is forecast to surpass South Africa as the largest electricity market on the continent between 2020 and 2025.
- **Western Africa.** With nearly 50 million new connections before 2025, corresponding to almost 60 TWh of annual consumption, the 9.8 percent demand growth CAGR up to 2025 in West-Africa is driven mainly by access expansion.
- **Central Africa.** On-grid demand in Central Africa is projected to grow at a CAGR of 8.8 percent up to 2025, with nearly 60 percent of the growth, or 14 TWh of 2025 demand, stemming from access expansion. The contribution to demand growth from access expansion increases to nearly 70 percent by 2030, as several major countries in the region approach universal access relatively late.
- **Northern Africa.** Northern Africa already has near universal access, so around 95 percent of the 5.6 percent demand CAGR up to 2025 stems from GDP growth. It is forecasted that Egypt will continue to dominate the region in terms of demand, accounting for more than 60 percent of the total by 2030.

Even with the very ambitious access expansion program outlined above, economic growth continues to be the main driver of demand, particularly in the larger economies. As see from the figure below, access expansion is forecast to contribute some 146 TWh of new net consumption, or about 35 percent of the total increase between 2016 and 2025.

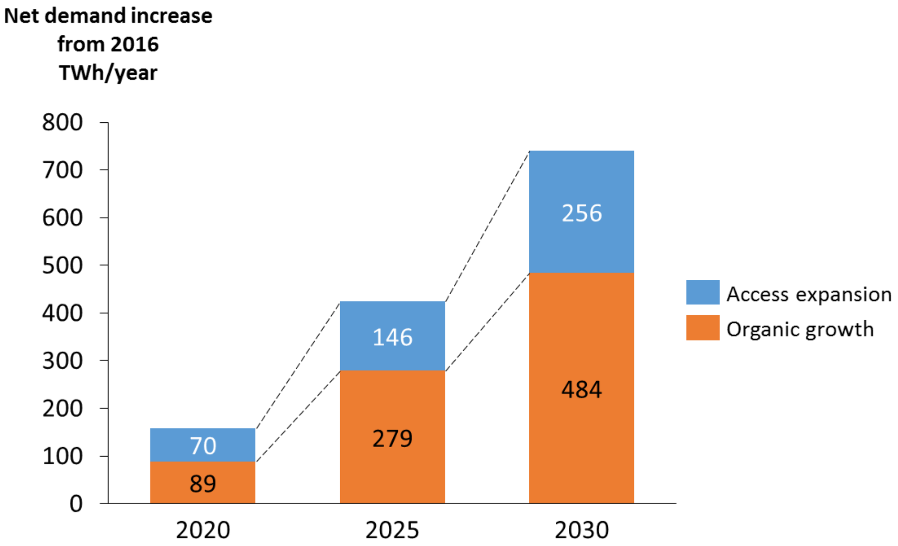


Figure 1-5. New on-grid demand in Africa, split by demand from access expansion, and organic growth

The figure below breaks the forecasted demand from access expansion down on the five regions. Even though East-Africa has the most ambitious access expansion program in absolute numbers, with 95 million new grid, mini-grid and off-grid connections, West Africa adds more on-grid connections. This is largely driven by Nigeria, which is forecasted to account for nearly 25 percent of new demand from access expansion on the continent by 2025.

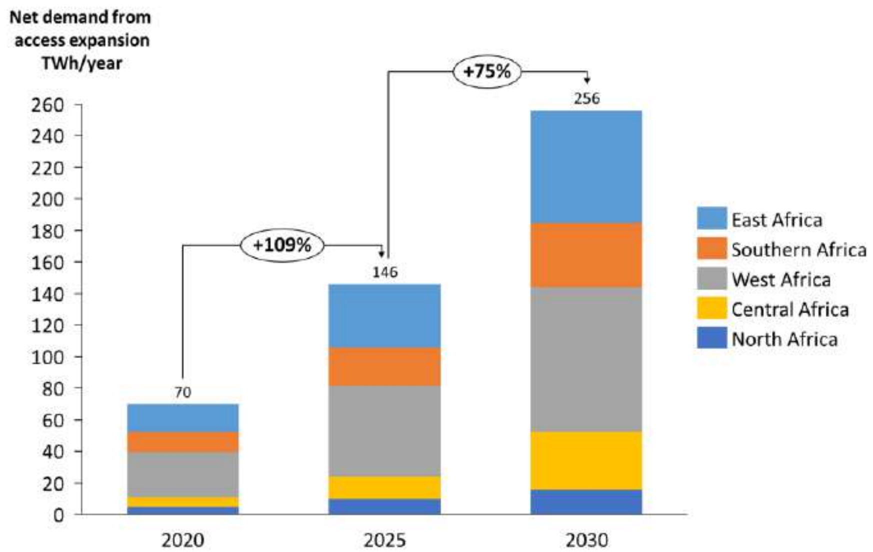


Figure 1-6. Projection of net on-grid electricity demand from access expansion program in 2020, 2025, and 2030

Finally, the Balmorel model also returns peak demand numbers for each country based, among other things, on estimated losses and demand profiles for different groups of countries. Please refer to Part B of Annex IV for details.

2 Optimal regional power supply expansion

In order to establish baseline investment needs for the New Deal vision, a Reference Scenario has been developed for the primary analysis. The core of this analysis involves the optimization of power supply options for each of the five regions (regional groupings are found in Annex I). That is, the Balmorel Model minimizes the costs associated with meeting power demand in each country and across the region by minimizing the system (life-cycle) costs. Annex IV provides a detailed description of the key inputs and assumptions underpinning this optimization and the various scenarios.

The Reference Scenario aims minimize the cost of meeting demand resulting from expected economic growth and the New Deal access targets, with no explicit ambitions as to domestic energy security or emissions reductions. Thus, it effectively provides a baseline for planning and eventually monitoring investment in and progress towards the New Deal vision.

The results of the optimization exercise for each region, presented below provides the basis for estimating the generation and inter-connector investments needed to realize the Reference Scenario. Combined with investment requirements related to domestic transmission and distribution (T&D), mini-grids and off-grid, this forms the basis for the subsequent estimates of total investment needs. Further, an analysis of the Reference Scenario results in light of the other scenarios provides a powerful tool for considering country-specific, regional and continent-wide policy and financing implications.

In the following sections, the results of the optimization for each region are presented, as are the key observations that can be made.

2.1 East Africa

Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Seychelles, Somalia, South Sudan, Sudan, Tanzania, and Uganda.

Over the next 13 years, on-grid demand in East-Africa is forecasted to grow at a CAGR of 10 percent, more than any other region in this study, resulting in a near quadrupling of total demand over the period. The growth is primarily driven by rapid access expansion, with Ethiopia, Kenya, Tanzania, and the Sudan having the largest impact.

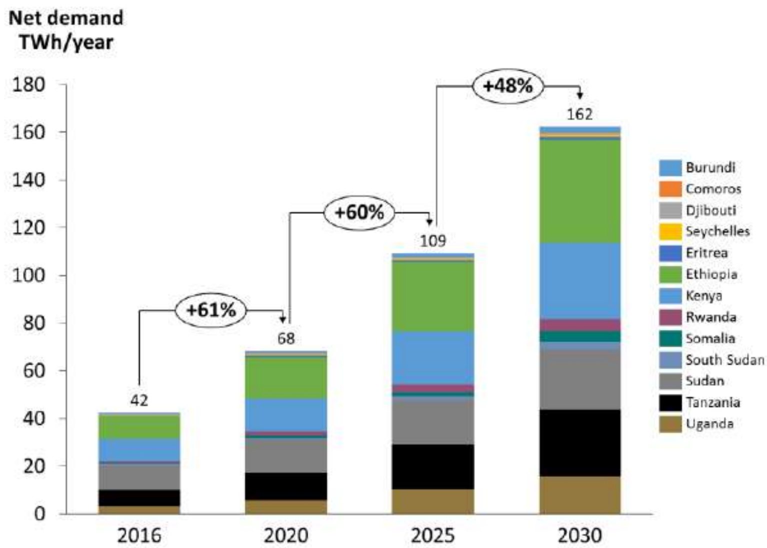


Figure2-1. Net electricity demand projections (2016, 2020, 2025, 2030)

The following key policy takeaways are highlighted from the subsequent analysis;

- With almost 12 GW already under construction, only 10 GW of additional generation capacity would suffice to meet the forecasted 2025 demand. It follows that policy-makers and financiers should be highly selective in terms of which new generation projects are taken forward over this period.
- Solar power complemented by utility-scale batteries as well as reservoir hydropower and natural gas power account for the majority of new investments between 2025 and 2030.
- The modelling reveals that East Africa would gain from seven GW and 11 GW of new inter-connector capacity up to 2025 and 2030, respectively. This includes lines already under construction.

2.1.1 Generation expansion

With large hydropower plants under construction in both Ethiopia and Uganda, the region is expected to add near 12 GW of new capacity between 2016 and 2025, entirely from plants which are already under construction. Adding this significant increase, representing a near doubling of total installed capacity in 2016, exogenously to the model leads to a capacity surplus in the region in the near term. As a result, very limited additional investments are required to meet demand until 2025. In fact, only an additional 10 GW are required in the entire region until 2025, beyond what is already being constructed, despite rapidly growing demand. That is, from an optimization perspective, only limited additional capacity is required throughout the region, thus implying that policy-makers and financiers should be highly selective in terms of planning for new capacity. All in all, installed capacity is forecasted to increase by approximately 180 percent from 2016 by 2025 and about 395 percent by 2030.

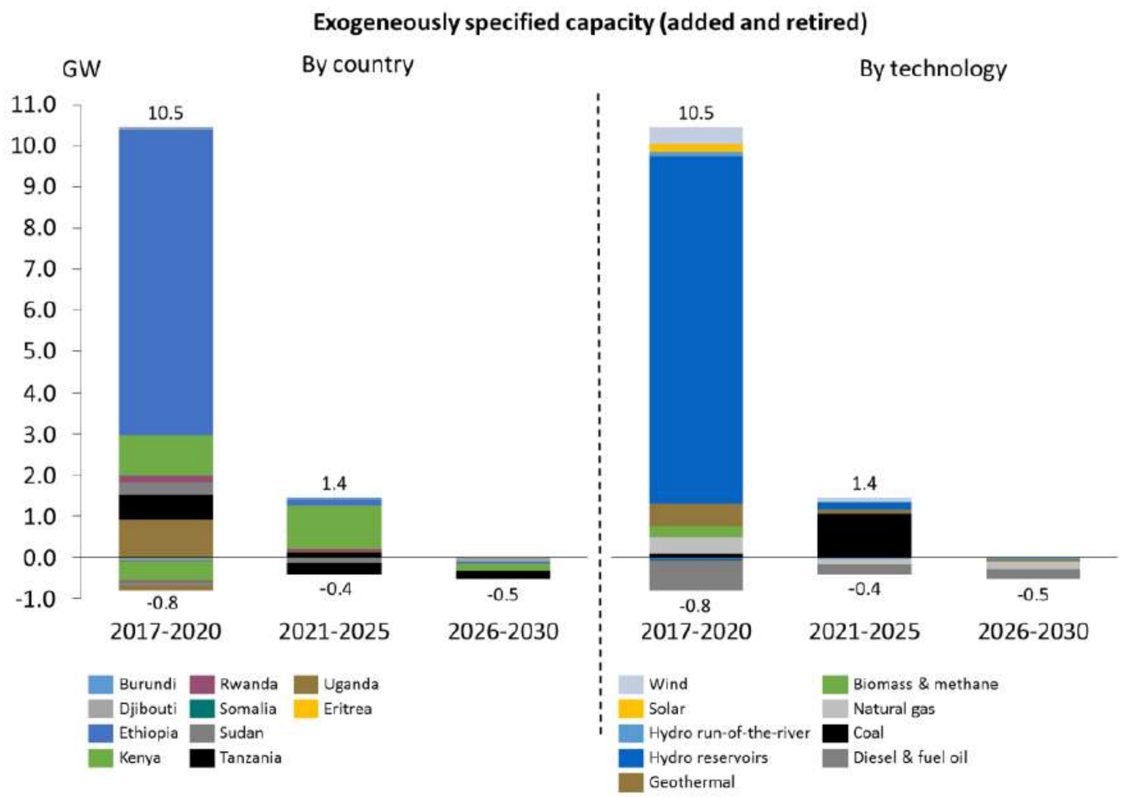


Figure 2-2. Exogenously specified capacity (added and retired) by a given year by country and technology

East-Africa is in the process of developing a diverse generation mix, with substantial flexibility being offered by reservoir hydropower, and solar becoming highly competitive in 2025 and dominant by 2030. Even with the moderate flexibility assumptions applied to the region's reservoir hydropower (see Annex IV), the flexibility offered by this source of power improves the viability and attractiveness of solar. In 2030, the optimization results in 38 percent of generation coming from reservoir hydropower and 19 percent from variable renewables – wind and solar. Nonetheless, the natural gas resources particularly in Tanzania also prove valuable, with five GW of gas-fired capacity installed in the region by 2030, 4.6 GW of which are added in Tanzania. While solar makes up some 32 percent of total capacity (including batteries) in 2030, it only accounts for 18 percent of total generation, due to low plant factors.

While renewables prove highly competitive, thermal plants already under construction and low cost natural gas resources in the region result in a near 70 percent forecasted increase in emissions from the sector between 2016 and 2025. The emission intensity (ton CO2/MWh), however, is reduced from 0.27 to 0.18, due to the expanded role of renewables and relatively clean gas fired power. As Figure 2-3 demonstrates, the modelled optimal solution includes significant build out of solar in most countries in the region. Additionally, by 2030, the model recommends investment in six GW of utility-scale battery storage, with Ethiopia and Sudan leading the way.

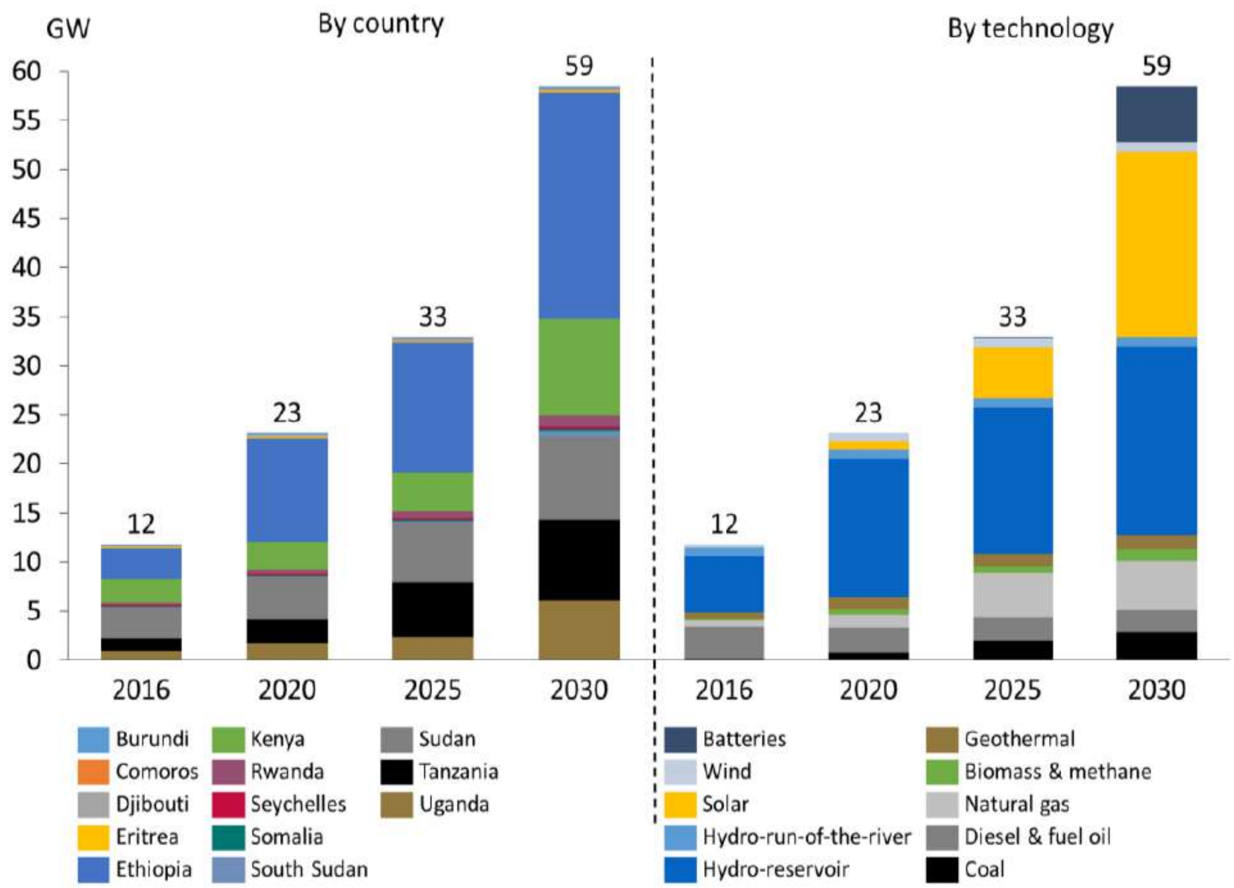
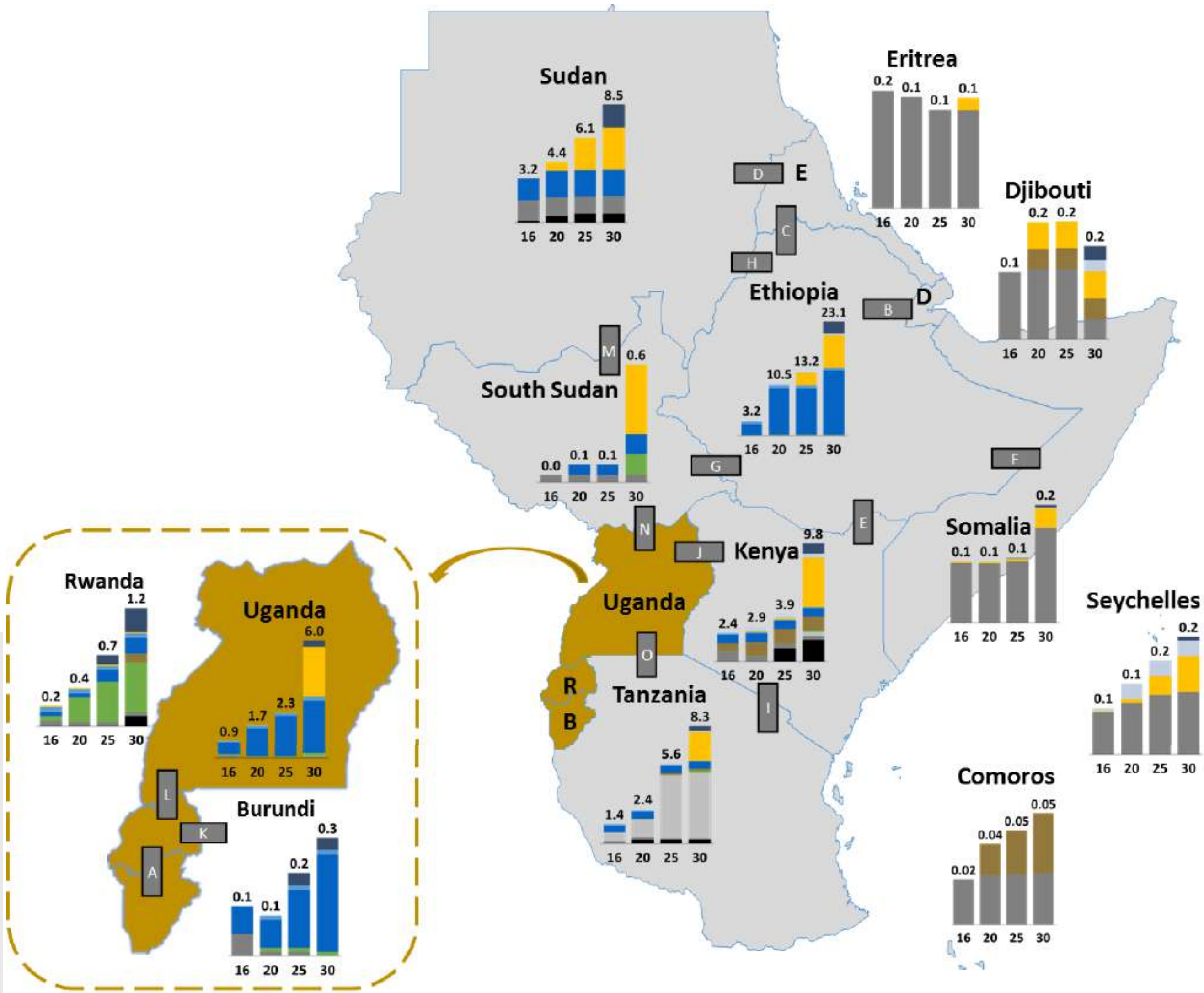


Figure 2-3. Total generation capacity by country and technology

2.1.2 The regional power system

In addition to the back-bone inter-connector already under construction between Ethiopia and Kenya, and Kenya and Tanzania, the optimal solution includes several new inter-connectors. As depicted in the figure below, in the near term, Ethiopia's large hydropower plants allow it to emerge as a large exporter. However, this situation changes significantly over the forecast period, with Tanzania emerging as a large exporter to Kenya, who in turn exports to Ethiopia who then exports to its other neighbours. Other larger inter-connectors deemed optimal include Uganda-South Sudan, Ethiopia-South Sudan and Ethiopia-Somalia. Burundi, Djibouti, Eritrea, Somalia and South Sudan in particular are forecasted to be highly dependent on imports by 2025 and 2030, benefiting significantly from increased regional integration.

Up to 2030, the region invests in 11 GW of inter-connector capacity, including the large inter-connectors already under construction. As a result, with a relatively modest average annual investment of 275 million USD each year, the region should emerge from relatively isolated national systems to a highly inter-connected regional power system over the period, with significant trade volumes. Again, the significant reservoir hydropower in the region and the inter-connectors contributing to enabling variable renewables and regional system management to meet peak demands.



Capacity (GW)

Batteries
Wind
Solar
Hydro-run-of-the-river
Hydro-reservoir
Geothermal
Biomass & methane
Natural gas
Diesel & fuel oil
Coal

Interconnector

Interconnector capacity (MW)

	Interconnector		2020	2025	2030
A	Burundi	Rwanda	124	224	358
B	Djibouti	Ethiopia	180	180	180
C	Eritrea	Ethiopia	106	106	206
D	Eritrea	Sudan	0	100	100
E	Ethiopia	Kenya	2 000	2 000	2 511
F	Ethiopia	Somalia	224	403	1 100
G	Ethiopia	South Sudan	176	276	1 370
H	Ethiopia	Sudan	378	748	855
I	Kenya	Tanzania	2 000	2 000	2 000
J	Kenya	Uganda	445	445	445
K	Rwanda	Tanzania	0	304	304
L	Rwanda	Uganda	305	305	405
M	South Sudan	Sudan	12	12	382
N	South Sudan	Uganda	0	226	1 059
O	Tanzania	Uganda	70	70	70

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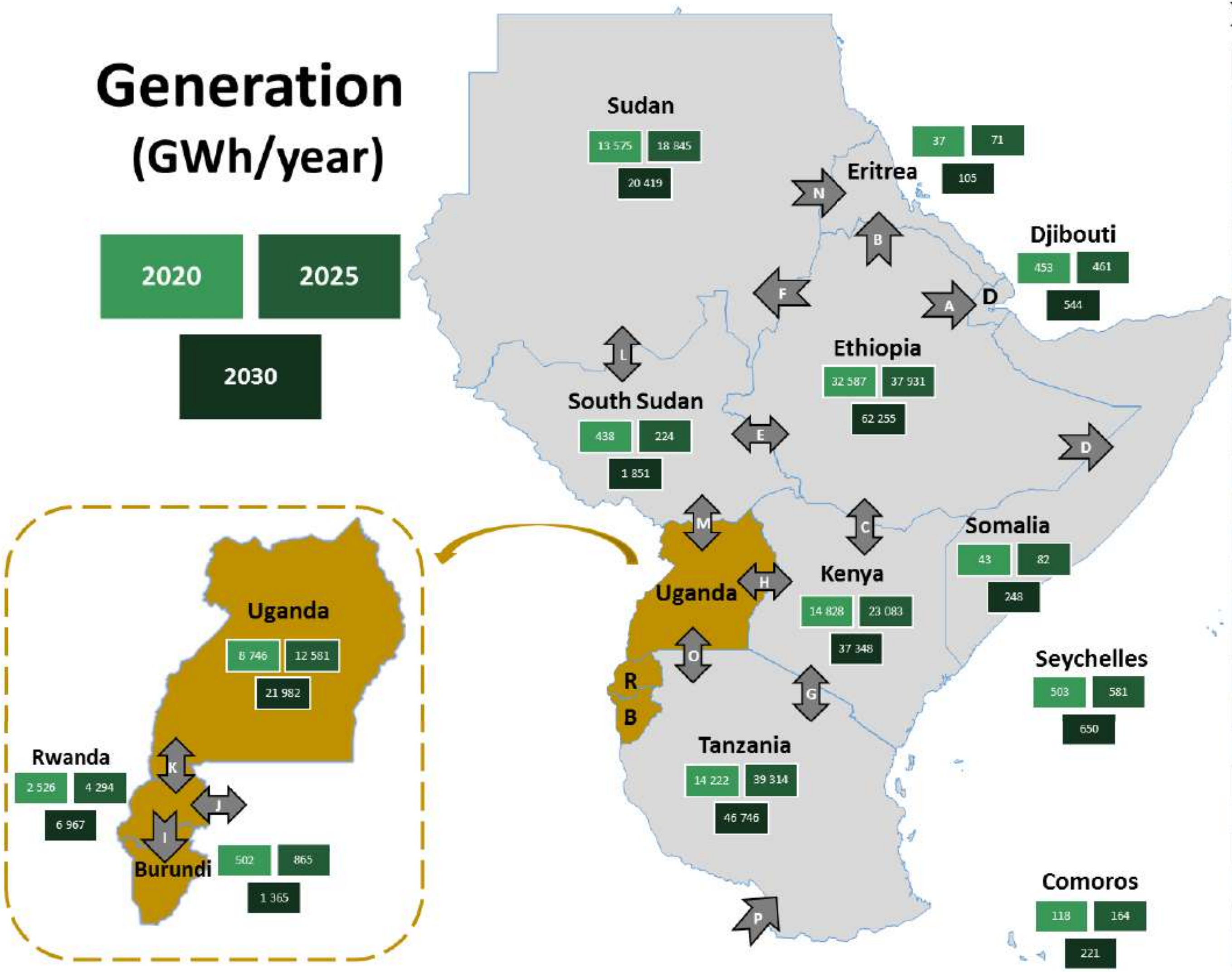


Export (GWh/year)

	From	To	2020	2025	2030
A	Ethiopia	Djibouti	376	626	788
B	Ethiopia	Eritrea	798	886	1 649
C	Ethiopia	Kenya	4 047	1 601	3 543
C	Kenya	Ethiopia	360	8 212	12 570
D	Ethiopia	Somalia	1 152	2 183	5 632
E	Ethiopia	South Sudan	777	375	2 262
E	South Sudan	Ethiopia	0	21	0
F	Ethiopia	Sudan	3 307	3 777	7 296
F	Sudan	Ethiopia	0	8	0
G	Kenya	Tanzania	316	0	13
G	Tanzania	Kenya	3	13 446	11 032
H	Kenya	Uganda	43	1 077	133
H	Uganda	Kenya	297	0	390
I	Rwanda	Burundi	603	1 143	1 895
J	Rwanda	Tanzania	0	0	26
J	Tanzania	Rwanda	0	1 799	1 332
K	Rwanda	Uganda	138	721	566
K	Uganda	Rwanda	774	92	517
L	South Sudan	Sudan	0	36	2 652
L	Sudan	South Sudan	5	9	124
M	South Sudan	Uganda	0	0	803
M	Uganda	South Sudan	0	1 601	3 652
N	Sudan	Eritrea	0	289	109
O	Tanzania	Uganda	22	266	469
O	Uganda	Tanzania	389	0	28
P	Zambia	Tanzania	20	20	20

2.1.3 System operations and costs

The cumulative daily production profile for the region in 2025 and 2030 is heavily influenced by the inter-play between solar and hydro/natural gas in terms of meeting the daily regional demand profile. As can be seen from the figure below, the regional integration and optimal system-wide planning allows the region to harness the characteristics of different technologies and the comparative advantage of renewable and gas resources of each country. Indeed, the region-wide optimization is a reflection of how the Eastern African Power Pool (EAPP) could contribute to an efficiently run power pool which minimizes total system costs.

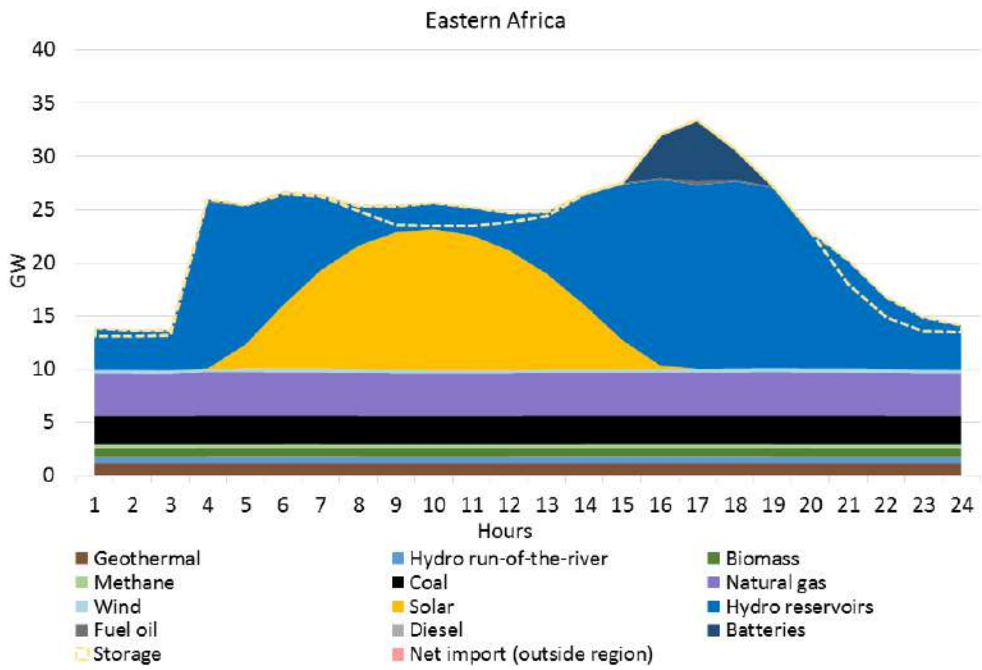


Figure2-4. Hourly power generation and trade profile in 2030

Total forecasted system costs are 37 USD/MWh in 2025 and 52 USD/MWh in 2030, with the cost of capital associated with hydropower and solar power as the primary driver of the cost levels.

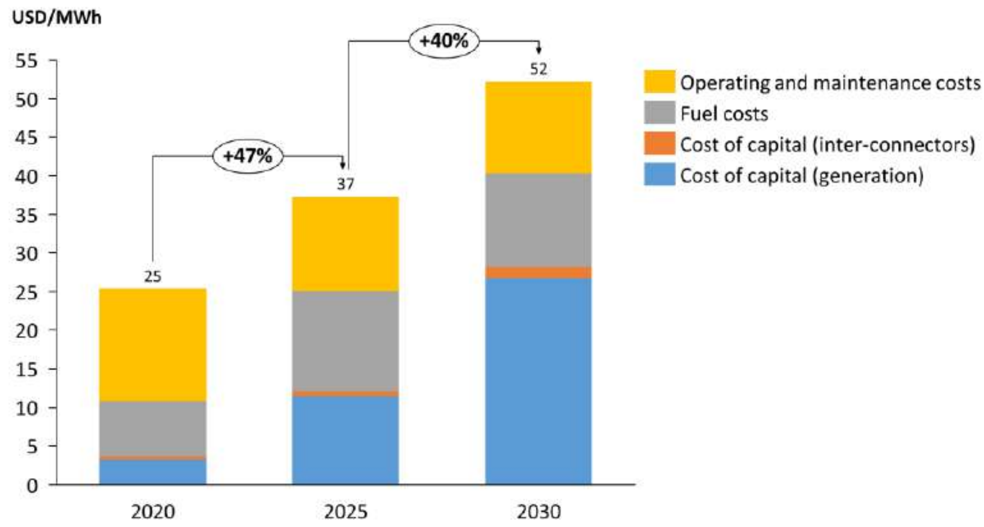


Figure 2-5. System costs by type

2.1.4 Aggregate investment requirements

The tables below present the aggregate investments required in the Reference Scenario for Eastern Africa from 2018 to 2025 and 2018 to 2030, respectively.

Table 2-1. Investment requirements in Eastern Africa between 2018 and 2025 [7]

	Average annual investment cost 2018-2025 (MUSD/year)						Total investment cost between 2018 and 2025 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Burundi	35	3	93	5	26	161	280	20	740	40	210	1 290
Comoros	13	-	10	0	0	23	100	-	80	0	0	180
Djibouti	30	-	5	0	1	36	240	-	40	0	5	285
Eritrea	-	8	19	1	14	41	-	60	150	10	110	330
Ethiopia	794	99	563	53	256	1 764	6 350	790	4 500	420	2 050	14 110
Kenya	438	83	321	28	114	983	3 500	660	2 570	220	910	7 860
Rwanda	193	13	108	4	11	328	1 540	100	860	30	90	2 620
Seychelles	14	-	0	-	-	14	110	-	0	-	-	110
Somalia	3	14	50	4	71	141	20	110	400	30	570	1 130
South Sudan	19	8	54	8	59	146	150	60	430	60	470	1 170
Sudan	341	10	284	15	60	710	2 730	80	2 270	120	480	5 680
Tanzania	721	19	311	25	128	1 204	5 770	150	2 490	200	1 020	9 630
Uganda	511	4	339	23	93	969	4 090	30	2 710	180	740	7 750
Total	3 110	258	2 155	164	832	6 518	24 880	2 060	17 240	1 310	6 655	52 145
Of which already under construction	1 583	174	-	-	-	1 756	12 660	1 390	-	-	-	14 050

[7] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in a new inter-connector between Rwanda-DRC (300 MW) are included into the calculations.

Table 2-2. Investment requirements in Eastern Africa between 2018 and 2030[8]

	Average annual investment cost 2018-2030 (MUSD/year)						Total investment cost between 2018 and 2030 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Burundi	47	4	115	3	16	185	610	50	1 490	40	210	2 400
Comoros	11	-	8	0	0	18	140	-	100	0	0	240
Djibouti	24	-	5	0	0	29	310	-	60	0	5	375
Eritrea	1	7	19	2	8	37	10	90	250	20	110	480
Ethiopia	1 419	107	655	55	158	2 393	18 450	1 390	8 510	710	2 050	31 110
Kenya	621	64	352	28	70	1 135	8 070	830	4 580	360	910	14 750
Rwanda	198	8	135	2	7	352	2 580	110	1 760	30	90	4 570
Seychelles	12	-	0	-	-	12	150	-	0	-	-	150
Somalia	11	23	85	6	47	172	140	300	1 100	80	610	2 230
South Sudan	59	31	77	10	36	213	770	400	1 000	130	470	2 770
Sudan	290	14	315	13	37	668	3 770	180	4 090	170	480	8 690
Tanzania	608	12	342	30	78	1 070	7 910	150	4 440	390	1 020	13 910
Uganda	645	6	415	20	57	1 143	8 380	80	5 400	260	740	14 860
Total	3 945	275	2 522	168	515	7 426	51 290	3 580	32 780	2 190	6 695	96 535
Of which already under construction	974	107	-	-	-	1 081	12 660	1 390	-	-	-	14 050

2.2 Southern Africa

Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, São Tomé & Príncipe, South Africa, Swaziland, Zambia, and Zimbabwe.

Over the next 13 years, demand in Southern Africa is forecast to grow at an average CAGR of 3.2 percent, resulting in an about 55 percent increase over the entire period. The sluggish demand growth in Southern Africa compared to the other regions in this study is largely explained by the expectation that South Africa's moderate economic growth and falling energy intensity will continue.

[8] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in new inter-connectors between Rwanda-DRC (300 MW) and Burundi-DRC (45 MW) are included into the calculations.

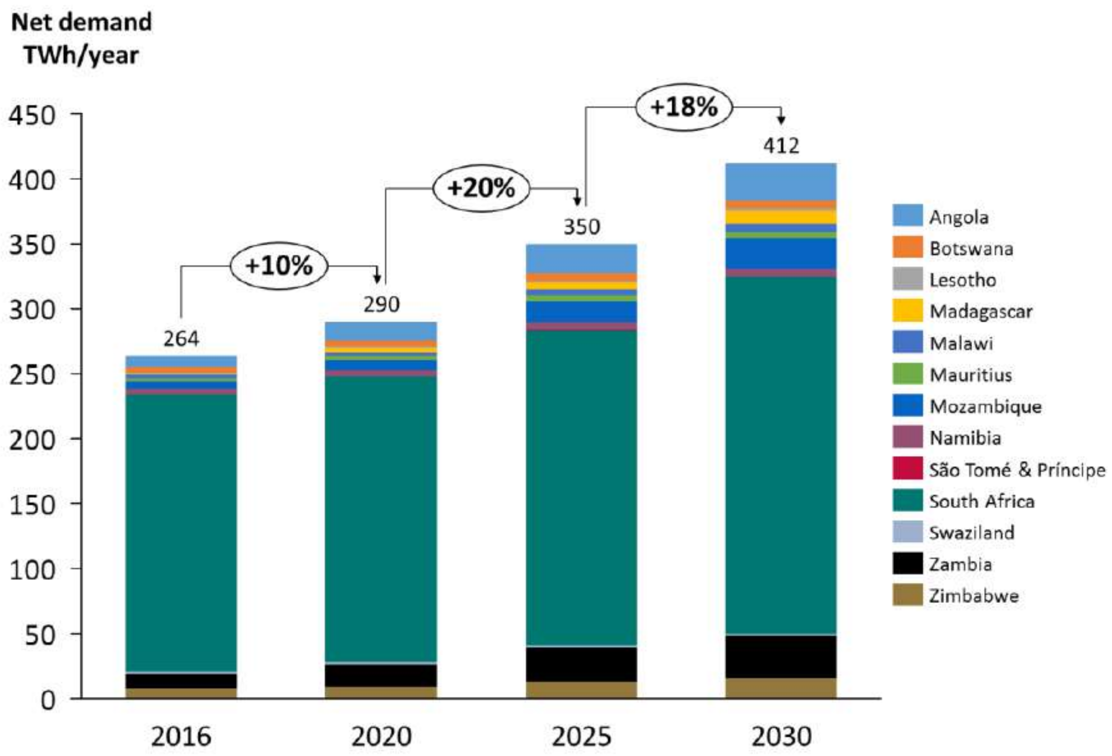


Figure 2-6. Net electricity demand projections (2016, 2020, 2025, 2030)

The following key policy takeaways are highlighted from the subsequent analysis;

- Beyond 16.4 GW already under construction, only an additional 14 GW of generation capacity is required to meet the slow demand growth up till 2025. It follows that for this period, policy-makers and financiers can afford to be selective when planning for new capacity.
- By 2030, the optimal solution suggests 47 GW of additional generation capacity, as the relative importance of coal plants is reduced in favour of reservoir hydropower and solar power supported by batteries.
- The power systems in Southern Africa are already relatively well integrated, and only three and five GW of new inter-connector capacity is found optimal by 2025 and 2030 respectively.

2.2.1 Generation expansion

Including large coal plants in South Africa and reservoir hydropower in Angola, the Southern African region has 16.4 GW of new capacity currently under construction, to be commissioned between 2016 and 2025. This is, however, expected to be countered by 7.8 GW of retirements by 2025, primarily coal fired capacity. These additions and retirements are exogenously added to and deducted from the capacity available to meet growing demand prior to running the optimization. While the net 8.6 GW increase is small relative to installed capacity, it does make a meaningful contribution to meeting the modest demand growth in the region. In fact, only an additional 14 GW of generation capacity, beyond the net 8.6 GW under construction is found to be necessary in order to meet demand in 2025. As a result, installed capacity is increased by approximately 35 percent and 80 percent by 2025 and 2030, respectively. This is modest compared to the more than quadrupling of installed capacity found optimal for East Africa by 2030.

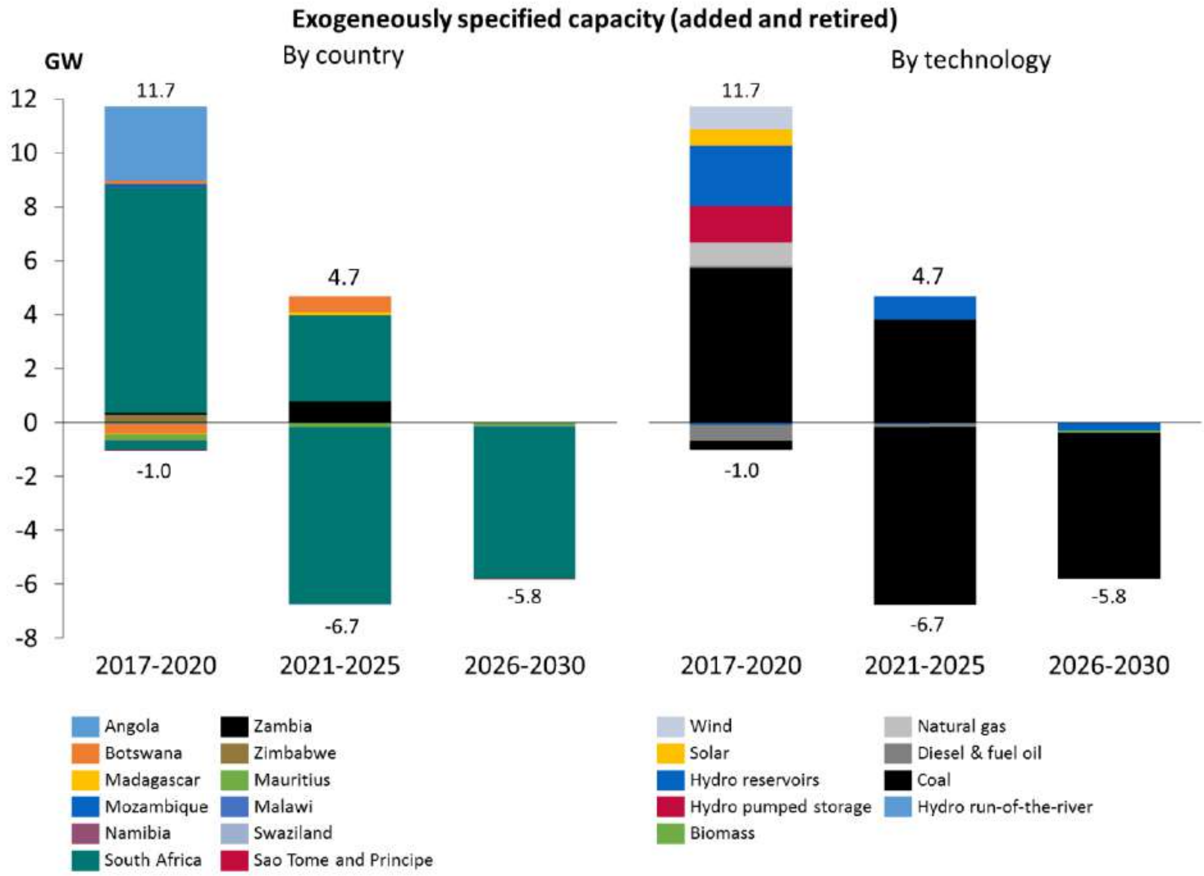


Figure 2-7. Exogenously specified capacity (added and retired) by a given year by country and technology

The region's power supply continues to be dominated by coal-fired power in South Africa, but with renewables making up a significant portion of the limited new investments. This is visualised in the figure below, with hydro, solar, wind and natural gas all playing a role in the optimal generation mix already in 2020. By 2030, these technologies are playing a prominent role, with solar and utility-scale batteries becoming particularly attractive. Mozambique, Angola and Zambia all see particularly strong growth during the period.

While generally attractive, the lack of a carbon price and modest requirements for new generation prevents replacement of fossil fuels and thus rapid growth in renewables. By 2030, coal plants are being retired and replaced by solar, hydro, and gas, coupled with utility-scale batteries. While variable renewables – solar and wind – only is forecasted to make up six percent of capacity (including pumped storage and batteries) and three percent of generation in 2025, the comparable numbers are 19 and 10 percent in 2030. By 2030, the model recommends installation of 15 GW of solar power, in addition to the two GW already installed by 2016, with South Africa, Angola, Zambia, Madagascar and Namibia leading the way. Particularly interesting is the emerging role of batteries in the region, not least in South Africa, which is expected to see five GW of batteries installed by 2030, offering considerable peaking capacity (see Figure 2-9).

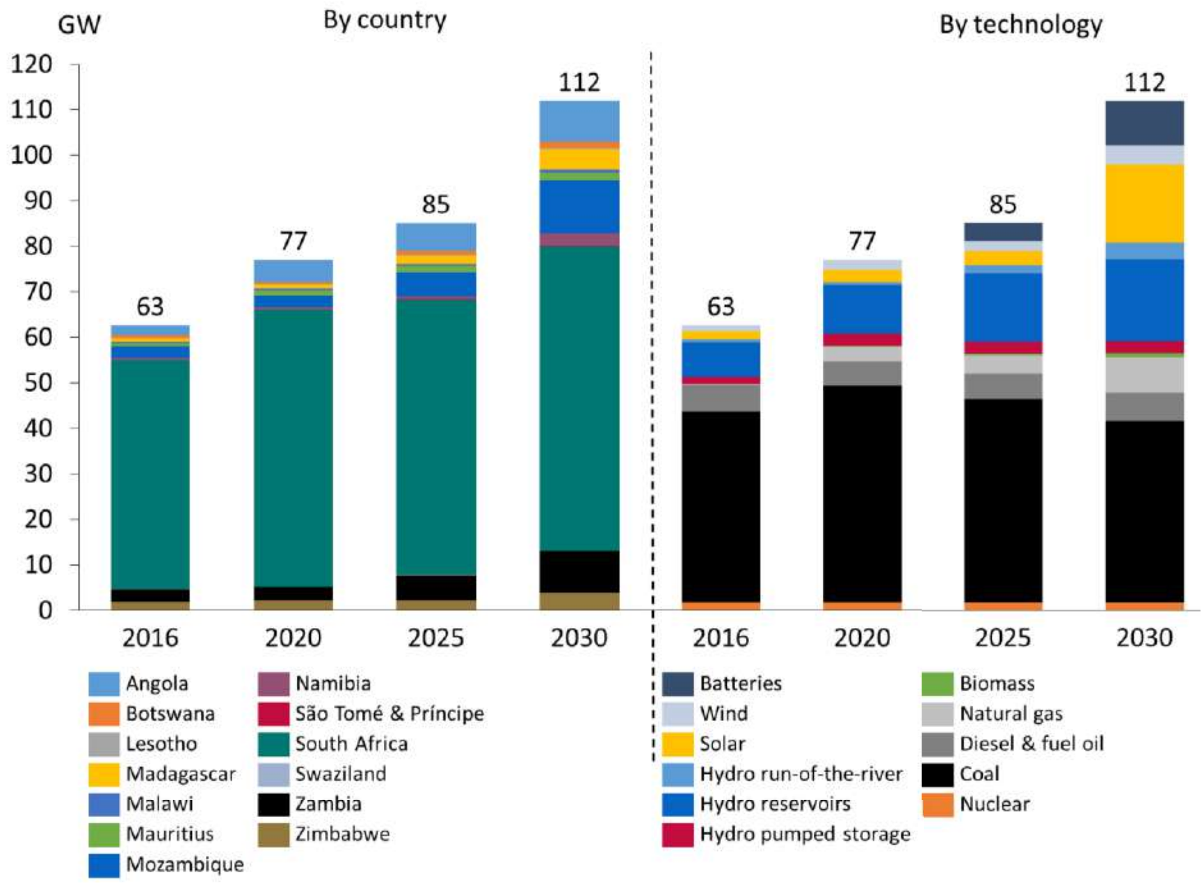


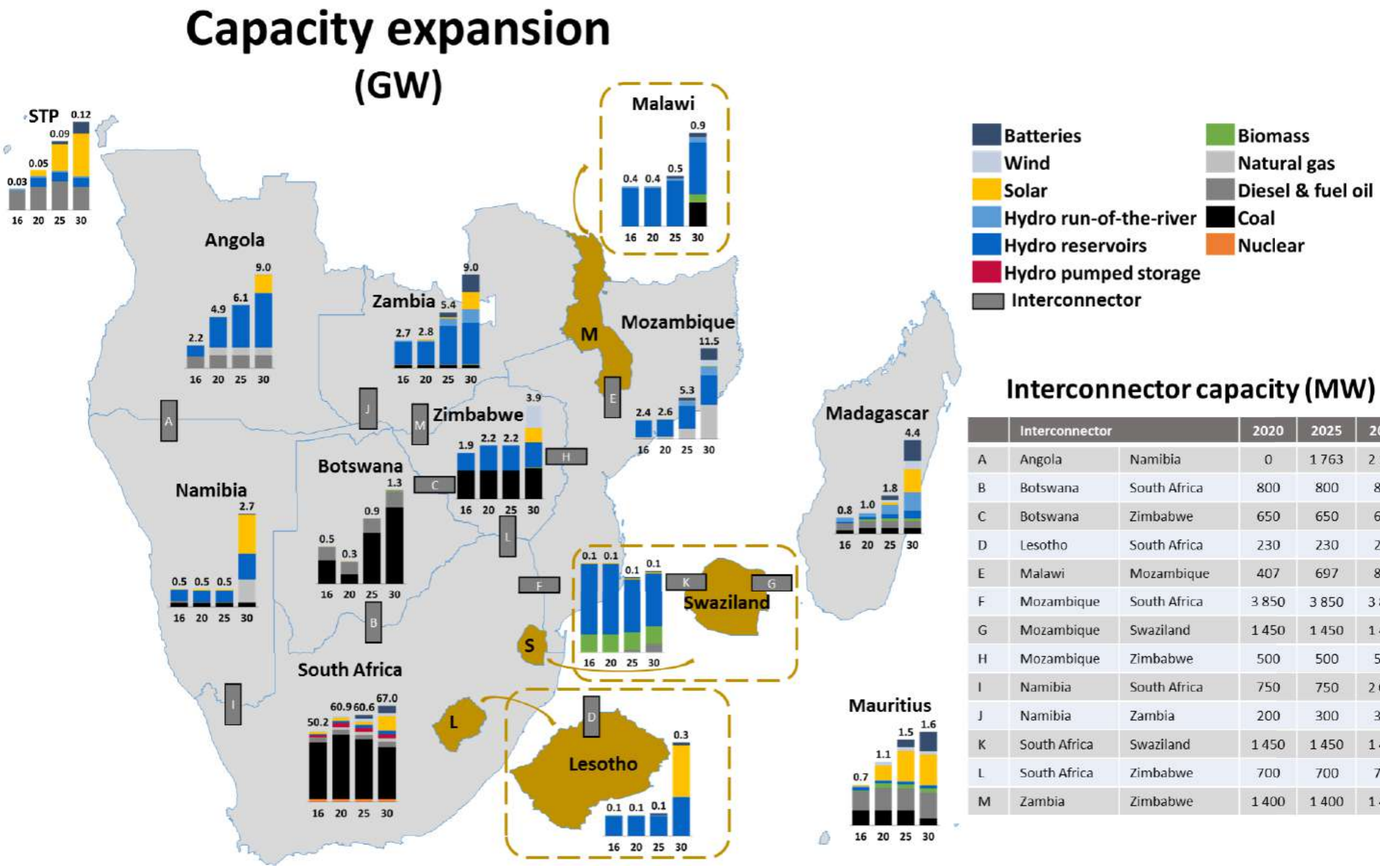
Figure 2-8. Total generation capacity by country and technology

2.2.2 The regional power system

The Southern African power markets are already relatively well integrated, with a number of inter-connectors allowing for considerable trade. As a result, the model only includes a modest three and five GW of new inter-connection capacity by 2025 and 2030, respectively. Further, the overall trade volumes are relatively modest. The largest volumes are traded between South Africa and its neighbours, as well as between Zambia and Zimbabwe. Notably, by 2030, the largest (by far) export volumes are from Mozambique to South Africa.

While there is limited need for increased integration, some new inter-connectors are deemed optimal, particularly between Namibia and Angola, Mozambique and Malawi, and South Africa and Namibia. The 300 MW back-bone inter-connector between Namibia and Zambia has been in place since 2010 and represents an important link in the regional system. While the trade volumes are limited, the regional integration is important for a few countries, including Swaziland, Lesotho, Malawi, and Namibia, who is expected to meet the majority of their demand growth towards both 2025 and 2030 by means of imports. It is notable that with tentative modelling, which incorporates the hydro potential of the Democratic Republic of Congo into the region, there is insufficient demand in the Southern Africa region alone to justify a major build out of the Inga cascade.

Capacity expansion (GW)



Interconnector capacity (MW)

	Interconnector		2020	2025	2030
A	Angola	Namibia	0	1 763	2 140
B	Botswana	South Africa	800	800	800
C	Botswana	Zimbabwe	650	650	650
D	Lesotho	South Africa	230	230	230
E	Malawi	Mozambique	407	697	889
F	Mozambique	South Africa	3 850	3 850	3 850
G	Mozambique	Swaziland	1 450	1 450	1 450
H	Mozambique	Zimbabwe	500	500	500
I	Namibia	South Africa	750	750	2 052
J	Namibia	Zambia	200	300	300
K	South Africa	Swaziland	1 450	1 450	1 450
L	South Africa	Zimbabwe	700	700	700
M	Zambia	Zimbabwe	1 400	1 400	1 400

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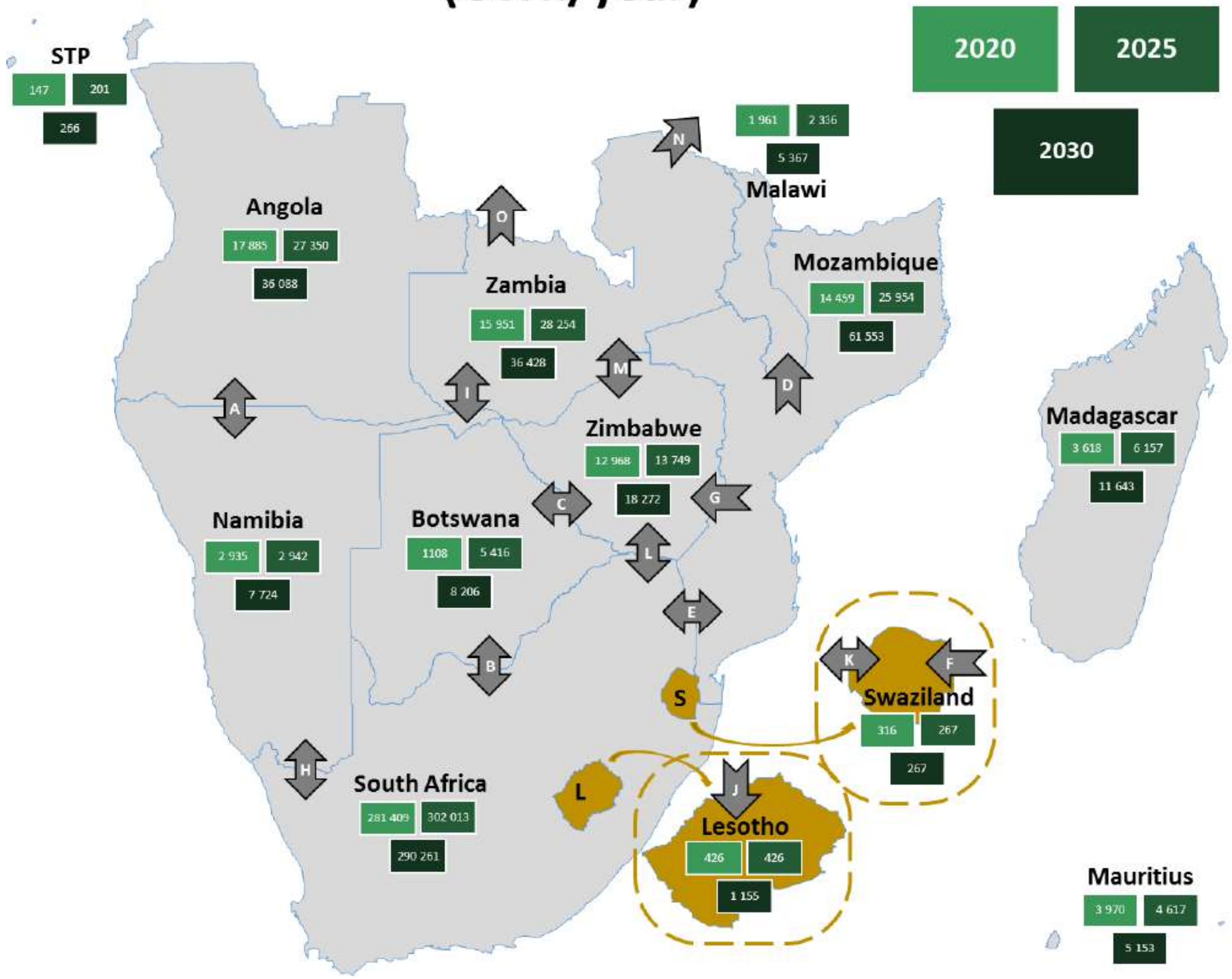
Generation expansion and trade
(GWh/year)



Export (GWh/year)

	From	To	2020	2025	2030
A	Angola	Namibia	0	1 219	3 251
A	Namibia	Angola	0	1 076	0
B	Botswana	South Africa	0	0	394
B	South Africa	Botswana	5 190	2 868	169
C	Botswana	Zimbabwe	495	1 454	555
C	Zimbabwe	Botswana	140	0	105
D	Mozambique	Malawi	1 801	3 326	3 080
E	Mozambique	South Africa	1 351	5	25 171
E	South Africa	Mozambique	2 341	2 695	0
F	Mozambique	Swaziland	958	707	2 199
G	Mozambique	Zimbabwe	1 971	2 792	2 556
H	Namibia	South Africa	0	185	2 693
H	South Africa	Namibia	3 433	4 222	0
I	Namibia	Zambia	658	329	716
I	Zambia	Namibia	0	0	~0
J	South Africa	Lesotho	861	1 254	822
K	South Africa	Swaziland	625	1 160	0
K	Swaziland	South Africa	0	0	28
L	South Africa	Zimbabwe	2 471	2 884	161
L	Zimbabwe	South Africa	0	0	5
M	Zambia	Zimbabwe	0	36	724
M	Zimbabwe	Zambia	5 538	2 741	1 450
N	Zambia	Tanzania	20	20	20
O	Zambia	DRC	95	95	95

2.2.3 System operations and costs

The regional system operations in 2030 are forecasted to be dominated by consumption and coal fired generation in South Africa, but with some major reservoir hydropower schemes playing an important role.

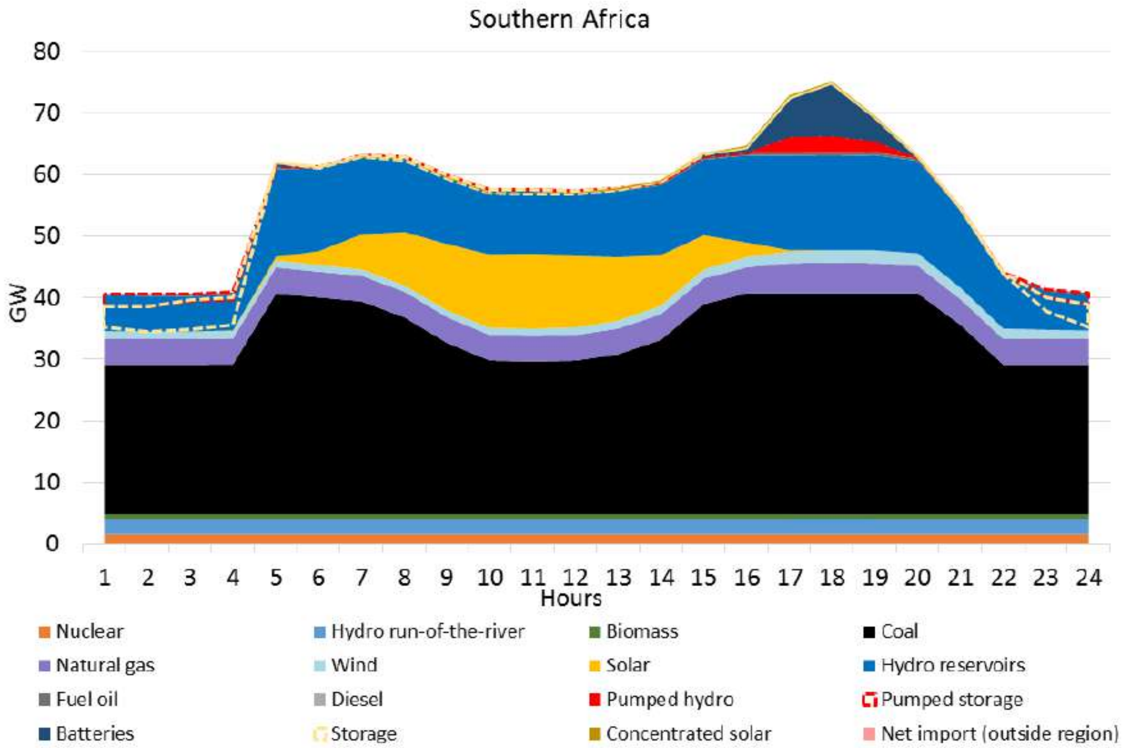


Figure 2-9. Hourly power generation and trade profile in 2030

Total modelled system costs are 44 USD/MWh in 2025 and 52 USD/MWh in 2030, with the cost of coal playing a particularly important role in Southern Africa.

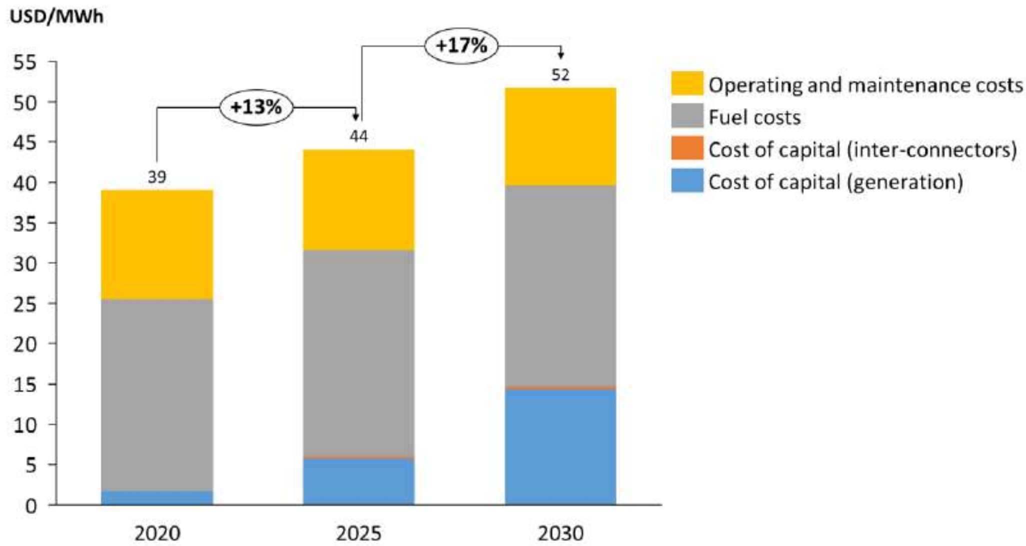


Figure 2-10. System costs by type

2.2.4 *Aggregate investment requirements*

The tables below present the aggregate investments required in the Reference Scenario for Southern Africa from 2018 to 2025 and 2018 to 2030, respectively.

Table 2-3. Investment requirements in Southern Africa between 2018 and 2025 [9]

	Average annual investment cost 2018-2025 (MUSD/year)						Total investment cost between 2018 and 2025 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Angola	463	39	245	10	40	796	3 700	310	1 960	80	320	6 370
Botswana	8	-	20	0	0	28	60	-	160	0	0	220
Lesotho	1	-	10	1	5	17	5	-	80	10	40	135
Madagascar	260	-	99	9	106	474	2 080	-	790	70	850	3 790
Malawi	26	8	88	11	73	205	210	60	700	90	580	1 640
Mauritius	173	-	1	-	-	174	1 380	-	10	-	-	1 390
Mozambique	570	8	153	10	73	813	4 560	60	1 220	80	580	6 500
Namibia	-	40	20	1	3	64	-	320	160	10	20	510
São Tomé & Príncipe	11	-	1	0	0	13	90	-	10	0	0	100
South Africa	3 360	1	389	-	-	3 750	26 880	10	3 110	-	-	30 000
Swaziland	1	-	11	1	1	14	5	-	90	5	10	110
Zambia	713	6	81	6	39	845	5 700	50	650	50	310	6 760
Zimbabwe	56	1	105	6	28	196	450	10	840	50	220	1 570
Total	5 640	103	1 223	56	366	7 387	45 120	820	9 780	445	2 930	59 095
Of which already under construction	3 041	5	-	-	-	3 046	24 330	40	-	-	-	24 370

[9] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in a new inter-connector between Zambia-DRC (340 MW) are included into the calculations.

Table 2-4. Investment requirements in Southern Africa between 2018 and 2030 [10]

	Average annual investment cost 2018-2030 (MUSD/year)						Total investment cost between 2018 and 2030 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Angola	582	28	249	6	25	891	7 570	370	3 240	80	320	11 580
Botswana	64	-	15	0	0	78	830	-	190	0	0	1 020
Lesotho	25	-	11	1	3	40	330	-	140	10	40	520
Madagascar	398	-	143	12	65	619	5 180	-	1 860	160	850	8 050
Malawi	94	6	117	13	45	275	1 220	80	1 520	170	580	3 570
Mauritius	125	-	2	-	-	127	1 630	-	20	-	-	1 650
Mozambique	1 031	6	172	12	45	1 265	13 400	80	2 230	160	580	16 450
Namibia	182	38	19	1	2	242	2 370	500	250	10	20	3 150
São Tomé & Príncipe	10	-	2	0	0	12	130	-	20	0	0	150
South Africa	2 806	9	310	-	-	3 125	36 480	120	4 030	-	-	40 630
Swaziland	1	-	15	0	1	17	10	-	190	5	10	215
Zambia	745	4	99	7	24	879	9 690	50	1 290	90	310	11 430
Zimbabwe	175	1	122	5	17	320	2 270	10	1 590	70	220	4 160
Total	6 239	93	1 275	58	225	7 890	81 110	1 210	16 570	755	2 930	102 575
Of which already under construction	1 872	3	-	-	-	1 875	24 330	40	-	-	-	24 370

2.3 Western Africa

Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

Over the next 13 years, demand in Western Africa is expected to grow at a CAGR of 8.9 percent, resulting in a near quadrupling of demand over the entire period. Access expansion is the dominant driver of demand growth, with Nigeria alone accounting for 25 percent of the total forecasted new demand from access expansion in Africa up till 2030.

[10] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in a new inter-connector between Zambia-DRC (340 MW) are included into the calculations.

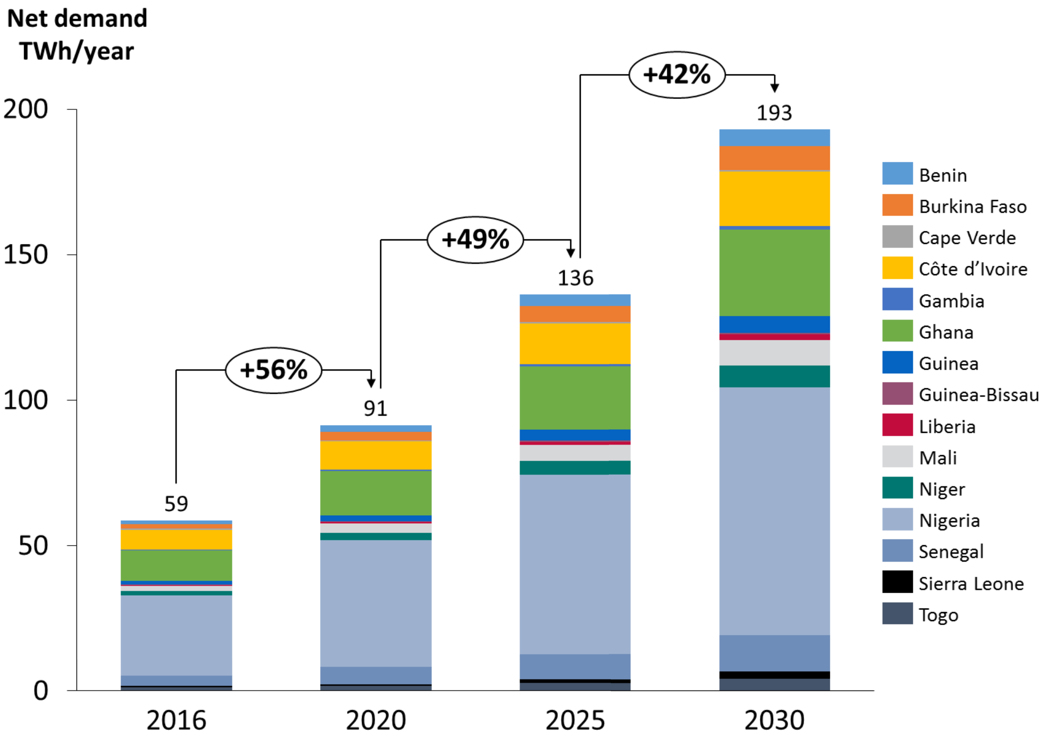


Figure 2-11. Net electricity demand projections (2016, 2020, 2025, 2030)

The following key policy takeaways are highlighted from the subsequent analysis;

- Approximately 23 GW of new generation capacity is needed by 2025, of which nearly half (11.4 GW) is already under construction.
- By 2030, investments in 30 GW of additional generation capacity are deemed to be optimal. Even as solar power complemented by utility-scale batteries becomes more attractive, investments in natural gas power plants is expected to remain dominant.
- Including a line already under construction, a total of four and six GW of new inter-connector capacity is deemed optimal by 2025 and 2030, respectively.

2.3.1 Generation expansion

West-Africa currently has 11.4 GW of new generation capacity under construction, to be commissioned between 2016 and 2025. In particular, the 3,050 MW Mambilla and 700 MW Zungeru hydropower plants – currently under construction in Nigeria will form an important foundation for the future regional generation mix. Only 1.9 GW of existing capacity is set to retire over the same period. Even with this exogenously added net capacity increase of 9.5 GW, the model recommends an additional 12 GW to be added before 2025. Accordingly, installed capacity is forecasted to increase by approximately 130 percent from 2016 by 2025 and about 235 percent by 2030.

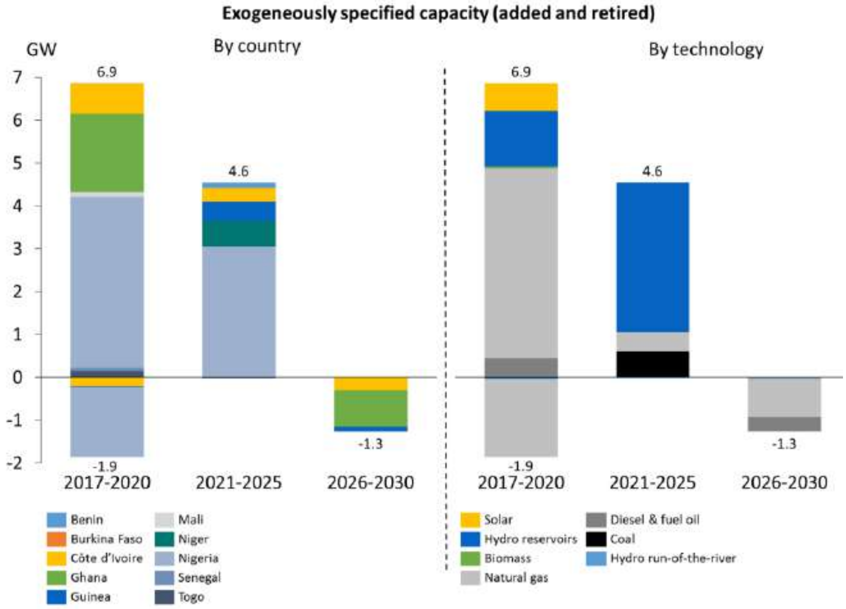
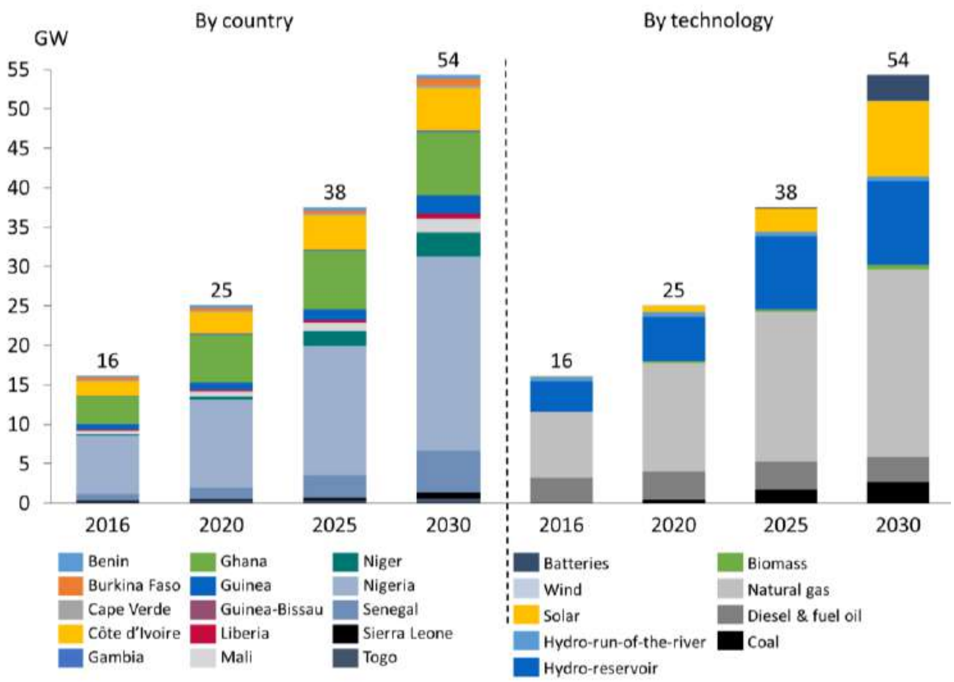


Figure 2-12. Exogenously specified capacity (added and retired) by a given year by country and technology

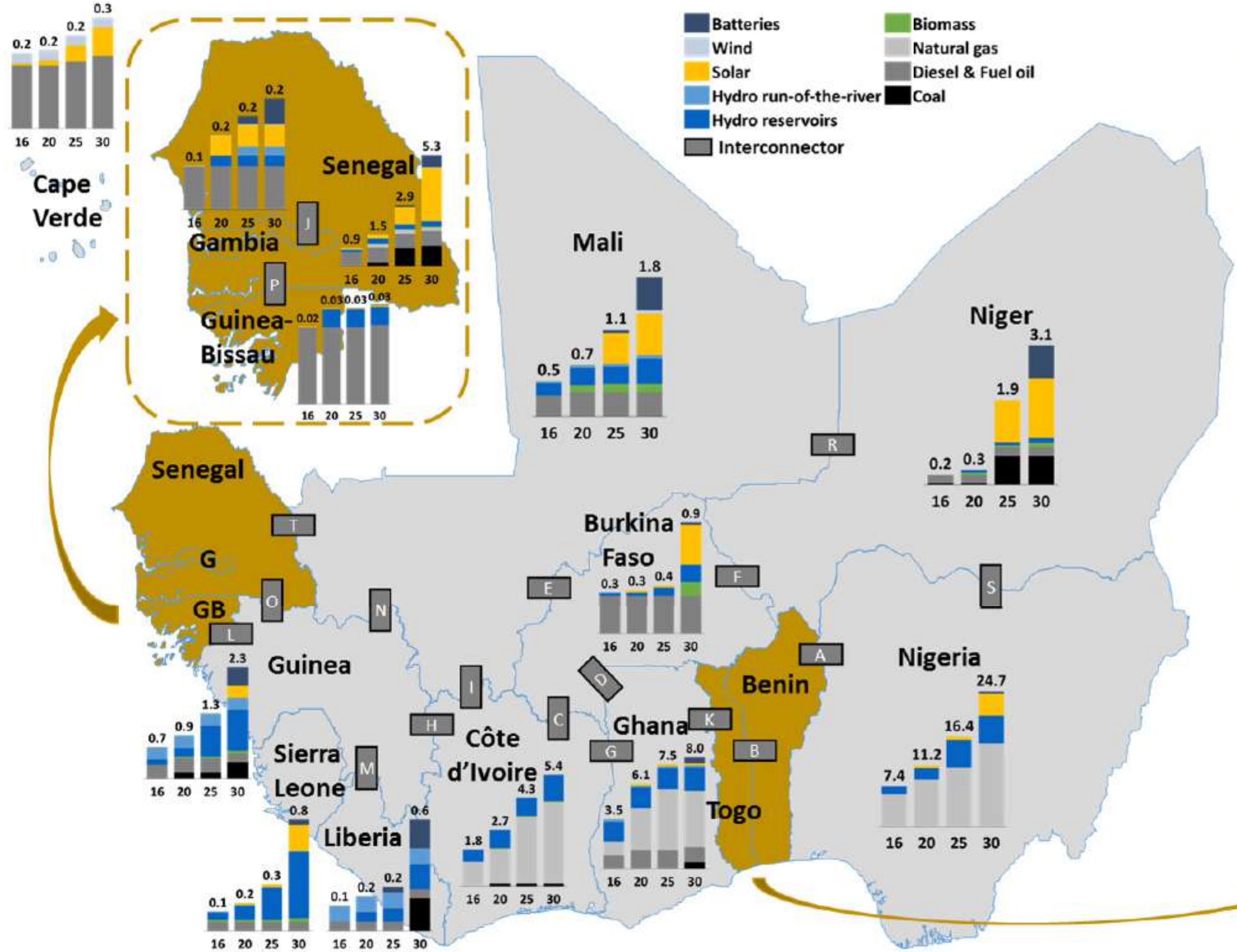
The region is projected to develop a highly diverse generation mix – geographically and technologically – in the optimal build out scenario. Specifically, low cost natural gas and reservoir hydropower provide the flexibility required to allow significant investments in solar towards 2030. As seen from the figure below, Nigeria, Ghana and Ivory Coast are forecast to lead the way in terms of new capacity. Interestingly, the optimization reveals that Guinea and Nigeria's reservoir hydropower potential is highly attractive, with a combined 4.5 GW of new capacity added by 2030. It is also notable that without a carbon price, the region experiences a significant build out of natural gas and even some limited coal-fired capacity.



2.3.2 The regional power system

The region already has several inter-connectors, but should continue to develop this capacity as several key trading partners can reap benefits from the continued integration. Specifically, a total of four and six GW of new inter-connector capacity is deemed optimal by 2025 and 2030, respectively, with larger lines between Burkina Faso and Ghana, Benin and Nigeria, and Ivory Coast and Mali. Nigeria and the Ivory Coast emerge as large net exporters, providing flexible gas-fired power, while Guinea's hydropower allows it to provide exports to several of its neighbours. The sun-rich countries of Mali, Niger, Burkina Faso and Senegal all build out significant solar generation, complemented by considerable battery storage towards 2030.

Capacity expansion (GW)



Interconnector capacity (MW)

	Interconnector		2020	2025	2030
A	Benin	Nigeria	686	686	1 356
B	Benin	Togo	465	465	565
C	Burkina Faso	Côte d'Ivoire	327	327	327
D	Burkina Faso	Ghana	799	1 131	1 131
E	Burkina Faso	Mali	0	295	295
F	Burkina Faso	Niger	383	383	566
G	Côte d'Ivoire	Ghana	327	327	327
H	Côte d'Ivoire	Guinea	446	446	446
I	Côte d'Ivoire	Mali	320	468	692
J	Gambia	Senegal	100	100	200
K	Ghana	Togo	310	310	310
L	Guinea	Guinea-Bissau	0	0	100
M	Guinea	Liberia	100	100	100
N	Guinea	Mali	0	0	121
O	Guinea	Senegal	528	528	839
P	Guinea-Bissau	Senegal	100	100	100
R	Mali	Niger	0	0	117
S	Niger	Nigeria	269	383	897
T	Mali	Senegal	265	265	265

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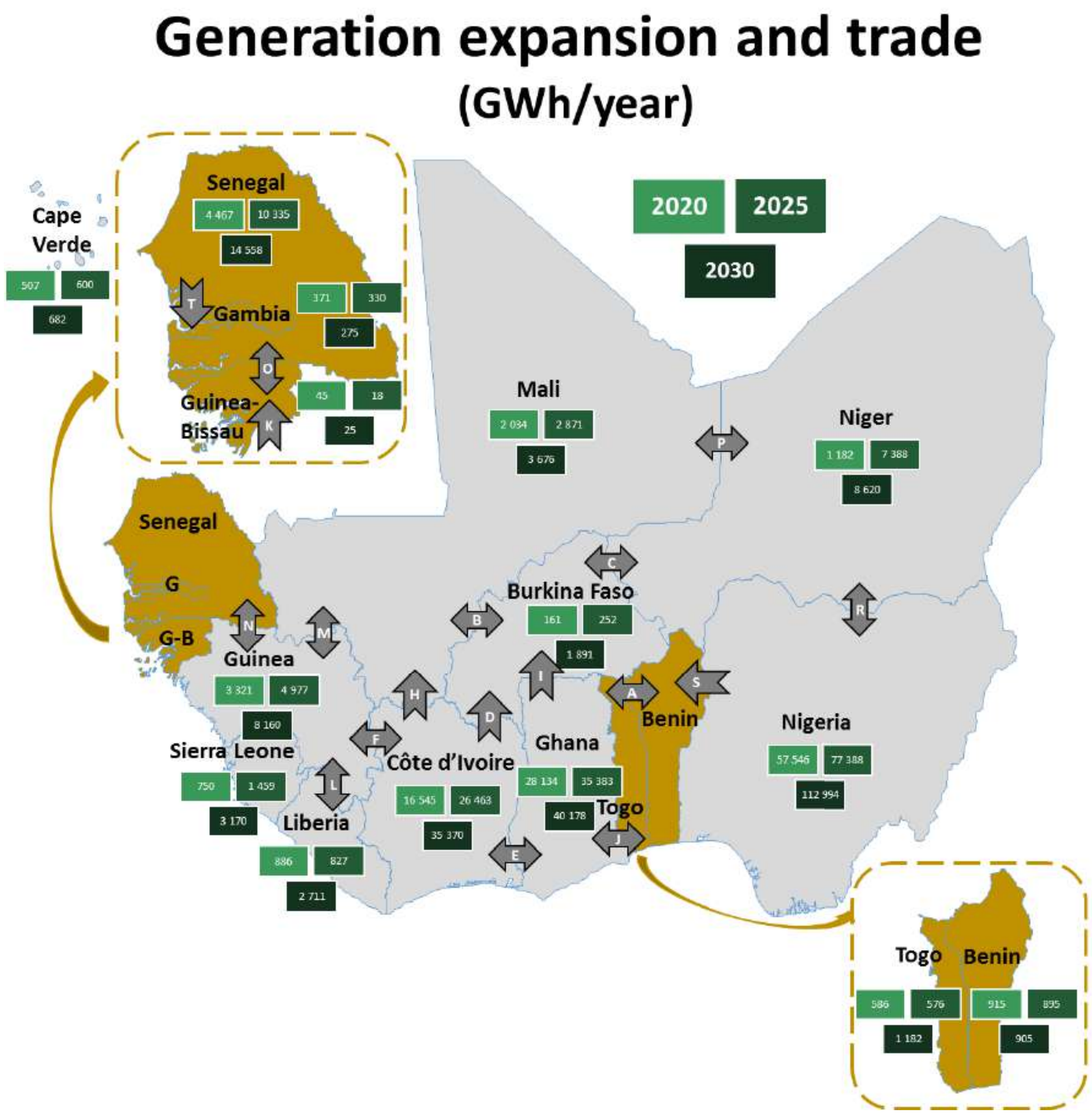


Export (GWh/year)

	From	To	2020	2025	2030
A	Benin	Togo	666	795	3 629
A	Togo	Benin	224	154	2
B	Burkina Faso	Mali	0	621	344
B	Mali	Burkina Faso	0	0	11
C	Burkina Faso	Niger	586	321	140
C	Niger	Burkina Faso	53	1 263	3 542
D	Côte d'Ivoire	Burkina Faso	94	1 369	2 105
E	Côte d'Ivoire	Ghana	0	1	686
E	Ghana	Côte d'Ivoire	2 373	17	63
F	Côte d'Ivoire	Guinea	3 220	2 545	2 522
F	Guinea	Côte d'Ivoire	0	0	181
H	Côte d'Ivoire	Mali	2 186	3 746	5 847
I	Ghana	Burkina Faso	4 367	5 412	3 411
J	Ghana	Togo	1 583	2 696	954
J	Togo	Ghana	0	0	3
K	Guinea	Guinea-Bissau	0	0	534
L	Guinea	Liberia	46	611	71
L	Liberia	Guinea	148	0	81
M	Guinea	Mali	0	0	534
M	Mali	Guinea	0	0	175
N	Guinea	Senegal	3 747	2 192	3 243
N	Senegal	Guinea	0	134	678
O	Guinea-Bissau	Senegal	0	0	2
O	Senegal	Guinea-Bissau	141	363	271
P	Mali	Niger	0	0	29
P	Niger	Mali	0	0	826
R	Niger	Nigeria	0	1 043	43
R	Nigeria	Niger	1 675	508	5 034
S	Nigeria	Benin	2 495	4 942	10 100
T	Senegal	Gambia	348	769	1 208

2.3.3 System operations and costs

With natural gas providing a solid base-load, the cumulative daily production profile is heavily influenced by the inter-play between solar and hydro/gas in terms of meeting the daily regional demand.

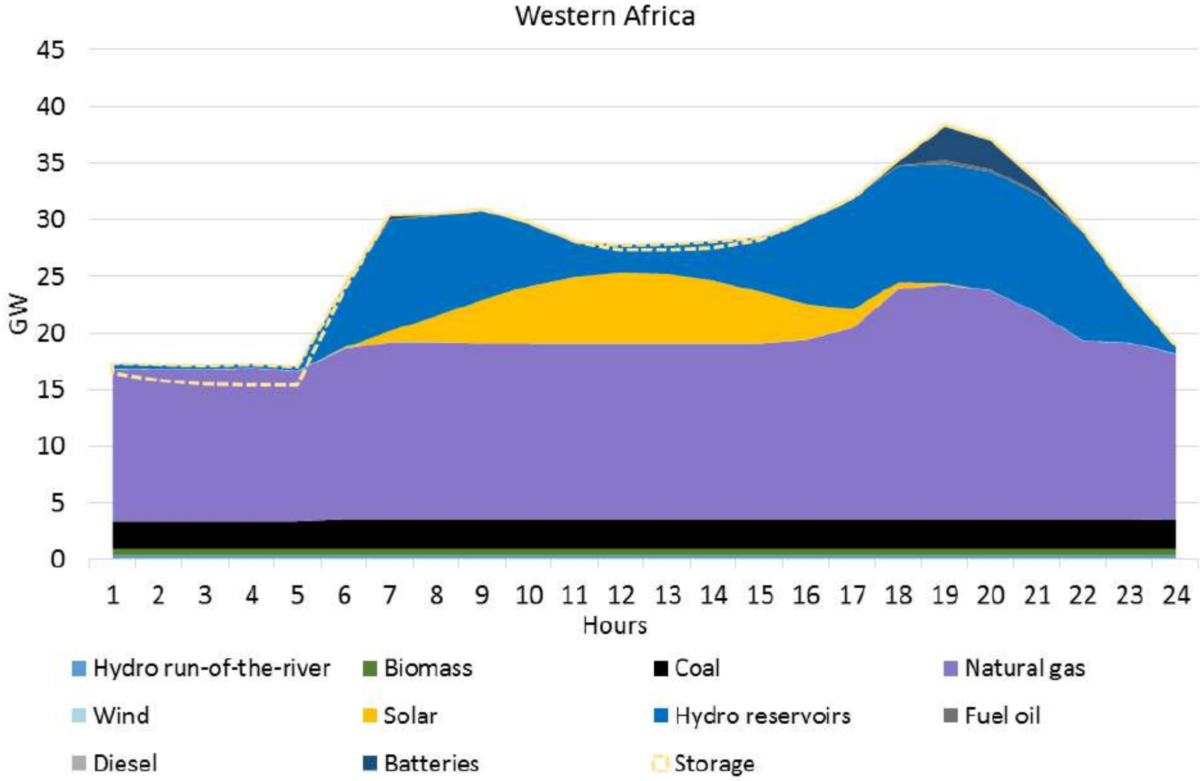
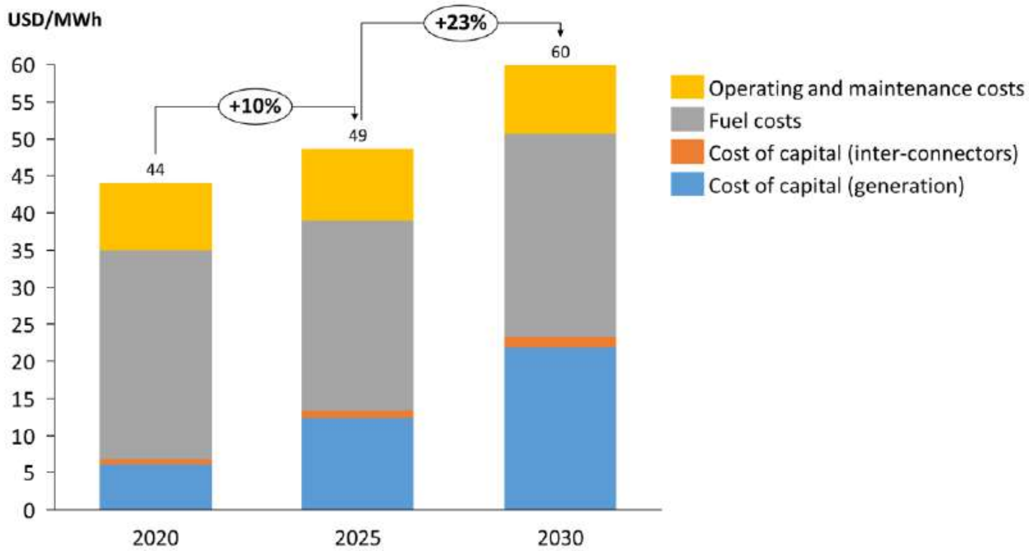


Figure 2-14. Hourly power generation and trade profile in 2030

Total system costs are 49 USD/MWh in 2025 and 60 USD/MWh in 2030, with the cost of capital associated with hydro, solar and natural gas power plants as the primary driver of the cost.



2.3.4 Aggregate investment requirements

The tables below present the aggregate investments required in the Reference Scenario for Western Africa from 2018 to 2025 and 2018 to 2030, respectively.

Table 2-5. Investment requirements in Western Africa between 2018 and 2025 [11]

	Average annual investment cost 2018-2025 (MUSD/year)						Total investment cost between 2018 and 2025 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Benin	70	-	70	4	23	166	560	-	560	30	180	1 330
Burkina Faso	15	35	120	10	50	230	120	280	960	80	400	1 840
Cape Verde	5	-	1	-	-	6	40	-	10	-	-	50
Côte d'Ivoire	446	23	126	5	28	628	3 570	180	1 010	40	220	5 020
Gambia	25	4	14	1	3	46	200	30	110	5	20	365
Ghana	464	19	159	1	6	649	3 710	150	1 270	10	50	5 190
Guinea	241	30	76	5	28	380	1 930	240	610	40	220	3 040
Guinea-Bissau	3	1	21	1	6	32	20	10	170	5	50	255
Liberia	29	4	26	1	15	75	230	30	210	10	120	600
Mali	119	20	115	8	45	306	950	160	920	60	360	2 450
Niger	124	14	125	15	86	364	990	110	1 000	120	690	2 910
Nigeria	1 739	5	1 954	14	50	3 761	13 910	40	15 630	110	400	30 090
Senegal	348	23	88	4	19	480	2 780	180	700	30	150	3 840
Sierra Leone	69	-	36	3	28	135	550	-	290	20	220	1 080
Togo	-	-	51	3	16	70	-	-	410	20	130	560
Total	3 695	176	2 983	73	401	7 328	29 560	1 410	23 860	580	3 210	58 620
Of which already under construction	1 773	21	-	-	-	1 794	14 180	170	-	-	-	14 350

[11] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in a new inter-connector between Senegal-Mali (120 MW) are included into the calculations.

Table 2-6. Investment requirements in Western Africa between 2018 and 2030[12]

	Average annual investment cost 2018-2030 (MUSD/year)						Total investment cost between 2018 and 2030 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Benin	53	11	69	3	14	150	690	140	900	40	180	1 950
Burkina Faso	67	25	126	7	31	255	870	320	1 640	90	400	3 320
Cape Verde	7	-	2	-	-	8	90	-	20	-	-	110
Côte d'Ivoire	461	21	126	3	17	628	5 990	270	1 640	40	220	8 160
Gambia	17	5	14	1	2	38	220	70	180	10	20	500
Ghana	435	12	175	1	4	626	5 650	150	2 280	10	50	8 140
Guinea	252	28	80	5	17	382	3 280	360	1 040	70	220	4 970
Guinea-Bissau	2	4	25	1	4	35	20	50	330	10	50	460
Liberia	63	2	35	2	9	112	820	30	460	20	120	1 450
Mali	120	23	126	8	28	305	1 560	300	1 640	110	360	3 970
Niger	133	21	149	19	53	375	1 730	270	1 940	250	690	4 880
Nigeria	1 644	19	1 942	8	31	3 644	21 370	250	25 240	110	400	47 370
Senegal	328	20	102	4	12	465	4 260	260	1 320	50	150	6 040
Sierra Leone	115	-	52	4	17	188	1 500	-	670	50	220	2 440
Togo	18	2	59	2	10	91	230	20	770	30	130	1 180
Total	3 714	192	3 082	68	247	7 303	48 280	2 490	40 070	890	3 210	94 940
Of which already under construction	1 091	13	-	-	-	1 104	14 180	170	-	-	-	14 350

2.4 Central Africa

Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea, and Gabon.

Over the next 13 years, demand in the Central African region is forecasted to grow at a CAGR of 9.4 percent, resulting in a 250 percent demand increase over the entire period. The main driver of demand is access expansion in the Democratic Republic of Congo, but due to the country's socio-economic situation and geography, the model backloads the relatively costly on-grid expansion. As a result, on-grid demand growth is comparatively sluggish in the early years.

[12] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in a new inter-connector between Senegal-Mali (120 MW) are included into the calculations.

[13] Cameroon, Central African Republic, Chad, Congo, Democratic Republic of Congo, Equatorial Guinea, Gabon.

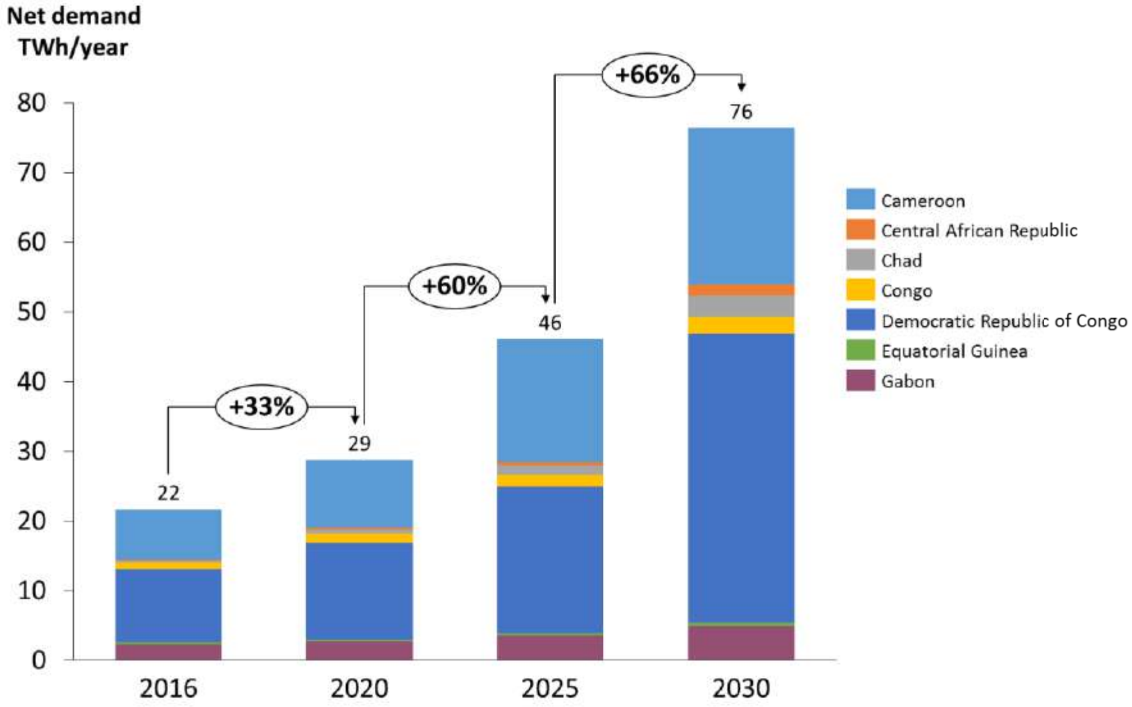


Figure 2-16. Net electricity demand projections (2016, 2020, 2025, 2030)

The following key policy takeaways are highlighted from the subsequent analysis;

- With little generation capacity under construction, nearly six GW will be required in order to meet the New Deal targets by 2025. This necessitates urgent action from decision makers.
- Central Africa currently has only one existing inter-connector between DRC and Congo, and notably the different regions of DRC are not properly connected. Improving this situation should be a key priority. The optimal solution includes investments in two GW and five GW of new inter-connectors by 2025 and 2030, respectively.

2.4.1 Generation expansion

Central Africa has nearly one GW of generation capacity under construction, less than one twelfth of the comparable number for Eastern Africa. Therefore, significant new investments will have to materialize quickly in order for the region to achieve the New Deal targets by 2025. Specifically, the model reveals that an additional six GW is required for the regional system by 2025, compared to the one GW that has been initiated. This clearly demonstrates that while Eastern and Southern Africa may be able to meet substantial portions of 2025 demand by means of projects already under construction, Central Africa will have to significantly and rapidly intensify efforts if it is to provide sufficient capacity. According to the model, it is optimal to increase installed capacity by approximately 110 percent and 315 percent by 2025 and 2030, respectively.

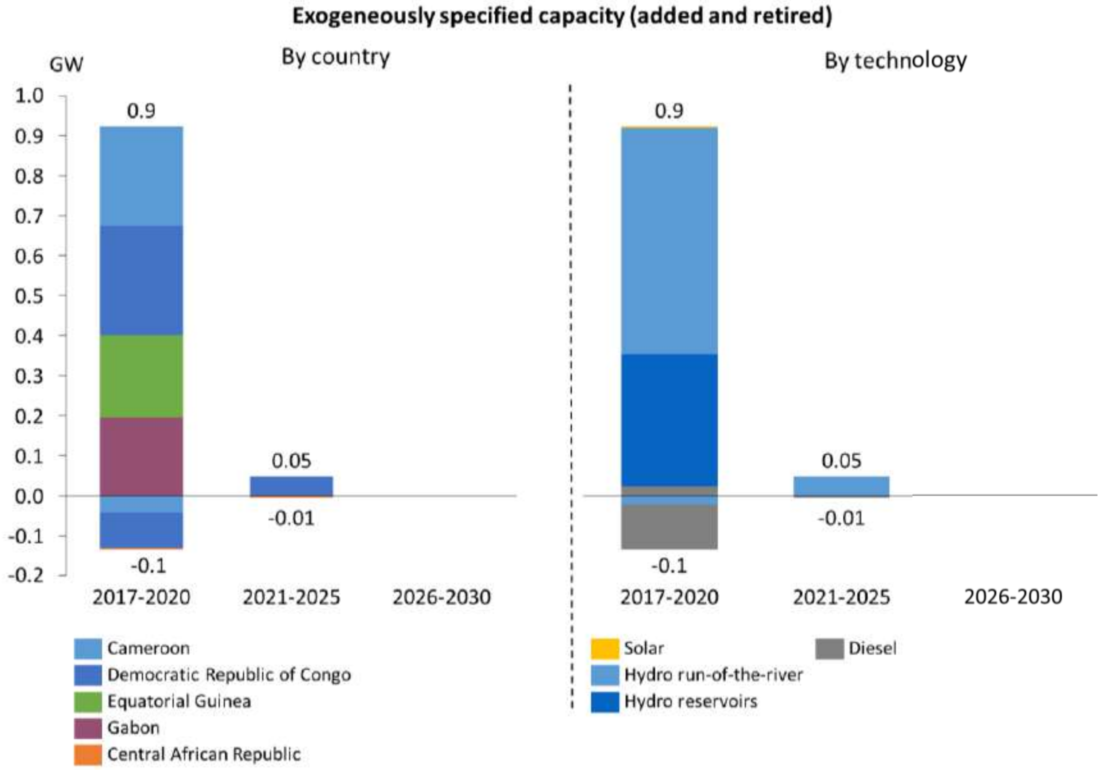


Figure 2-17. Exogenously specified capacity (added and retired) by a given year by country and technology

Since Central Africa currently has only one existing inter-connector, investments in new cross-border transmission lines are crucial for the development of an integrated power system. Specifically, the solar capacity is set to be added in the countries with limited hydropower potential, such as Chad and Cameroon. It is also interesting to note that even though the absolute generation based on natural gas is set to increase, its relative importance will decline as the system expands.

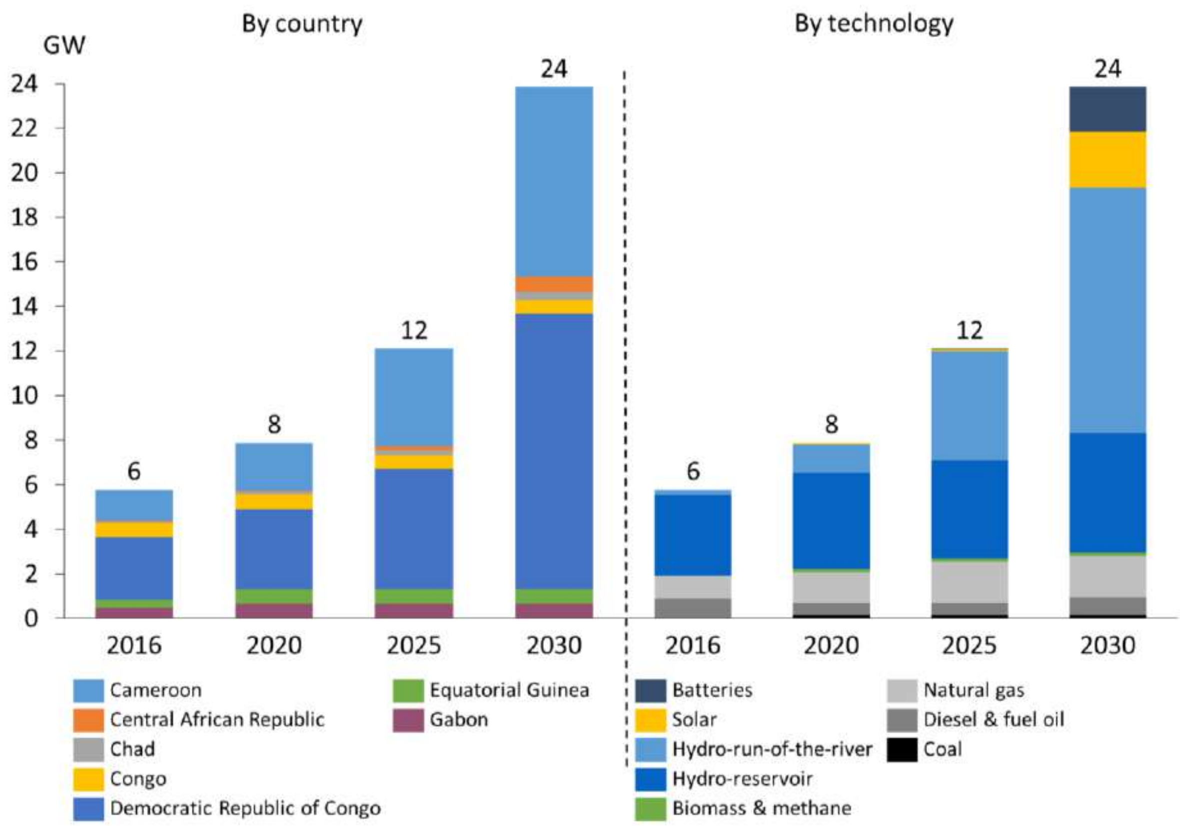
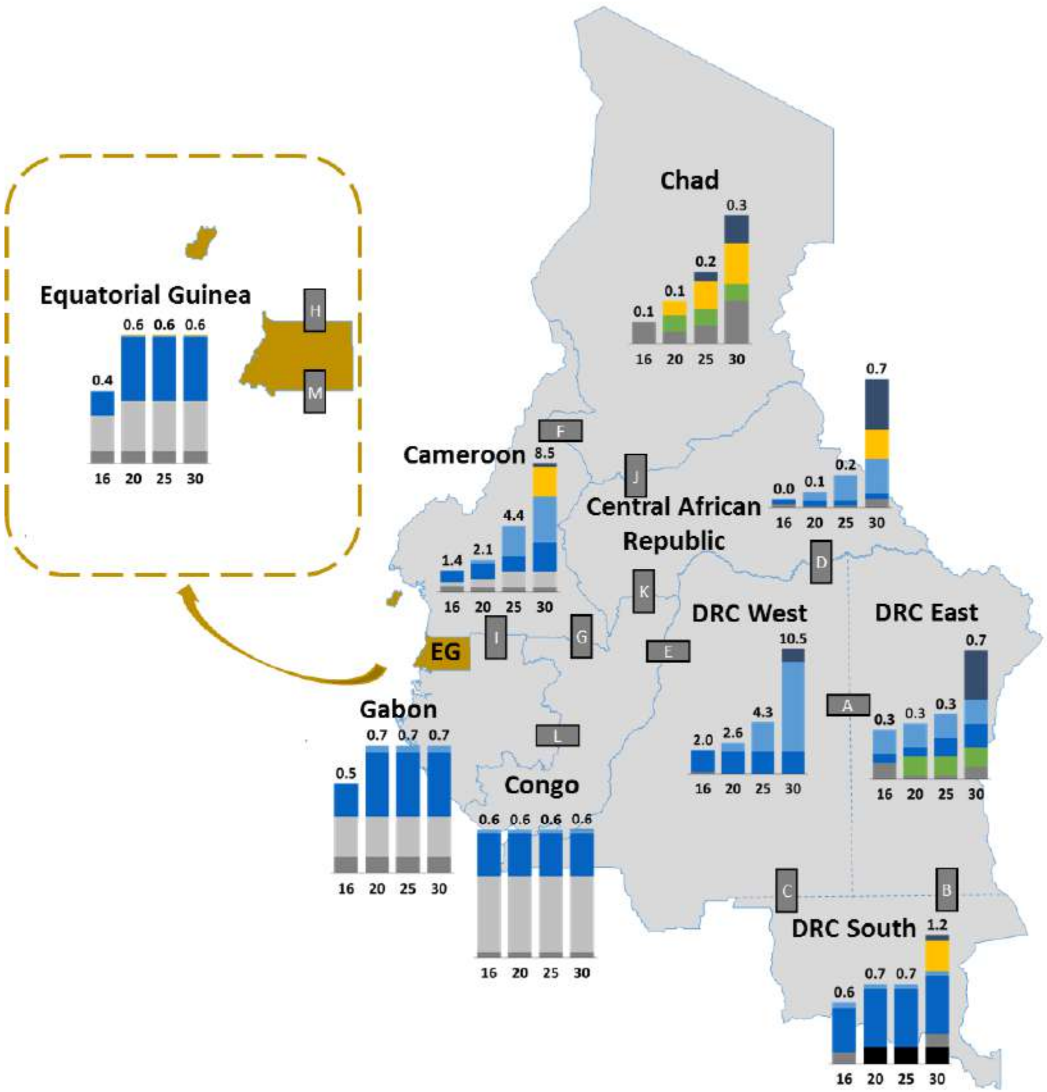


Figure 2-18. Total generation capacity by country and technology

2.4.2 The regional power system

With only one existing inter-connector in Central Africa, investments in new cross-border transmission lines are crucial for the development of an integrated power system. The existing inter-connector between the Democratic Republic of Congo and Congo has a capacity of only 60 MW, and notably the different regions of the Democratic Republic of Congo are not even properly connected. In order to remedy this, and allow for better utilization of the region´s resources, investments in two GW and five GW of new inter-connectors are required by 2025 and 2030, respectively. New inter-connectors are deemed to be optimal, among others, between the Democratic Republic of Congo and Congo, the Democratic Republic of Congo and Central Africa Republic, Gabon and Congo, and the Central African Republic and Chad. Enhanced integration is important for many countries in the region, including Gabon and Chad, who is set to meet the majority of their demand growth in both 2025 and 2030 by means of imports.



Capacity expansion (GW)

- Batteries
- Solar
- Hydro run-of-the-river
- Hydro reservoirs
- Interconnector
- Biomass & methane
- Natural gas
- Diesel & fuel oil
- Coal

Interconnector capacity (MW)

	Interconnector		2020	2025	2030
A	DRC East	DRC West	100	205	416
B	DRC East	DRC South	0	0	100
C	DRC West	DRC South	560	560	1 388
D	DRC West	Central African Republic	0	0	397
E	DRC West	Congo	160	160	965
F	Cameroon	Chad	0	143	143
G	Cameroon	Congo	0	0	100
H	Cameroon	Equatorial Guinea	102	245	245
I	Cameroon	Gabon	0	157	157
J	Central African Republic	Chad	100	100	472
K	Central African Republic	Congo	118	118	118
L	Congo	Gabon	0	0	459
M	Equatorial Guinea	Gabon	202	202	202

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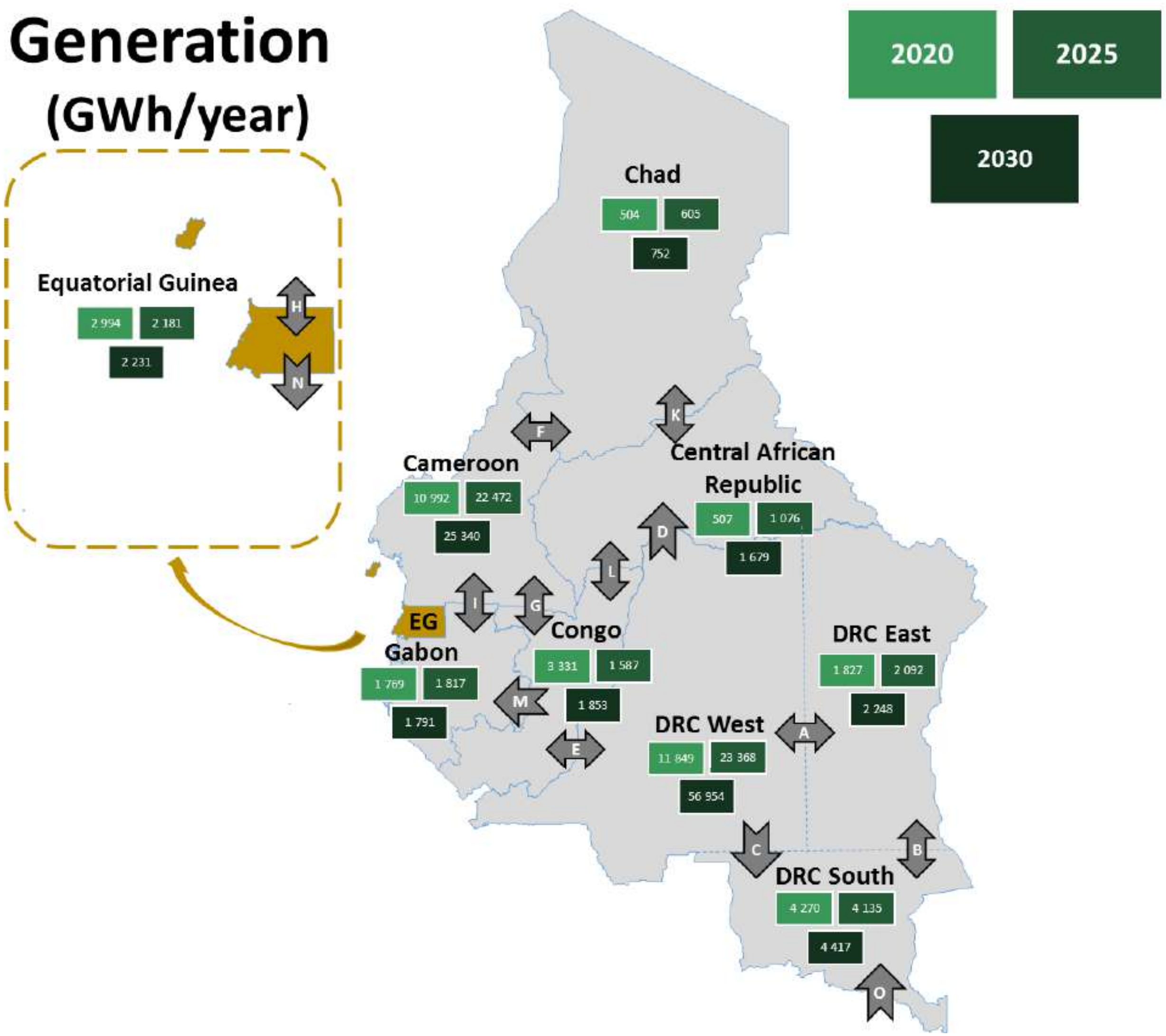
Generation (GWh/year)



Export (GWh/year)

	From	To	2020	2025	2030
A	DRC East	DRC West	151	24	0
A	DRC West	DRC East	261	809	3 328
B	DRC East	DRC South	0	0	47
B	DRC South	DRC East	0	0	69
C	DRC West	DRC South	471	3 014	9 446
D	DRC West	Central African Republic	0	0	3434
E	DRC West	Congo	0	1 211	5 576
E	Congo	DRC West	1 319	88	0
F	Cameroon	Chad	0	541	511
F	Chad	Cameroon	0	0	348
G	Cameroon	Congo	0	0	64
G	Congo	Cameroon	0	0	545
H	Cameroon	Equatorial Guinea	0	354	0
H	Equatorial Guinea	Cameroon	893	355	496
I	Cameroon	Gabon	0	1 106	221
I	Gabon	Cameroon	0	13	59
K	Central African Republic	Chad	335	646	3 309
K	Chad	Central African Republic	0	6	0
L	Central African Republic	Congo	35	75	0
L	Congo	Central African Republic	305	380	560
M	Congo	Gabon	0	0	2 976
N	Equatorial Guinea	Gabon	1 768	1 768	1 215
O	Zambia	DRC South	95	95	95

2.4.3 System operations and costs

The 2030 regional system´s base-load largely consists of run-of-the-river hydro and natural gas, while reservoir hydropower provides much of the peaking capacity. Interestingly, solar power supported by batteries also has a small role to play.

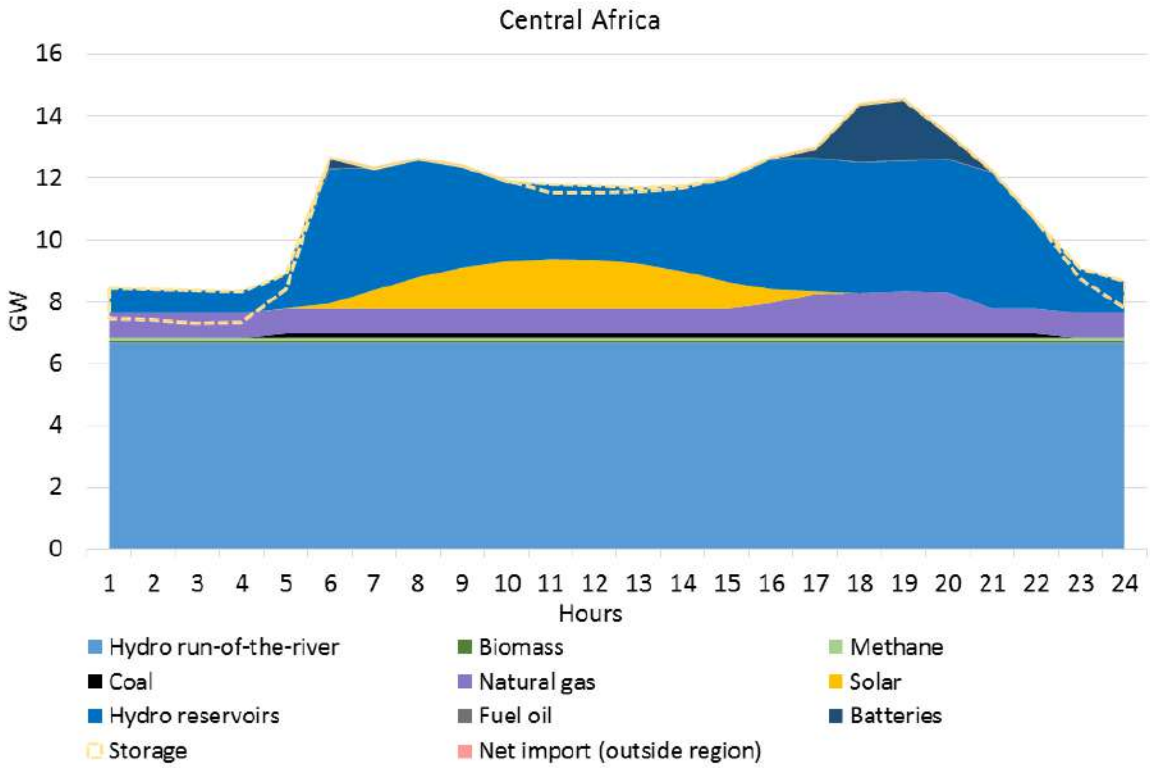


Figure 2-19. Hourly power generation and trade profile in 2030

Total 2030 system costs are 45 USD/MWh in 2025 and 68 USD/MWh in 2030, with the cost of capital associated with hydro projects, solar power and batteries as the primary cost drivers.

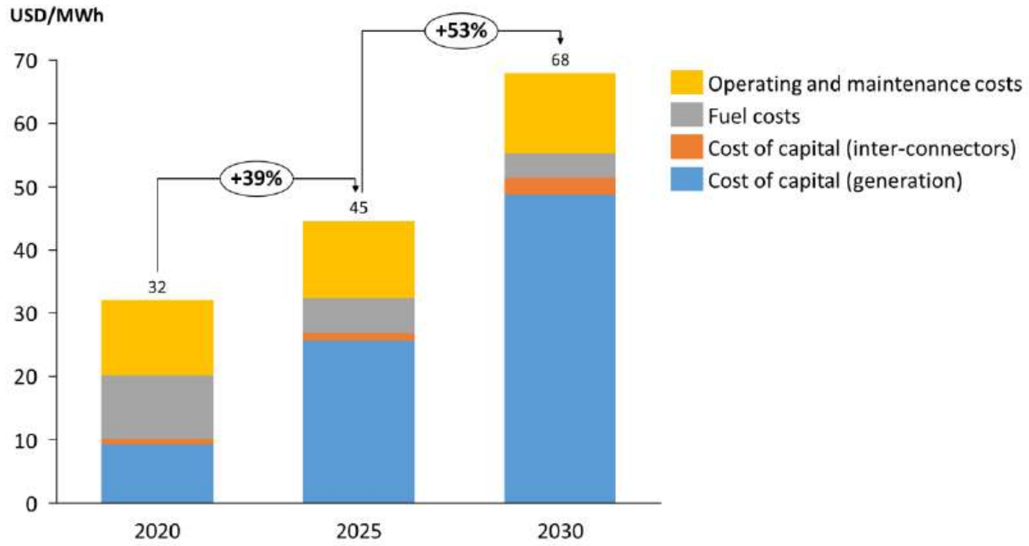


Figure 2-20. System costs by type

2.4.4 *Aggregate investment requirements*

The tables below present the aggregate investments required in the Reference Scenario for Central Africa from 2018 to 2025 and 2018 to 2030, respectively.

Table 2 7. Investment requirements in Central Africa between 2018 and 2025 [14]

	Average annual investment cost 2018-2025 (MUSD/year)						Total investment cost between 2018 and 2025 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Cameroon	701	16	120	6	24	868	5 610	130	960	50	190	6 940
Central African Republic	54	9	13	1	24	100	430	70	100	10	190	800
Chad	29	13	69	10	66	186	230	100	550	80	530	1 490
Congo	-	6	36	1	5	49	-	50	290	10	40	390
Democratic Republic of Congo	819	20	353	26	375	1 593	6 550	160	2 820	210	3 000	12 740
Equatorial Guinea	74	13	18	0	0	104	590	100	140	0	0	830
Gabon	11	10	8	0	0	29	90	80	60	0	0	230
Total	1 688	86	615	45	494	2 928	13 500	690	4 920	360	3 950	23 420
Of which already under construction	98	10	-	-	-	108	780	80	-	-	-	860

Table 2 8. Investment requirements in Central Africa between 2018 and 2030 [14]

	Average annual investment cost 2018-2030 (MUSD/year)						Total investment cost between 2018 and 2030 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Cameroon	941	12	134	4	15	1 105	12 230	160	1 740	50	190	14 370
Central African Republic	64	25	27	2	15	132	830	320	350	20	200	1 720
Chad	29	16	96	8	41	191	380	210	1 250	110	530	2 480
Congo	0	20	35	1	3	58	0	260	450	10	40	760
Democratic Republic of Congo	1 571	81	574	24	235	2 484	20 420	1 050	7 460	310	3 050	32 290
Equatorial Guinea	45	8	15	0	0	68	590	100	200	0	0	890
Gabon	7	15	8	0	0	29	90	190	100	0	0	380
Total	2 657	176	888	38	308	4 068	34 540	2 290	11 550	500	4 010	52 890
Of which already under construction	60	6	-	-	-	66	780	80	-	-	-	860

[14] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements. Investments in new inter-connectors between DRC-Rwanda (300 MW), DRC-Zambia (340 MW) and DRC-Burundi (45 MW) are included into the calculations.

2.5 Northern Africa

Algeria, Egypt, Libya, Mauritania, Morocco, and Tunisia.

Over the next 13 years, demand in North Africa is forecasted to grow at a CAGR of 5.3 percent, thus doubling over the period. Because the region already has near universal access, 95 percent of this increase is driven by economic growth rather than access expansion.

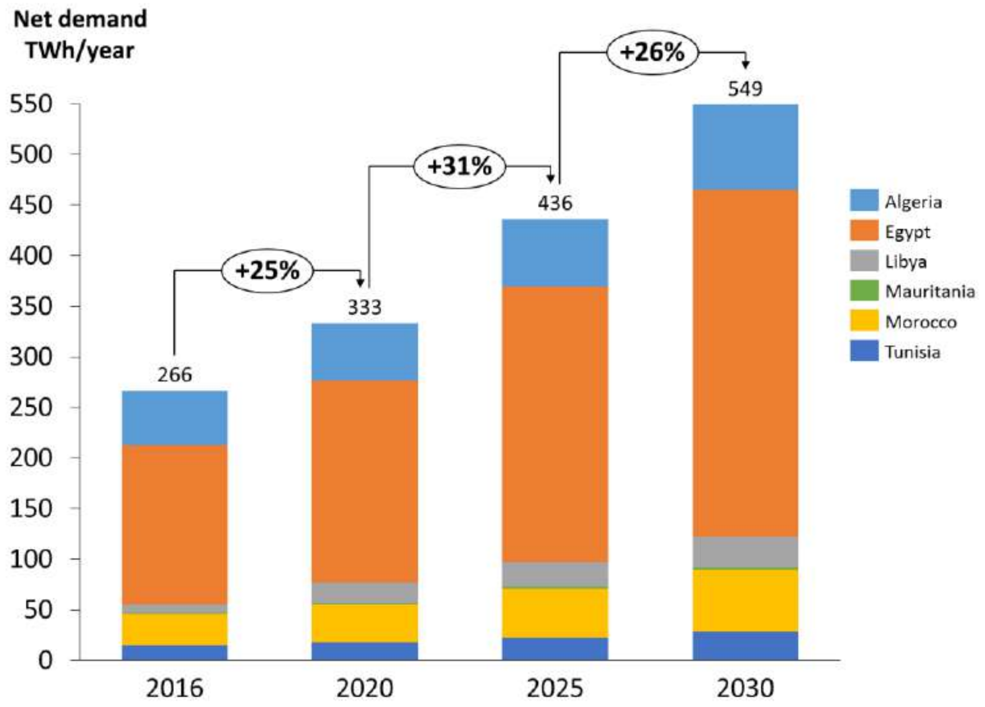


Figure 2-21. Net electricity demand projections (2016, 2020, 2025, 2030)

The following key policy takeaways are highlighted from the subsequent analysis;

- 14 GW of additional generation capacity would be required in order to meet the 2025 demand, on top of the 39 GW already under construction. It is therefore important that investors and policy-makers take a critical approach to new potential project in order to avoid over-supply.
- By 2030 substantial investments in solar power are found optimal, both to meet growing demand, and to replace more costly fossil production.
- The North African power markets are already quite well integrated. Therefore, only two GW of new inter-connector capacity is found optimal by 2025, and four GW by 2030.

2.5.1 Generation expansion

With some 39 GW of new capacity under construction, the region is already on track to add net capacity amounting to nearly 20 GW by 2025. With gas-fired power plants in Egypt and Algeria making up the lion's share, these 39 GW represent about 49 percent of the total capacity under construction on the African continent. Consequently, only 14 GW of additional capacity is deemed necessary in order to meet demand in 2025. That is, from an optimization perspective, only limited additional capacity is required throughout the region, thus implying that policy-makers and financiers should be highly selective in terms of planning for new capacity.

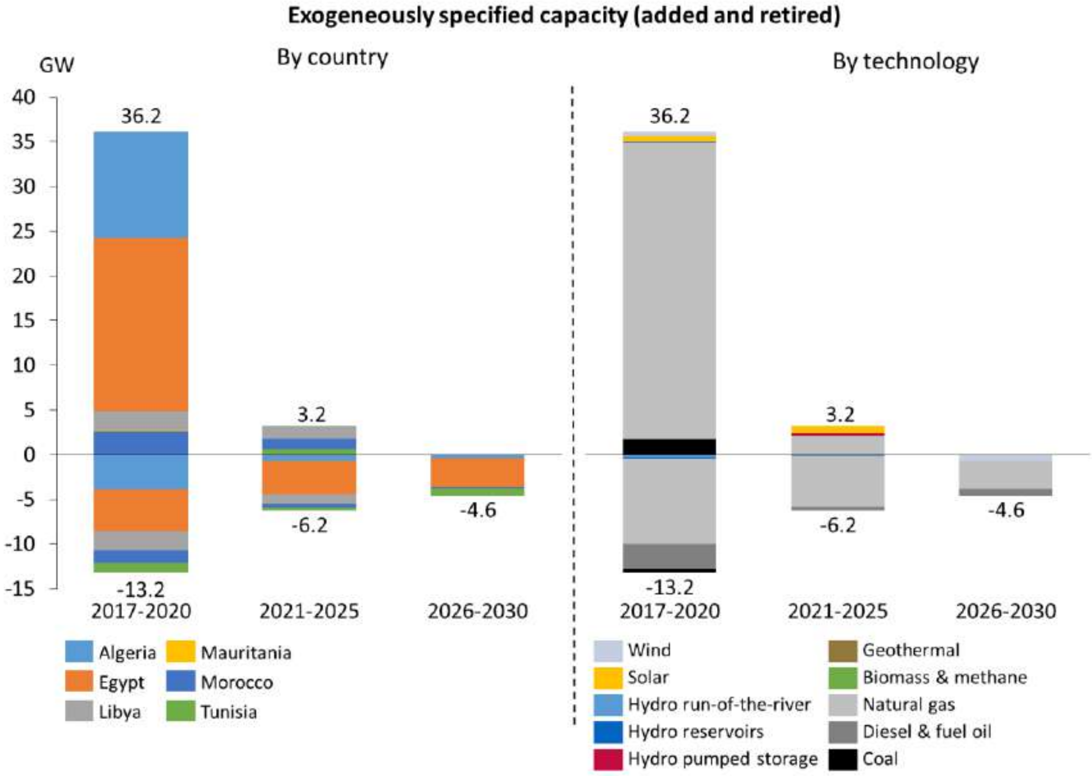


Figure 2-22. Exogenously specified capacity (added and retired) by a given year by country and technology

The region's power supply continues to be dominated by natural gas power, but with renewable capacity, mainly solar power, constituting 41 percent of the total required generation capacity additions. This is visualised in the figure below, with solar and natural gas playing an important role in the optimal generation mix, particularly after 2025. By 2030, solar technologies are becoming particularly attractive. According to the model, installed capacity is expected to increase by approximately 40 percent from 2016 by 2025 and about 85 percent by 2030.

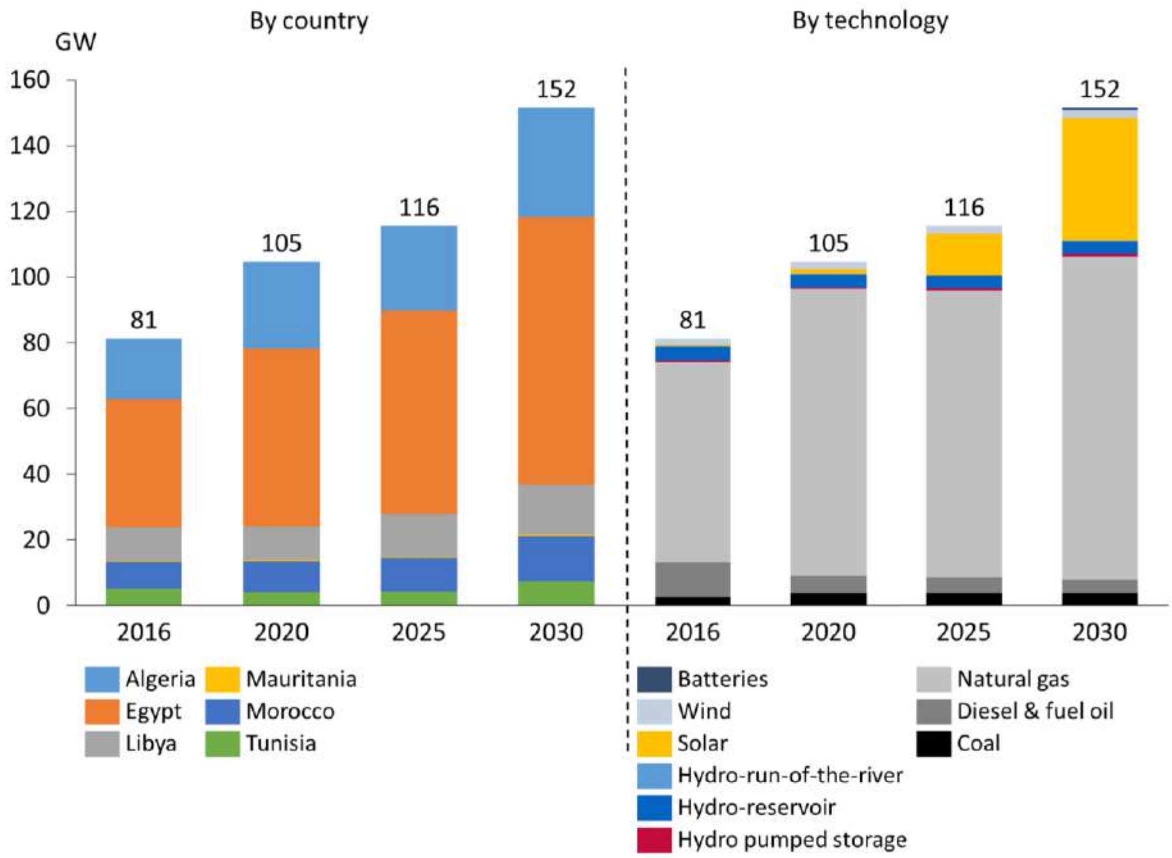


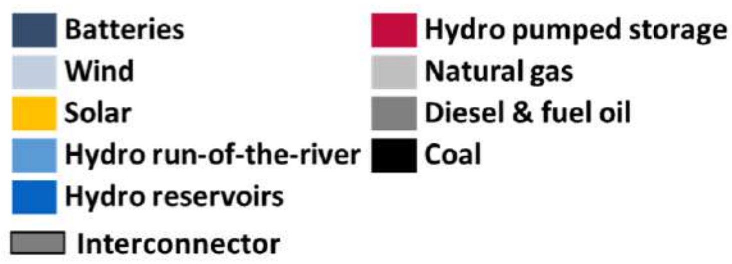
Figure 2-23. Total generation capacity by country and technology

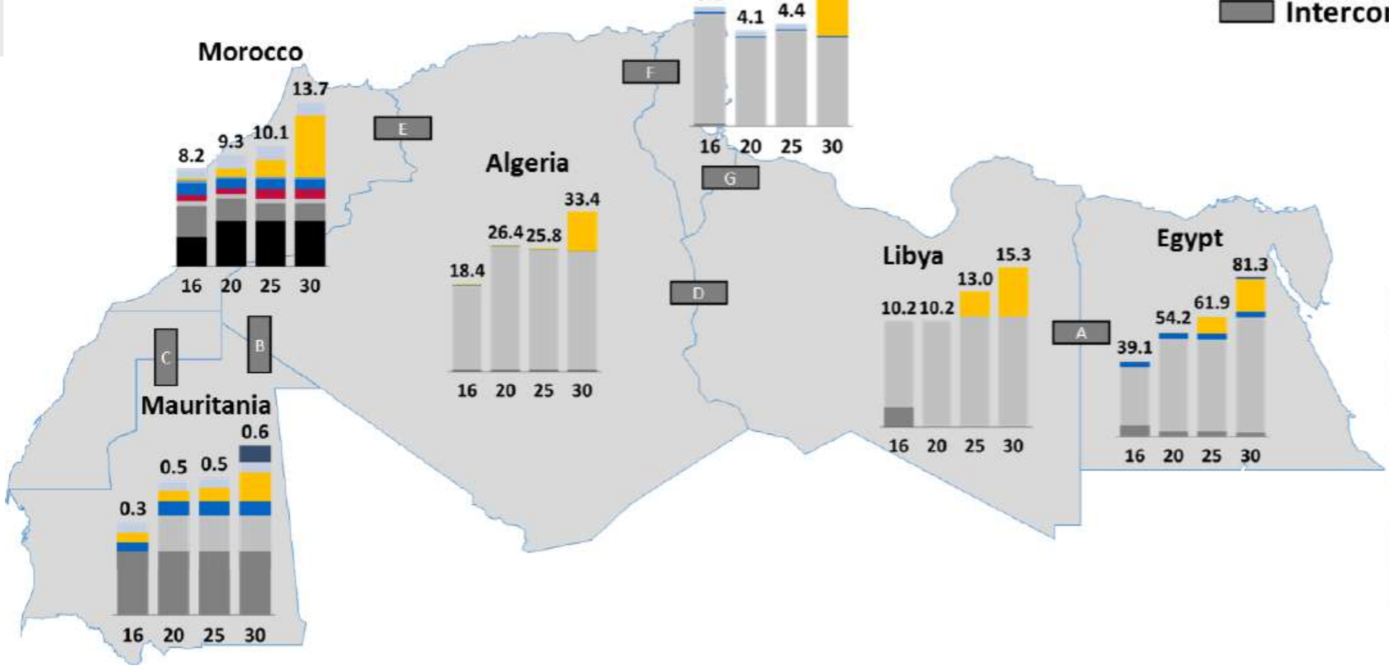
2.5.2 The regional power system

While there is limited need for increased integration, some new inter-connectors are deemed optimal, particularly between Algeria and Libya, Algeria and Morocco, and Algeria and Tunisia. According to the optimization, investments in two GW and four GW of new inter-connectors are required by 2025 and 2030, respectively. The amount of tradable power within the region is modest compared to its total electricity demand. The largest volumes are traded between Algeria and its neighbors, especially Morocco.

Estimating Investment Needs for the Power Sector in Africa

Capacity expansion (GW)





Interconnector capacity (MW)

	Interconnector		2020	2025	2030
A	Egypt	Libya	170	170	170
B	Mauritania	Algeria	0	143	243
C	Mauritania	Morocco	100	100	100
D	Algeria	Libya	1 000	1 000	1 000
E	Algeria	Morocco	1 400	2 148	3 686
F	Algeria	Tunisia	900	1 021	1 021
G	Libya	Tunisia	300	300	300

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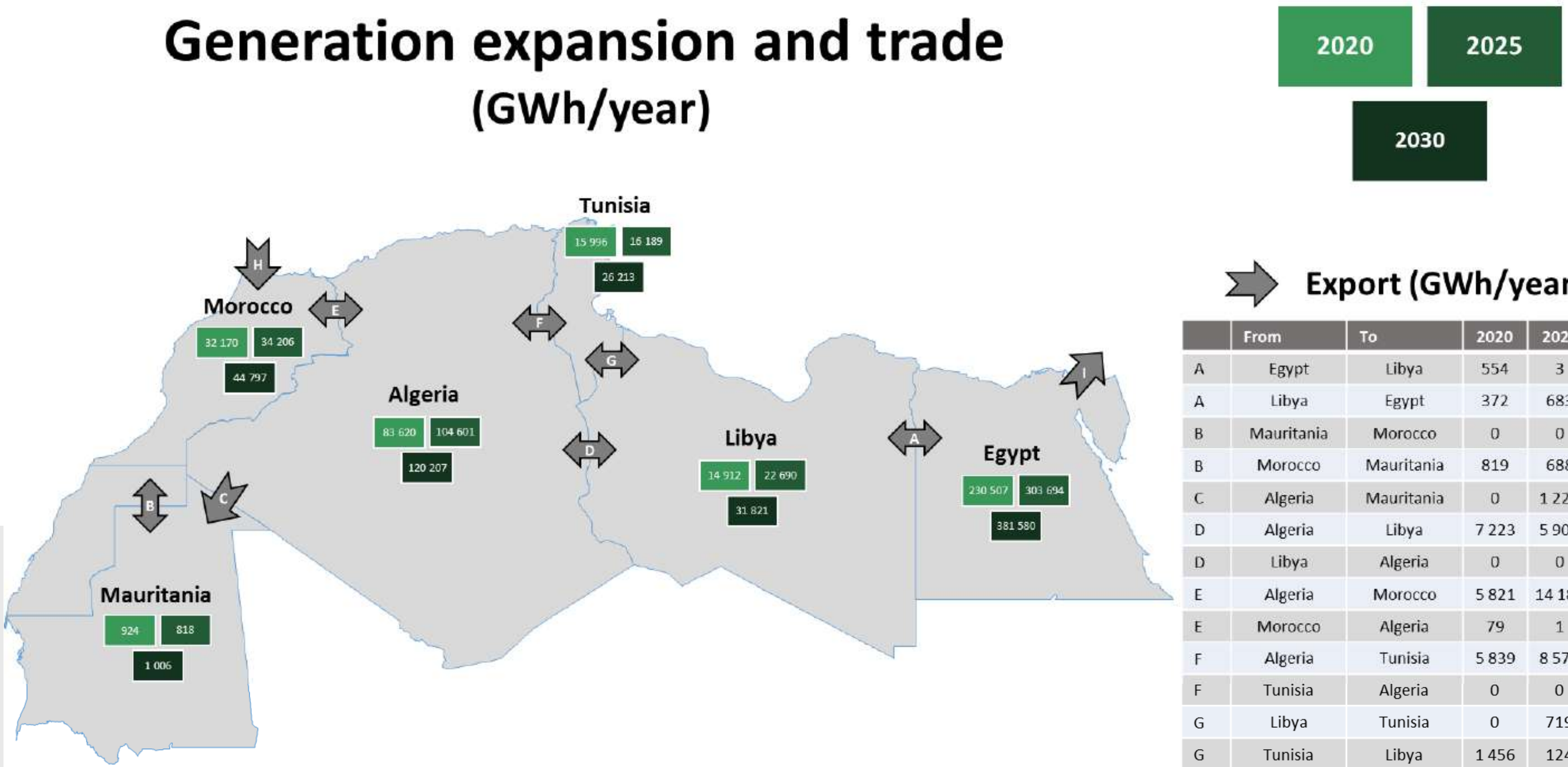
Generation expansion and trade (GWh/year)



Export (GWh/year)

	From	To	2020	2025	2030
A	Egypt	Libya	554	3	662
A	Libya	Egypt	372	683	355
B	Mauritania	Morocco	0	0	1
B	Morocco	Mauritania	819	688	645
C	Algeria	Mauritania	0	1 227	2 118
D	Algeria	Libya	7 223	5 902	2 868
D	Libya	Algeria	0	0	421
E	Algeria	Morocco	5 821	14 189	17 603
E	Morocco	Algeria	79	1	3
F	Algeria	Tunisia	5 839	8 575	4 555
F	Tunisia	Algeria	0	0	1
G	Libya	Tunisia	0	719	853
G	Tunisia	Libya	1 456	124	232
H	Spain	Morocco	4 912	4 912	4 912
I	Egypt	Jordan	317	317	317

Estimating Investment Needs for the Power Sector in Af
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2.5.3 *System operations and costs*

The cumulative daily production profile is heavily influenced by the inter-play between solar and natural gas in terms of meeting the daily regional demand profile. It is interesting to note that natural gas provides both base-load and peaking capacity, underlining its competitiveness in this environment.

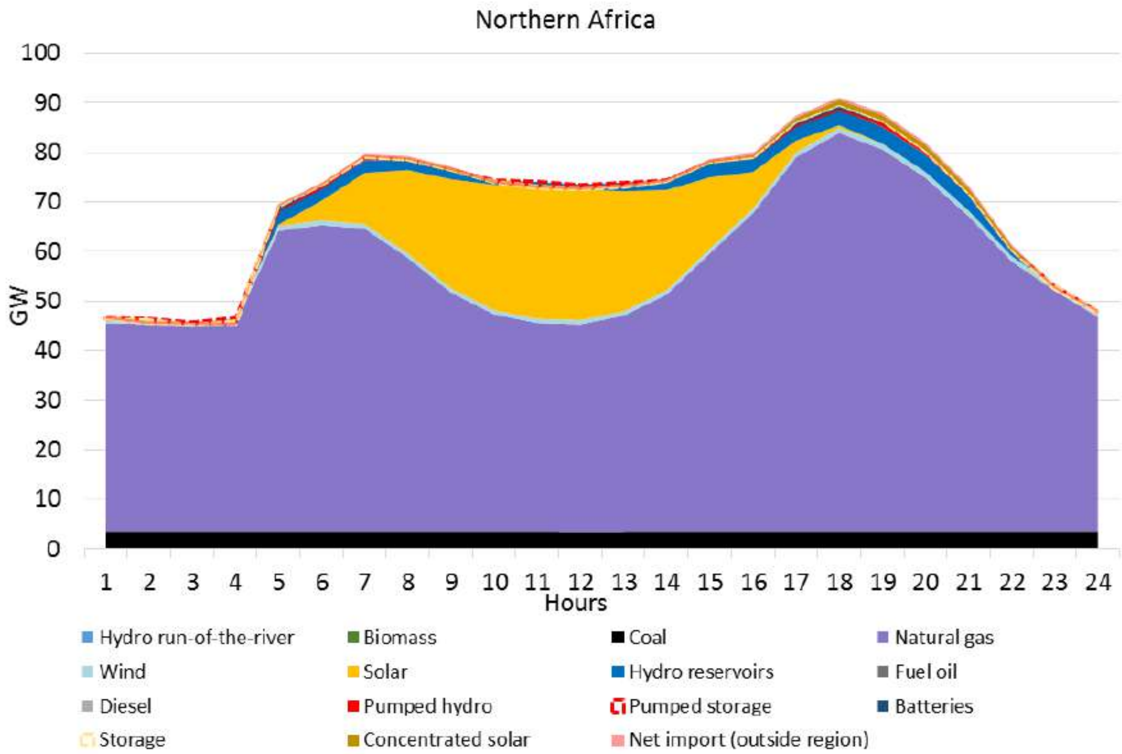
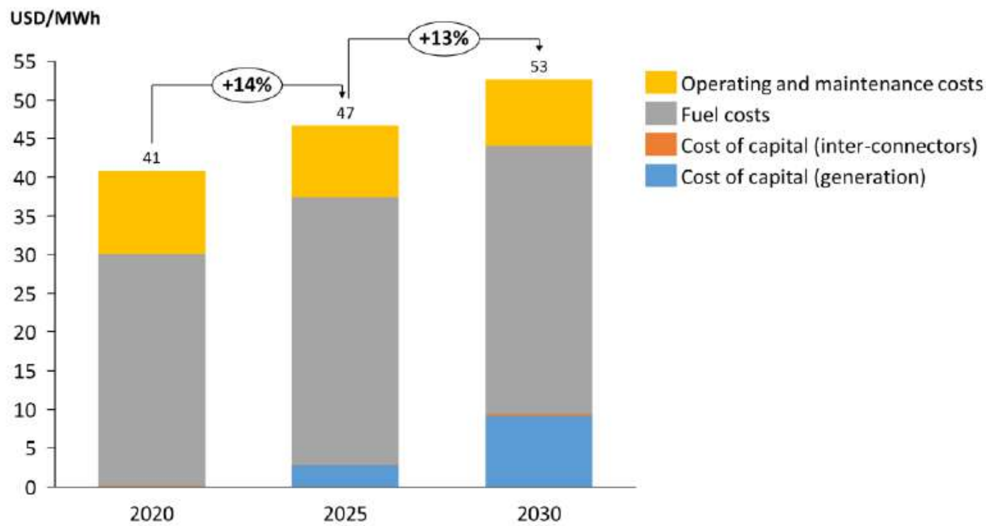


Figure 2-24. Hourly power generation and trade profile in 2030

Total system costs are 47 USD/MWh in 2025 and 53 USD/MWh in 2030, with the cost of capital associated with natural gas and solar power plants as the primary driver of the cost levels.



2.5.4 *Aggregate investment requirements*

The tables below present the aggregate investments required in the Reference Scenario for Northern Africa from 2018 to 2025 and 2018 to 2030, respectively.

Table 2 9. Investment requirements in Northern Africa between 2018 and 2025 [15]

	Average annual investment cost 2018-2025 (MUSD/year)						Total investment cost between 2018 and 2025 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Algeria	696	40	56	-	-	793	5 570	320	450	-	-	6 340
Egypt	1 834	-	406	-	-	2 240	14 670	-	3 250	-	-	17 920
Libya	530	18	11	-	-	559	4 240	140	90	-	-	4 470
Mauritania	1	14	31	1	8	55	10	110	250	10	60	440
Morocco	1 043	15	49	-	-	1 106	8 340	120	390	-	-	8 850
Tunisia	35	3	19	-	-	56	280	20	150	-	-	450
Total	4 139	89	573	1	8	4 809	33 110	710	4 580	10	60	38 470
Total already under construction	2 704	-	-	-	-	2 704	21 630	-	-	-	-	21 630

Table 2 10. Investment requirements in Northern Africa between 2018 and 2030 [15]

	Average annual investment cost 2018-2030 (MUSD/year)						Total investment cost between 2018 and 2030 (MUSD)					
	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment	Generation	Inter-connectors	Grid	Mini-grid	Off-grid	Total investment
Algeria	795	42	55	-	-	891	10 330	540	710	-	-	11 580
Egypt	2 792	-	381	-	-	3 172	36 290	-	4 950	-	-	41 240
Libya	432	11	11	-	-	454	5 620	140	140	-	-	5 900
Mauritania	5	13	30	2	5	54	60	170	390	20	60	700
Morocco	814	22	48	-	-	884	10 580	290	620	-	-	11 490
Tunisia	248	2	18	-	-	268	3 230	20	230	-	-	3 480
Total	5 085	89	542	2	5	5 722	66 110	1 160	7 040	20	60	74 390
Total already under construction	1 664	-	-	-	-	1 664	21 630	-	-	-	-	21 630

[15] "-" denotes no investments, while "0" denotes low investments (below 2.5 million USD). For projects already under construction, 85 percent of the investment costs are considered as the investment requirements.

3 Total investment requirements and scenario implications

In addition to the AfDB New Deal Reference Scenario laid out above, three additional scenarios have been analysed, so as to explore the implications of key policy choices related to Greenhouse Gas (GHG) emission reductions, protectionism (trade stagnation), and access expansion. This chapter presents the results of these analyses, in particular as they relate to investment and system costs, along with key policy implications for decision makers.

3.1 The AfDB New Deal Reference Scenario

The total average annual investment required to achieve the New Deal 2025 targets is estimated at 29 billion USD per year, or 230 billion USD until 2025 and 420 billion USD until 2030. With 80 GW of generation capacity and a few inter-connectors already under construction, it is estimated that some 75 billion USD out of the abovementioned 230 already is under construction. As illustrated in the figure below, the total amount required for Western Africa is estimated at 7.3 billion USD. A large share of this goes to access expansion and T&D investments, as the region, and Nigeria in particular, is set for a massive expansion of its T&D network. The relatively modest forecasted investments in Northern Africa are overwhelmingly related to generation expansion.

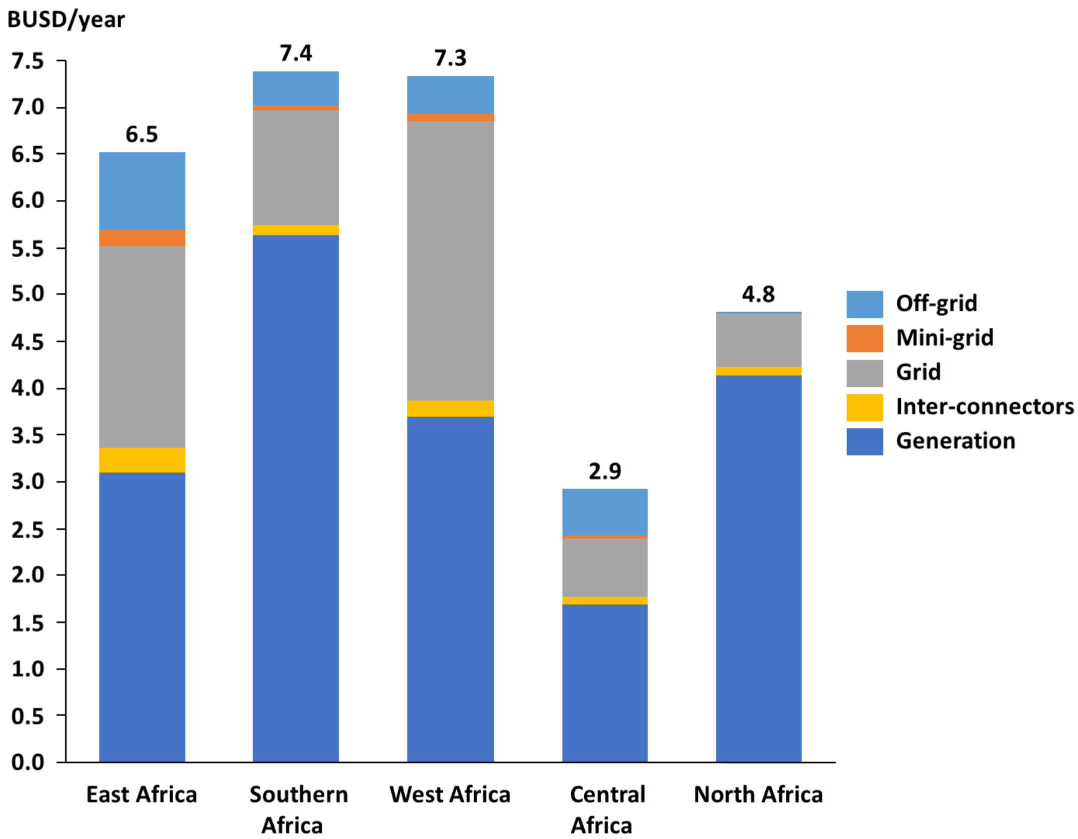


Figure 3-1. Total average annual investment cost 2018-2025 by type

While coal, reservoir hydropower, and gas account for most of the investment, solar and even utility-scale batteries in Southern Africa is forecasted to attract significant investment in 2025 and truly take off by 2030. Besides the coal capacity that is already under construction, relatively little additional coal (4.5 GW for the whole continent by 2030) is deemed optimal. While the daily production profiles of each region visualizes how the base-load, variable, and peaking technologies interact, the figure below demonstrates how investment contributes to the required diversification of regional generation mixes.

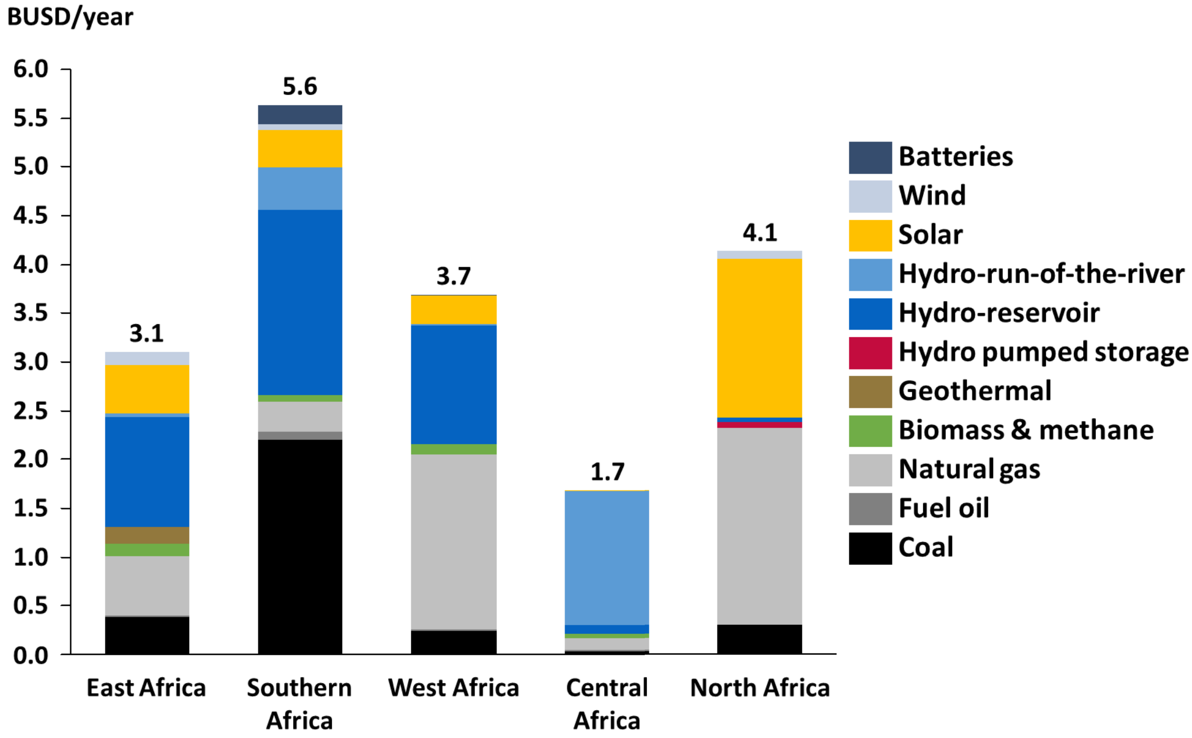


Figure 3-2. Average annual generation investment cost 2018-2025 by technology

With unprecedented amounts of capacity already under construction on the continent, and significant investment expected to be deployed over the next few years, additional investment needs, in particular in Southern and Northern Africa, are relatively low until 2025. However, as the systems continue to grow at cumulative rates, investment requirements are set to reach new heights in the period from 2025 to 2030.

Even without dedicated efforts to avoid emissions, the model recommends an uptick in solar and battery investments towards 2030. As for investments in solar, it should be noted that on the one hand this will imply falling average plant factors and a need for balancing power sources, meaning that more capacity is required to meet the same production. On the other hand, the investment cost per MW is expected to become very low over the period, thus lowering investment needs. It is also notable that investments in utility-scale batteries are deemed optimal in South Africa by 2025. Total battery investments are forecasted to reach 22 GW by 2030, with all regions having some batteries in the optimal solution. As highlighted below, the developments described here are significantly enhanced when one considers a carbon price, or other coordinated and dedicated action to avoid future emissions in Africa.

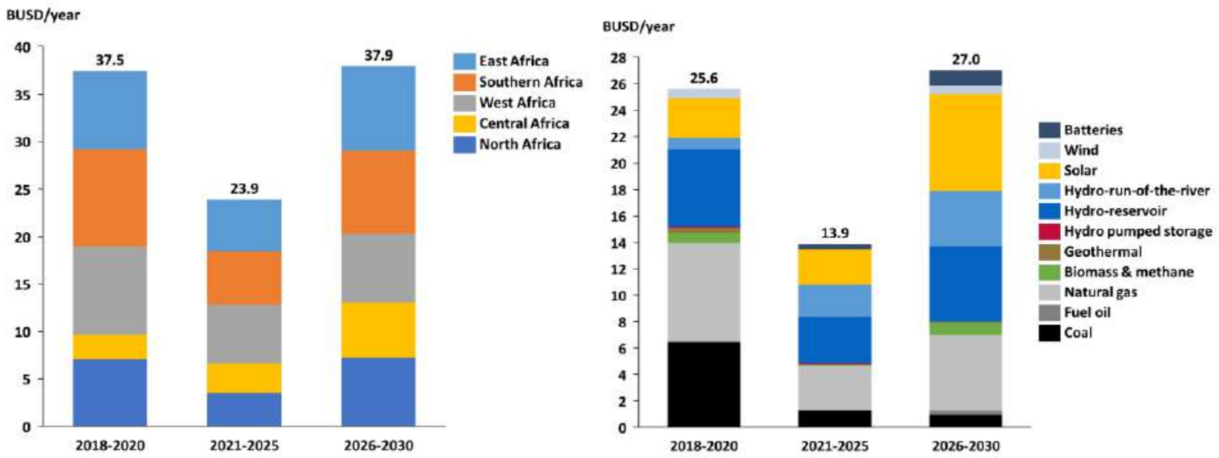


Figure 3-3. Average annual investment cost (total and generation) in a given period of time

3.2 Low Carbon Scenario

In the Low Carbon Scenario, a price is set on GHG emission, to help mitigate global climate change. The applied carbon price is based on the team's review of a range of estimates including World Energy Outlook 2016 and Bloomberg New Energy Finance 2017, and is set equal to USD 20 per ton of CO_2-equivalent emitted in 2020, USD 30 in 2025, and USD 40 in 2030.

The introduction of dedicated emission reduction ambitions and/or carbon pricing within the Low Carbon Scenario has dramatic impacts on the optimal generation mix, investment requirements and system cost levels. In terms of system cost, the carbon price has the most prominent effect on the power system in Southern Africa, reducing the reliance on coal power plants in favor of wind, solar and hydro. This effect is also considerable for Eastern and Western Africa, since these regions rely on natural gas and partially coal in the Reference Scenario. Furthermore, the Low Carbon Scenario results in higher investment needs for all regions, and particularly for the Sothern and Northern Africa, with renewable power plants replacing more costly fossil production.

Greenhouse gas emissions in the Low Carbon Scenario are forecasted to be nearly 35 percent lower than in the Reference Scenario in 2025 and about 40 percent lower in 2030. Total 2030 emission reductions as compared to the Reference Scenario amount to 235 million ton of CO_2-equivalent per year, equal to half the 2016 emissions of South Africa [16]. Such a green shift, in accordance with the Nationally Determined Contributions set forth by all African countries during the 2015 COP 21 in Paris, would imply an increase of total system costs in 2030 by approximately five percent and an increase of annual investment needs over the forecasted period by 30 percent. Specifically, the Low Carbon Scenario would imply an increase in total system costs for Africa of 5.8 billion USD per year from 2030.

[16] Available at: http://www.globalcarbonatlas.org/en/CO2-emissions

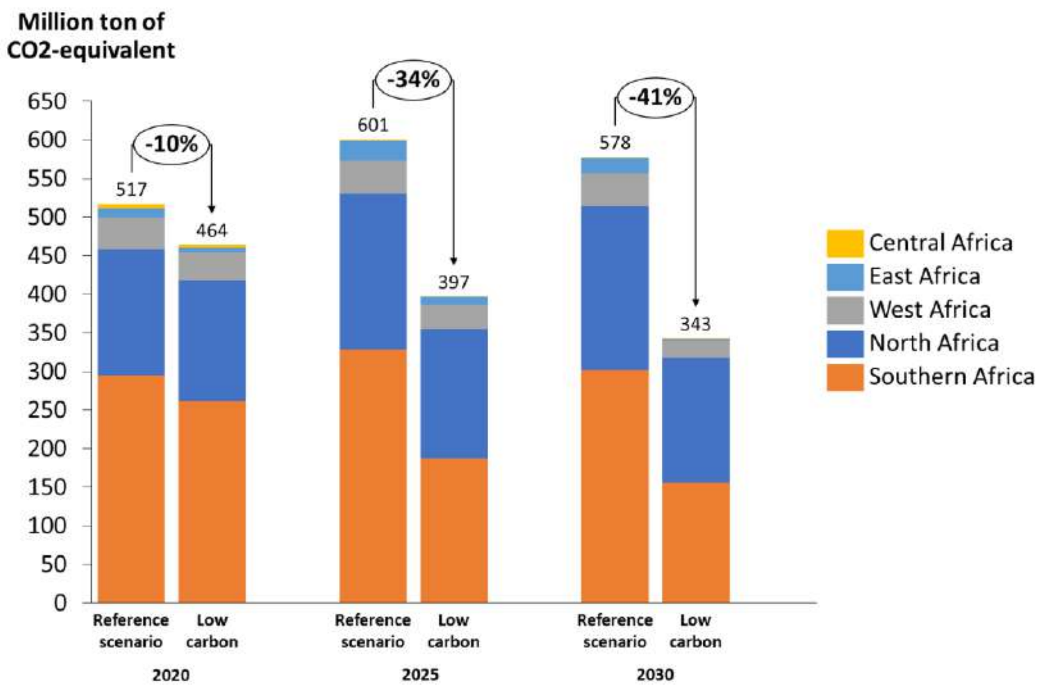


Figure 3-4. Carbon emissions in the Reference and Low Carbon Scenarios

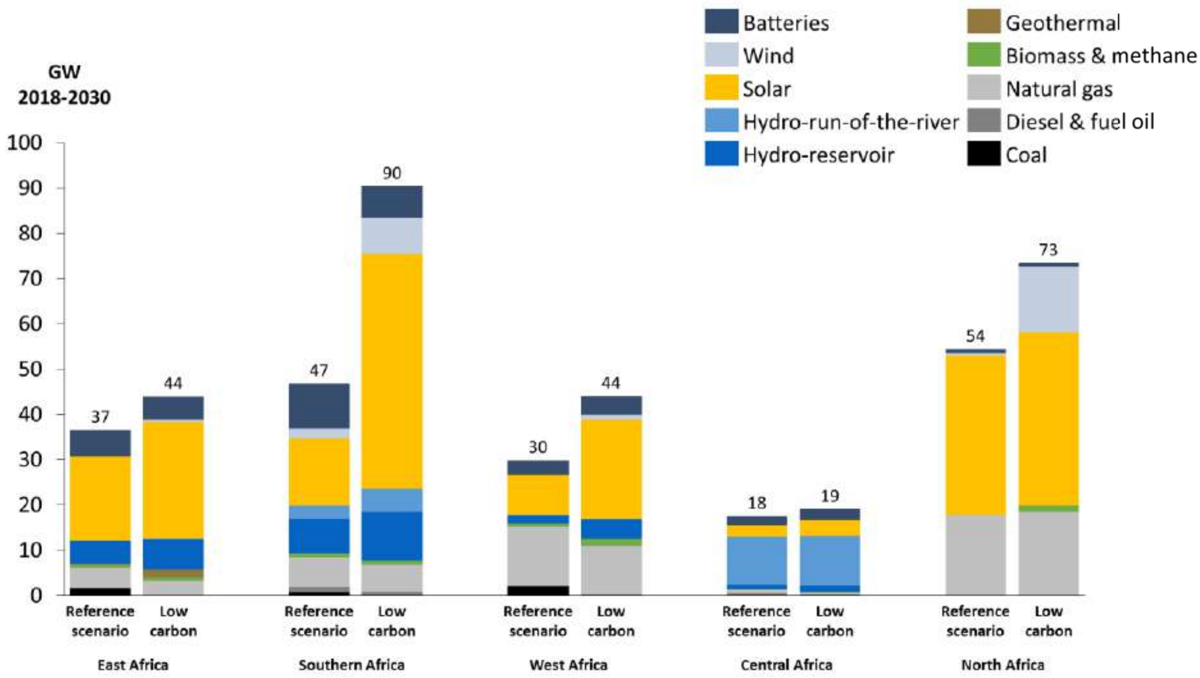


Figure 3-5. Total required generation capacity additions by technology in the Reference and Low Carbon Scenarios between 2018 and 2030[17]

[17] Power plants already under construction are excluded when comparing required capacity additions across the scenarios.

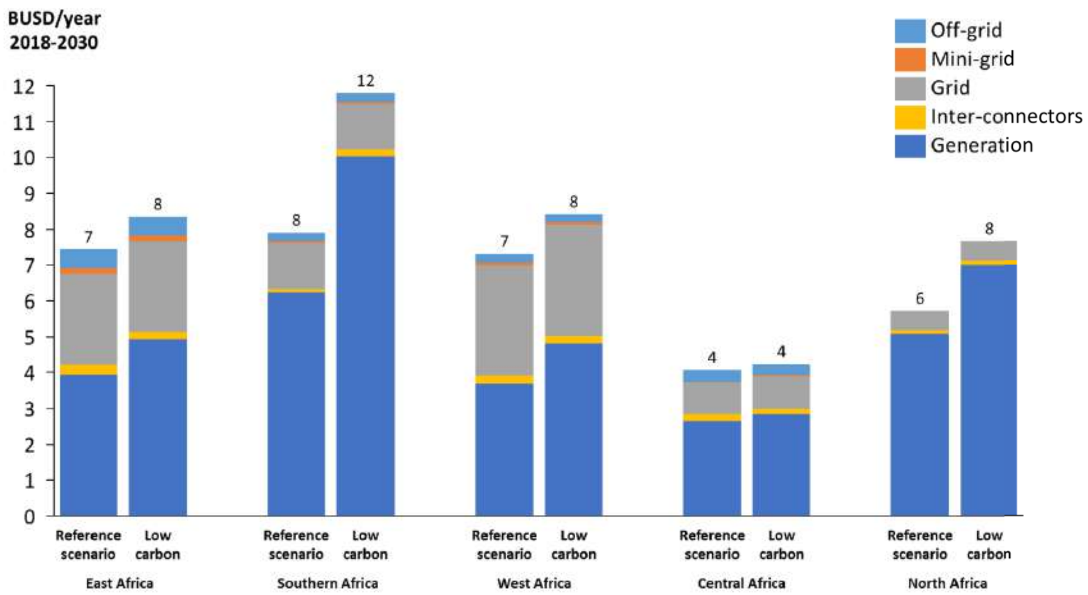


Figure 3-6. Total average annual investment cost 2018-2030 by type in the Reference and Low Carbon Scenarios

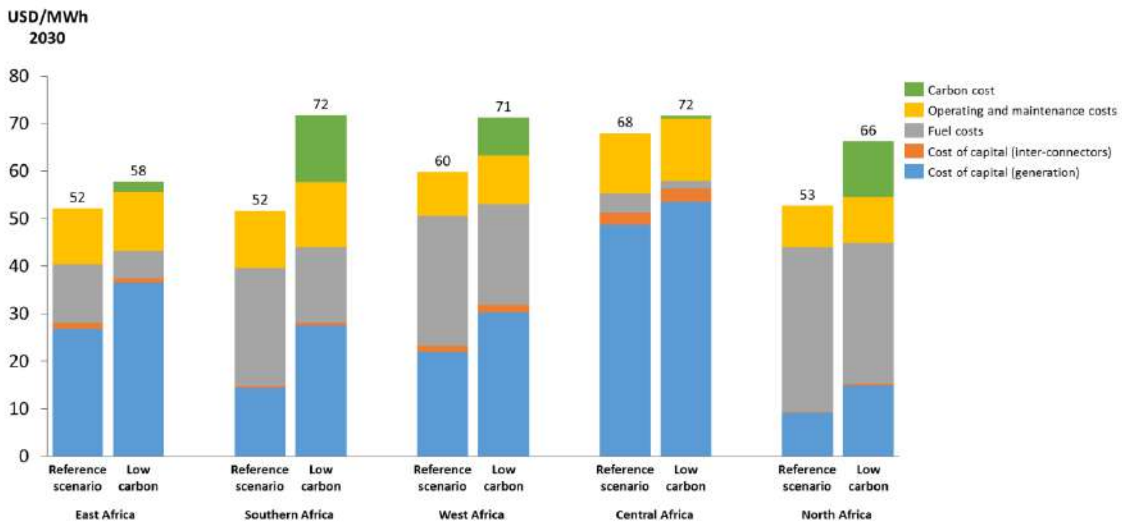


Figure 3-7. System costs by type in the Reference and Low Carbon Scenarios in 2030

3.3 Trade Stagnation Scenario[18]

The Trade Stagnation Scenario adds restrictions on the trade allowed in the region, to mimic a situation where the countries fail to further integrate their power markets. In this scenario, the building of new

[18] Please refer to Part D of Annex IV for a full list of scenarios modelled in this study.

inter-connectors (in addition to the ones that exist and are under construction) is not permitted in the optimization, while the maximum share of imported power to cover domestic demand is also limited.

The Trade Stagnation Scenario reveals that while regional integration has surprisingly limited aggregate impacts on the continental level, it is nonetheless critical for several smaller countries that stand to benefit significantly from low cost imports. At the regional levels, the investment mix in the Trade Stagnation Scenario does not differ significantly from the Reference Scenario. The most notable difference in the Trade Stagnation Scenario seems to be a substantial increase in investments in run-of-the-river hydropower in Central Africa. The limited aggregate impact is primarily driven by the dominant role of the larger power markets within each region and the fact that a number of major inter-connectors already are under construction. However, the impact of the trade restrictions is more notable in countries that in the Reference Scenario meet the majority of their demand growth by means of import. Such countries as Burundi, Eritrea, Swaziland, Lesotho, Benin, Togo, Chad, Gabon, and Mauritania would reap significant benefits from increased integration. The figures 3-8 and 3-9 display investments in generation for those countries that in the Reference Scenario are forecasted to cover more than 50 percent of their domestic demand by import in 2025 and/or 2030. The trade benefits also differ across regions due to the differing nature of their current power systems and resource base. While it is found optimal to trade significant amount of power for countries in Central, Eastern and Western Africa, countries in Southern and Northern Africa trade lower amount of power relative to the total electricity demand in the regions. However, while total investment in inter-connectors is a mere 8.9 billion USD, this increased integration results in an estimated 3.4 billion USD reduction in annual system costs across the continent.

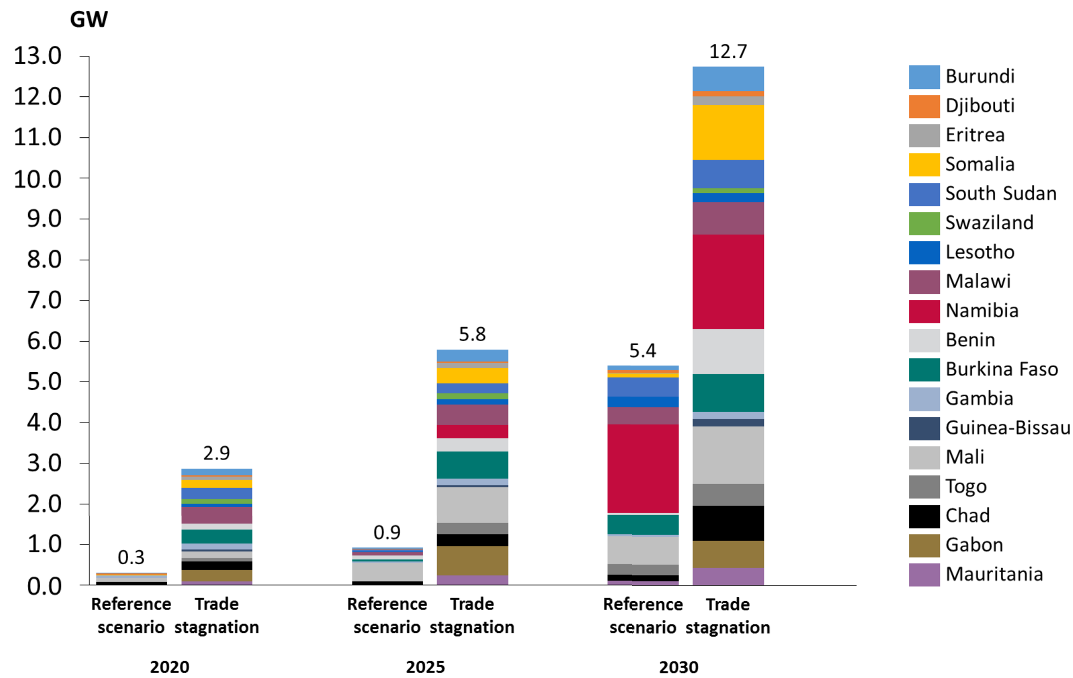


Figure 3-8. Required generation capacity additions in a selection of power importing countries in the Reference and Trade Stagnation Scenarios [19]

[19] Power plants already under construction are excluded when comparing required capacity additions across the scenarios.

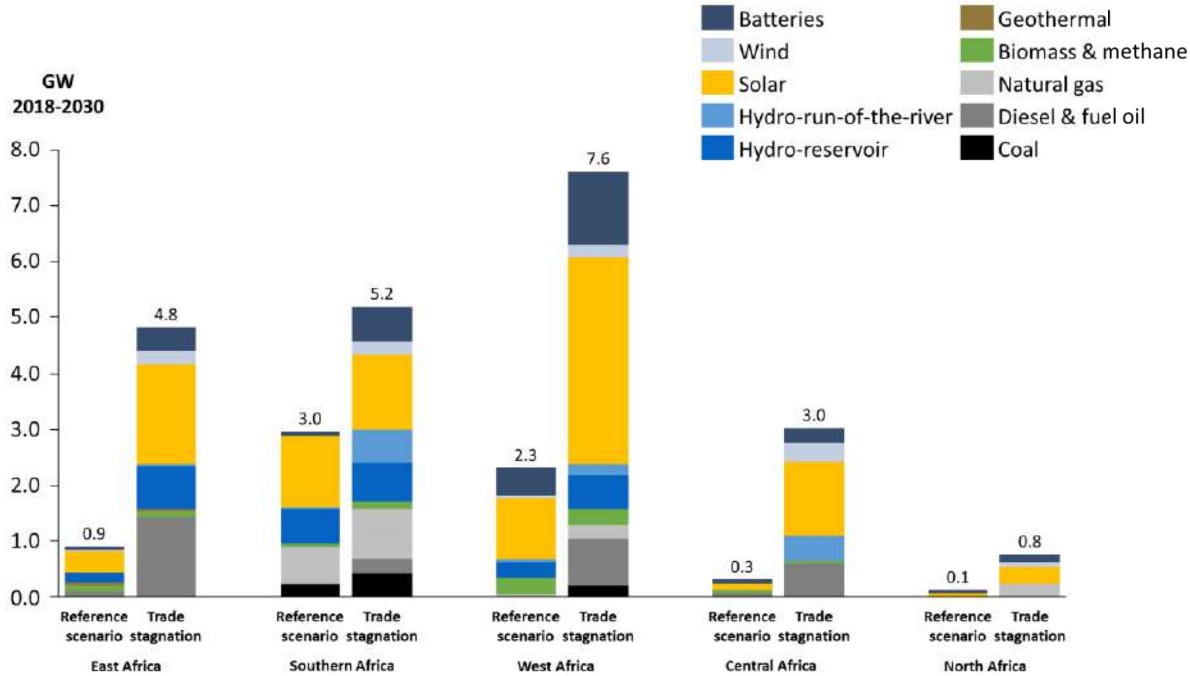


Figure 3-9. Total required generation capacity additions in a selection of power importing countries by technology in the Reference and Trade Stagnation Scenarios between 2018 and 2030[20]

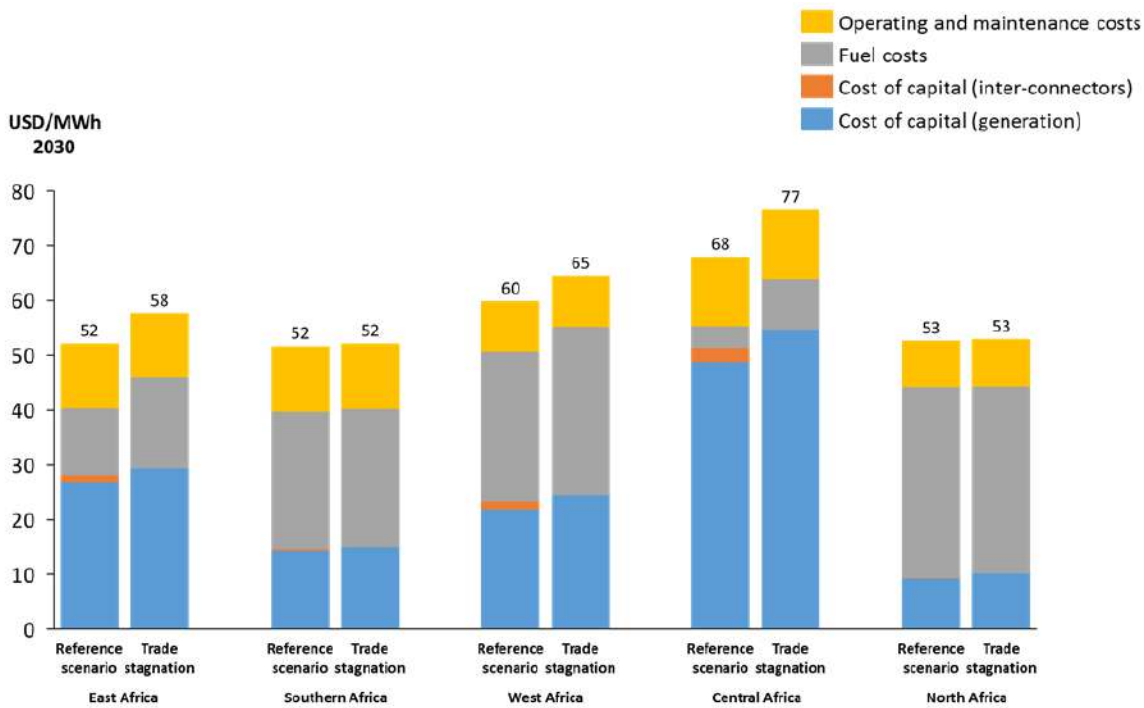


Figure 3-10. System costs by type in the Reference and Trade Stagnation Scenarios in 2030

[20] Power plants already under construction are excluded when comparing required capacity additions across the scenarios.

3.4 Business-as-Usual Access Expansion Scenario

The Business-as-Usual Access Expansion Scenario builds loosely on the New Policies Scenario of the IEA World Energy Outlook 2014. This scenario projects that 618 million people in Sub-Saharan Africa will be without access to electricity by 2030. In the interest of simplicity, “electricity access” is taken to include grid, mini-grid and off-grid connections. To arrive at a Business-as-Usual Scenario, the overall access ambitions of the New Deal Scenario are reduced proportionally across the three access types by a total 150 million connections (roughly equal to 618 million people).

Compared with the less ambitious Business-as-Usual (BaU) Scenario, the New Deal access expansion vision implies a ramping up of investment by approximately 45 percent, or about 130 billion USD over the next 13 years. This is equal to an average increase of USD 10 billion per year. While the lion’s share of this increase is related to T&D investments, the New Deal Scenario also impacts generation, as it implies an additional 38 GW of installed capacity compared with the BaU Scenario. The additional capacity consists mainly of natural gas and hydropower plants as well as solar projects and utility-scale batteries. Notably, the New Deal Scenario results only in a marginal increase in the total investment cost for Northern Africa because that region already has near universal access.

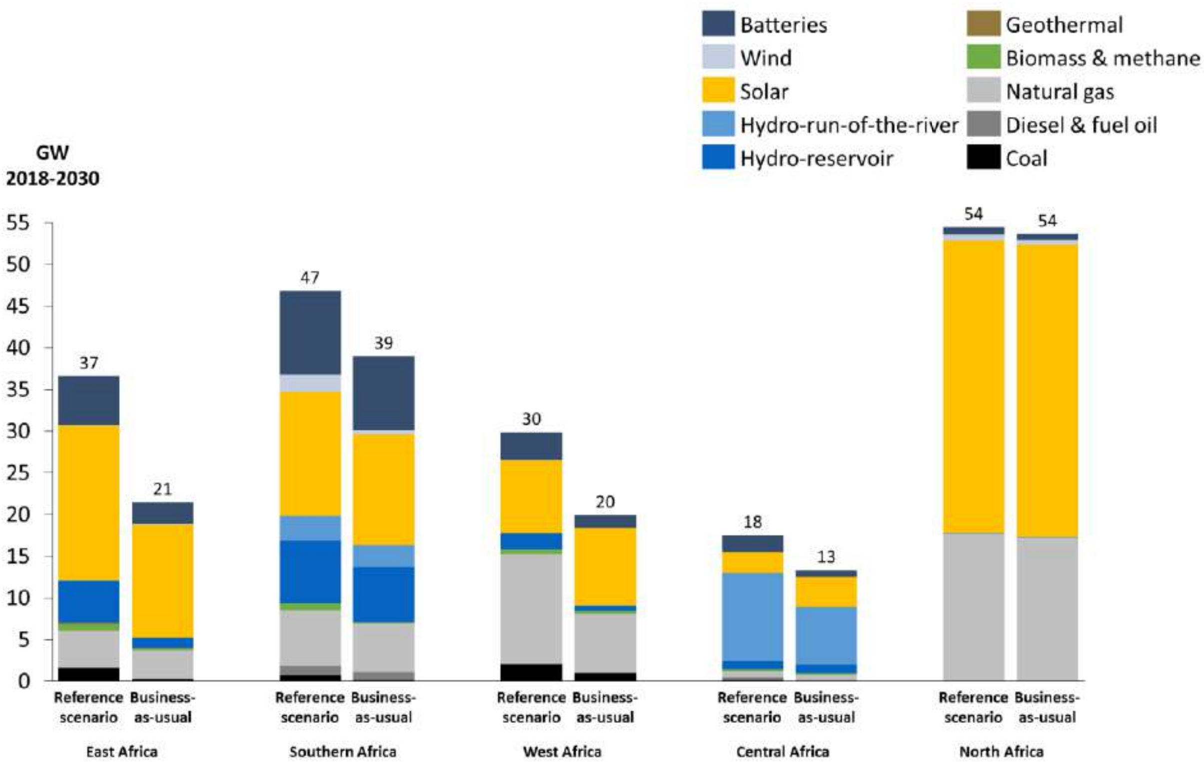


Figure 3-11. Total required generation capacity additions by technology in the Reference and Business-as-Usual Scenarios between 2018 and 2030[21]

[21] Power plants already under construction are excluded when comparing required capacity additions across the scenarios.

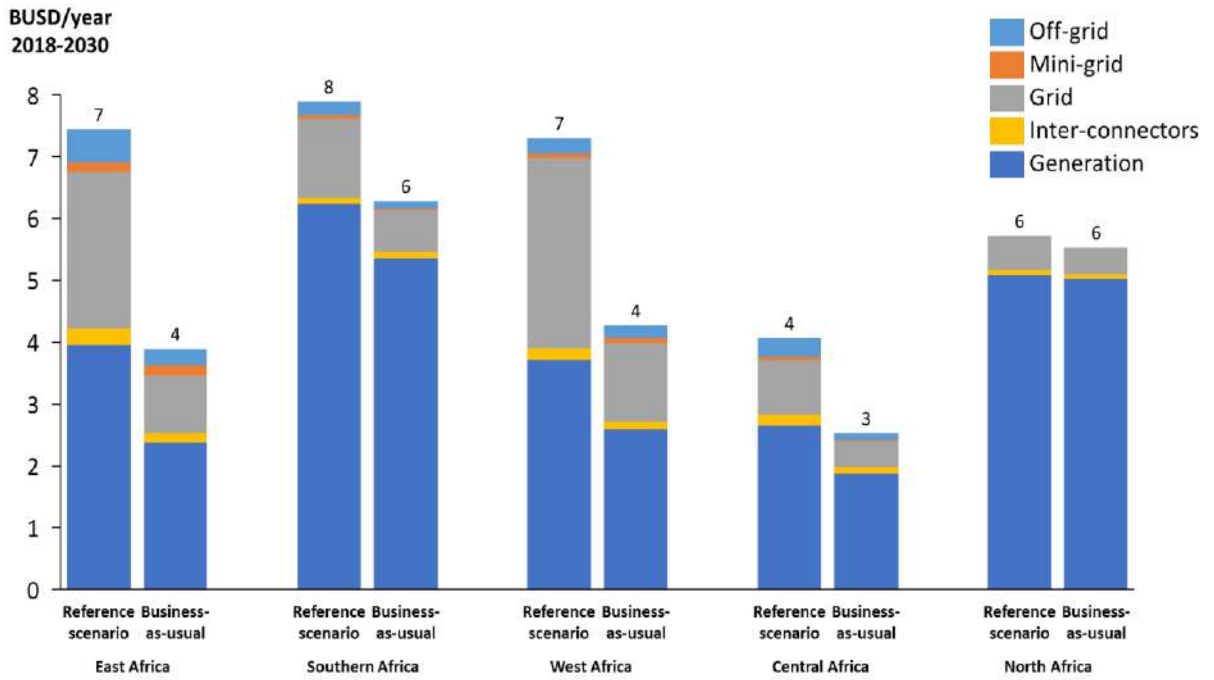


Figure 3-12. Total average annual investment cost 2018-2030 by type in the Reference and Business-as-Usual Scenarios

4 Implications for AfDB

The modelling results and analysis in this report have many potential policy and financing implications for the AfDB.

- **Overall investment requirements to achieve the New Deal.** Achieving universal access is possible and perhaps requires less additional funding than previously thought. The estimates presented in this report indicate an investment requirement of some 29-39 billion USD per year to achieve universal access, if an optimal investment plan is realized. This implies that with good regional planning and wise investment decisions, Africa can achieve its high ambitions within a reasonable investment window. This analysis would indicate that the AfDB can champion the view that with good and coordinated investment decisions by public, private and multilateral investors the New Deal is possible. However, when it comes to access expansion, the indication is that the pace is already too slow when comparing the base year of 2016 with what must be achieved by 2025.

- **A benchmark for future investment appraisals.** The analyses for each region provides AfDB staff with a rather detailed indication of what an optimal regional system is expected to look like, and thus what energy mix and inter-connectors one could expect in such a system. While the situation will change going forward, and each country has specific challenges, the results at the country and regional level can serve as benchmarks in terms of identifying and appraising future investment projects. Taken one step further, the AfDB can utilize the results to set priorities and actively pursue projects that are consistent with the outcomes presented in this analysis.

- **A tracking tool for monitoring progress towards the New Deal.** As the estimates arrived at in this study present a development whereby optimal technology mixes, inter-connectors and overall investments are realized, the estimates provide a likely lower-bound for investments to achieve the New Deal ambitions. If followed-up and monitored actual investment levels and access levels can be compared against these projections to determine progress towards achieving these ambitions.

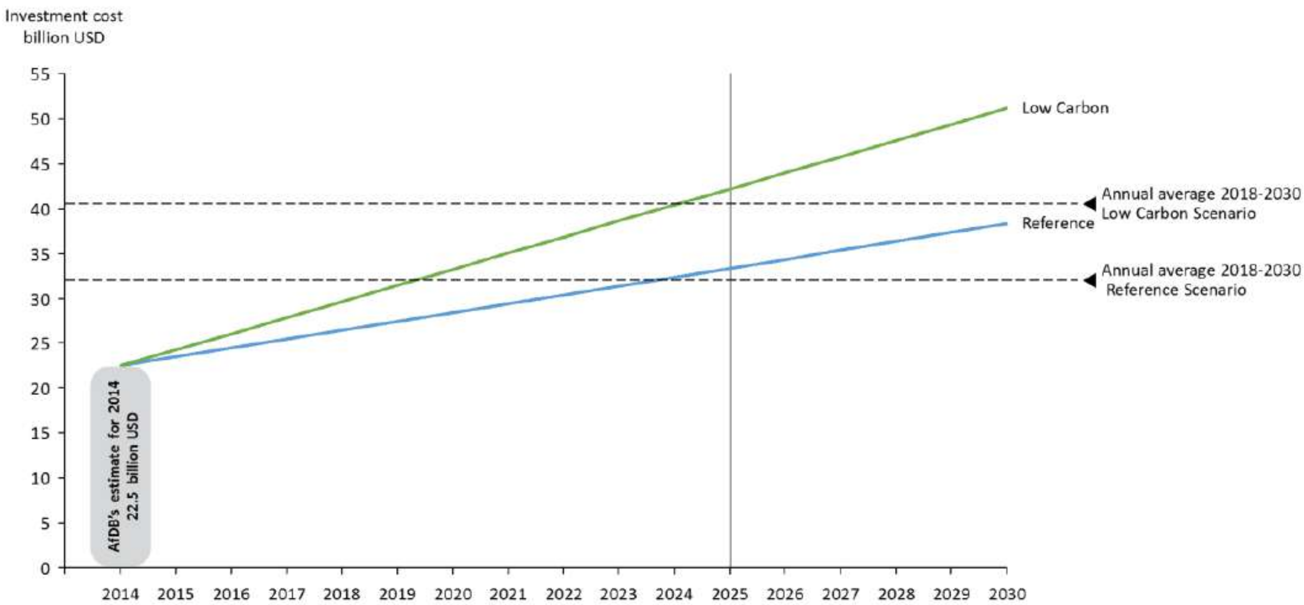


Figure 4 1. Depiction of required investment ramp-up to achieve universal access targets of the New Deal and beyond into 2030 (figure draws on the analysis results but is for illustrative purposes only).

- **Sub-sector investment requirements and priorities.** With more than 60 GW of generation currently under construction, additional generation needs are tempered in the near term. Meanwhile, the access expansion and demand growth rates assumed and projected in this study are aggressive, and concerted efforts will be required to realize them. That is, in the near term, ensuring access expansion and demand growth should be a priority, as such a focus will also lay the foundation for enabling further investments in generation and/or inter-connectors. Having said this, with such high access ambitions, there will have to be equal focus on enabling solar home system and mini-grid penetration. These access solutions will require as much of a policy effort as a financing one. Further, experience from the field would indicate that especially for mini-grids, sizeable subsidies will be required. Rapid grid expansion will likely require a combination of public sector lending, international grants and (cross-) subsidization. Private investment should not be expected to make significant contributions in the grid expansion space, and low-cost public-/multilateral lending will likely have to carry the lion's share of the investment. Finally, unless progress is made on the continent to improve the cost reflectiveness of utilities, a sustainable grid expansion is unlikely to emerge. Thus, AfDB's role in working with utilities on lending for grid reinforcements, technical/commercial loss efforts and policy/regulatory matters should be considered as a particular focus for its efforts in the sector throughout the continent. AfDB is already supporting many utilities in this regard, and it could very well establish itself as the leading partner in this regard, as other funders turn more and more to the private sector and off-grid solutions.

- **Role of specific countries in the regional context.** This analysis allows for a comprehensive consideration of the relative role and comparative advantage of each sector in their respective regions. As indicated in the heat-maps below, some countries are best served by imports, while for others it will make sense to utilize low-cost and flexible resources to export. With a range of starting points, unique resource bases and falling costs for renewables, this picture will change over time as some countries can be expected to transition from net exporter to net importer and vice versa. No matter, a key finding is that the role of regional integration in allowing for an increasing share of low-cost variable renewable is likely as important as the contribution that integrations gives in terms of volume of power exchange.

- **Country-level prioritization. Each country has a unique starting point.** In order to achieve the ambitious access targets, all countries will essentially have rapidly scale up expansion efforts. One should expect significant variation across countries with regards to value for money, as population density, role of mini- and off-grid and resource-bases vary considerably. Across countries, this observation would indicate the need to prioritize funds. However, AfDB is likely not in a position to "cherry pick" the countries and interventions that deliver the most value for money, as this would imply leaving some countries to fend for themselves. This would not be consistent with the New Deal ambitions, which basically requires that all countries experience a considerable lift. Nonetheless, the analysis provides a basis for considering how to prioritize and stage interventions in terms of types of access, between sub-sectors and technologies.

- **Individual paths to universal access.** With the specified ambitions of the New Deal for 2025, access to grid electricity will approach 100% by 2030. However, there is no doubt that mini-grids and particularly off-grid solutions will play a key role if the ambitions are to be achieved. Each country is unique and while all countries must experience a rapid access expansion, the path and contributions of each country to the continent-wide ambition levels will be unique. If this path is to be realized, one should carefully consider how to best achieve access expansion in each country considering the individual starting points of each country. The algorithm developed for this study and the resulting analysis should provide a good start for considering in which countries mini- and off-grid solutions will play a particularly important role until 2025.

- **The changing energy landscape.** The AfDB has embarked on its New Deal agenda in the midst of an exciting transition for the global energy sector. Renewable energy sources are already the most competitive sources of power in most markets and the costs continue to fall. Energy efficient solutions are becoming wide-spread and one is witnessing a general weakening of the economic-demand coupling which is likely to dampen future demand growth while also increasing the economic value of every kWh delivered. Low cost variable renewables will put national and regional power systems to the test, while utility-scale battery solutions will likely come into full maturity during the New Deal timeframe. Finally, off-grid solutions are now offering a more complex understanding of what constitutes access and mini-grids will likely contribute to increased decentralized generation, which will also dampen transmission investment needs. For the most part, these developments are foreseen and incorporated in this analysis and drive much of the results and estimates. All in all, these developments contribute to making the ambitions of the New Deal less overwhelming and more achievable. AfDB will need to be at the forefront of anticipating and leveraging on these developments.

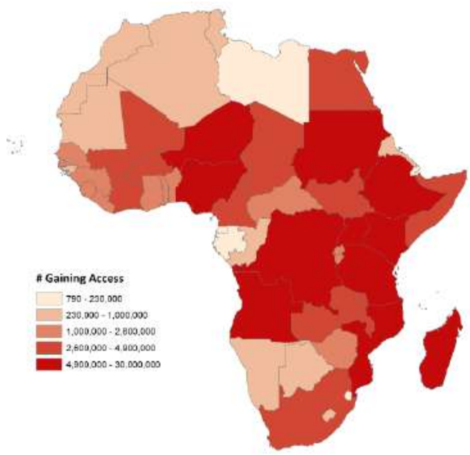
- **Implications of the global climate agenda for Africa.** The additional costs for Africa in pursuing a low carbon development path are laid out in this report and provide AfDB with an opportunity to front the case for these costs being covered by the global community. The global policy agenda has already implied that most international funders are no longer willing to finance fossil-fuel based generation sources. Indeed, the global community wants to see a “clean development path” for Africa. Specifically, the Low Carbon Scenario implies 10 billion USD in additional annual investment and 5.8 billion USD in additional annual system costs from 2030 compared to an economically optimal development path. While the costs are not astronomical, they are real and ultimately put an estimated price tag on the annual cost for the continent to pursue such a development path. Surely, AfDB is in a position to front the continental-case for the international community to cover these costs.

In order to put the specific country-needs in the continental perspective, a series of “heat-maps” have been developed. They are meant to illustrate the outlook and priorities across the continent and within countries, as determined by the optimizations and analysis done in this report.

4.1 The evolving path to universal access

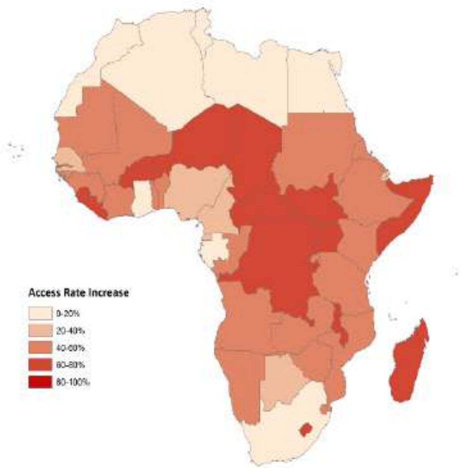
The New Deal Scenario of this study is built up so as to achieve the AfDB´s definition of universal access by 2025. However, each country will follow its own pace and path towards this goal. **The heat maps below visualize the key challenges facing each region and country, so as to guide the tailoring of policies and support schemes required to reach the ambitious New Deal targets.** More details on country-by-country rural and urban access expansion can be found in annex II.

Number of new connections



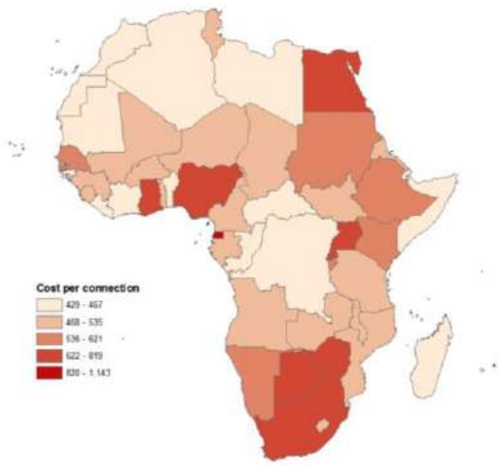
Number of new on-grid, mini-grid and off-grid connections forecasted for the period 2017-2025

Increase in access rate



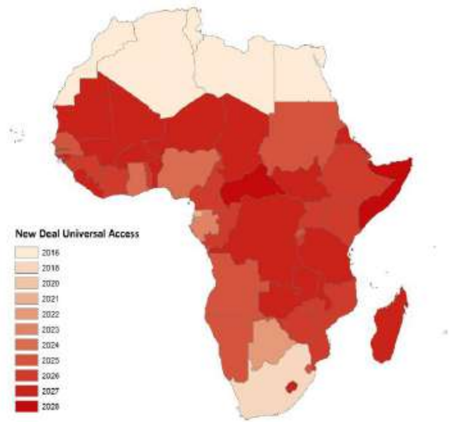
Increase in access rate (on-grid, mini-grid and off-grid connections) forecasted for the period 2017-2025

Cost per connection



Cost (USD) per household connection made between 2017 and 2030.

Realization of universal access.

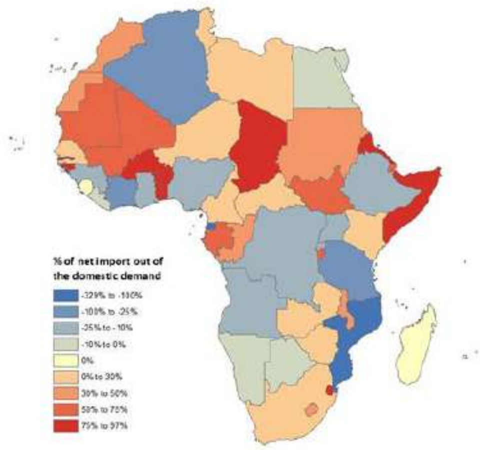


The year in which each country (individually) achieves the New Deal definition of universal access (100% urban and 95% rural)

4.2 Meeting the energy demands of the New Deal

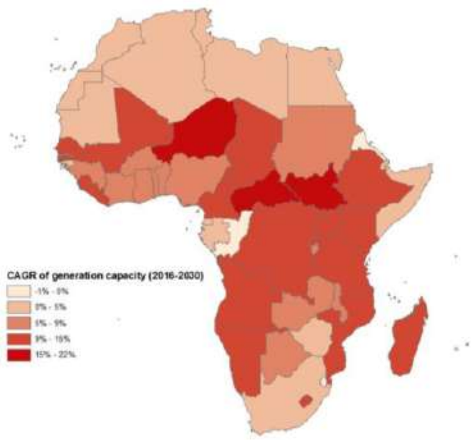
Ensuring supply of sufficient electricity to meet growing demand in an efficient and sustainable manner will remain a key challenge for national governments and development partners. In particular, this study clearly demonstrates the importance of understanding how national and regional comparative advantages can be leveraged to ensure rational and cost-effective utilization of the continent's energy resources. **The subsequent heat maps visualize key issues related to optimal power supply and capacity expansion on the continent in the Reference Scenario.**

Net electricity import and export



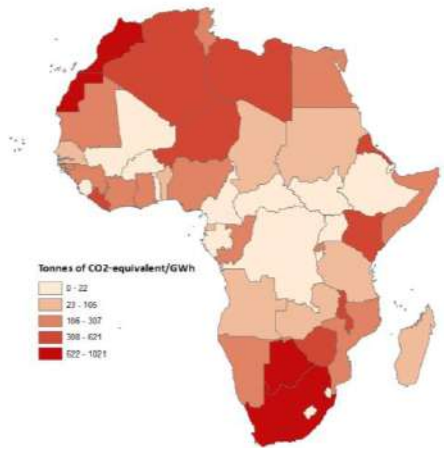
Net import (red)/export (blue) of electricity, as a share of total domestic consumption in 2030.

Annual growth of generation capacity



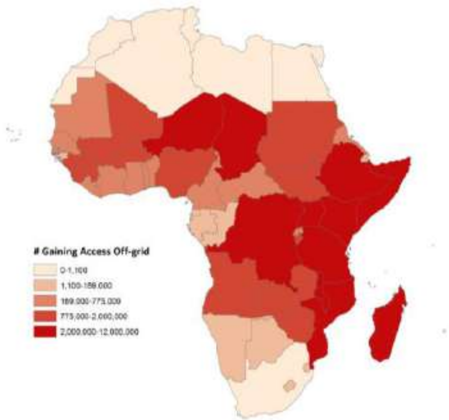
Annual growth (CAGR) in generation capacity between 2016 and 2030.

Greenhouse gas emissions



Emissions of CO_2-equivalent per GWh of electricity produced in 2030.

Off-grid access



Number of households that gain access by means of off-grid SHS at some point during the period 2017-2025.

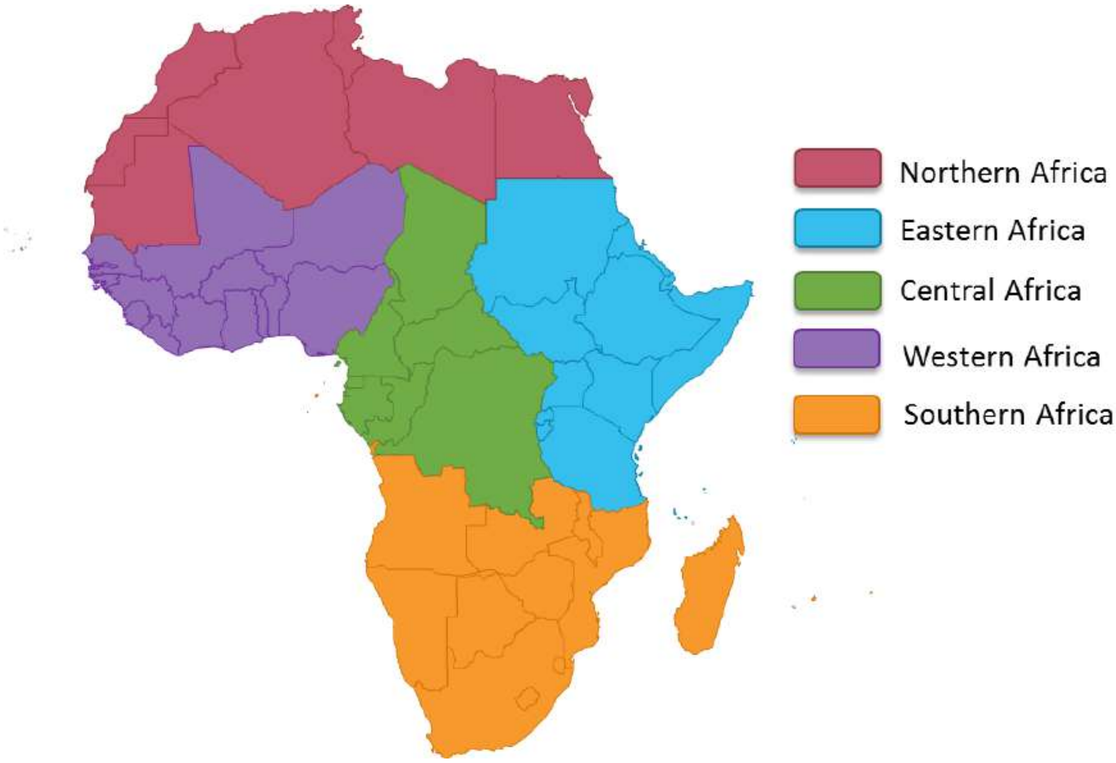
Box 4 Generation expansion heat maps for the New Deal ambitions

4.3 Concluding remarks

This study has set out to address the investment requirements to achieve the ambitions set out in the AfDB's New Deal for Africa on Energy. The analysis provides a comprehensive state of the sector as the starting point for 2016 and incorporates our best knowledge and projections as to the future of costs and technology. Accordingly, the results provide much more than a mere estimate of investment needs. It gives insights into country-specific and regional development paths, the power system operations of the future, country-specific access expansion paths, the value of regional integration and implications of the global push towards reduced emissions. The study offers both high-level continent-wide estimates and insights that are built bottom-up for all 54 countries and 5 regions.

Accordingly, the policy and financial implications of this analysis are numerous and impossible to cover in a concluding chapter without restating the full range of key findings and conclusions for each region. We encourage the reader to review carefully relevant parts of the analysis and consider the wide ranging implications of the results. The hope is that the findings and insights will provide meaning and reference points for a broad set of stakeholders looking for guidance as to what the global agenda implies for the continent, individual regions and each of the 54 countries.

Annex I: Regions applied in the study



East Africa	Southern Africa	Central Africa	North Africa	West Africa
Burundi	Angola	Cameroon	Algeria	Benin
Comoros	Botswana	Central African Republic	Egypt	Burkina Faso
Djibouti	Lesotho	Chad	Libya	Cape Verde
Seychelles	Malawi	Congo	Mauritania	Côte d'Ivoire
Eritrea	Mauritius	Democratic Republic of Congo	Morocco	Gambia
Ethiopia	Mozambique	Equatorial Guinea	Tunisia	Ghana
Kenya	Namibia	Gabon		Guinea
Rwanda	Sao Tome and Principe			Guinea-Bissau
Somalia	South Africa			Liberia
South Sudan	Swaziland			Mali
Sudan	Zambia			Niger
Tanzania	Zimbabwe			Nigeria
Uganda	Madagascar			Senegal
				Sierra Leone
				Togo

Annex II: Tabulated year-by-year access expansion numbers for each country

Total (urban & rural)

Households

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	2 449 217	2 518 084	2 588 642	2 660 952	2 734 762	2 809 762	2 886 429	2 964 286	3 043 333	3 123 571	3 205 000	3 288 095	3 372 143	3 457 619	3 544 286	3 631 905	3 721 190	2,6 %
Burkina Faso	4 187 137	4 312 053	4 439 627	4 569 762	4 702 857	4 838 333	4 976 905	5 118 333	5 262 619	5 409 286	5 559 286	5 712 143	5 868 095	6 026 667	6 188 095	6 352 619	6 519 524	2,8 %
Cape Verde	125 342	126 884	128 467	130 000	131 667	133 333	135 000	136 667	138 571	140 000	141 667	143 333	145 000	146 429	148 095	149 524	151 190	1,2 %
Côte d'Ivoire	3 884 716	3 984 219	4 085 503	4 188 793	4 294 138	4 401 897	4 512 414	4 625 517	4 741 034	4 858 966	4 979 310	5 101 897	5 226 552	5 353 448	5 482 586	5 614 138	5 747 759	2,5 %
Gambia	456 631	470 855	485 357	500 238	515 238	530 476	546 190	561 905	577 857	594 286	610 952	627 619	644 524	661 667	679 048	696 667	714 524	2,8 %
Ghana	6 419 658	6 567 338	6 715 888	6 865 238	7 015 000	7 165 952	7 317 381	7 470 000	7 623 333	7 777 381	7 932 381	8 088 095	8 244 524	8 401 905	8 560 000	8 719 286	8 879 524	2,0 %
Guinea	2 810 835	2 878 936	2 951 410	3 028 095	3 107 857	3 190 000	3 274 048	3 359 524	3 446 429	3 535 000	3 625 238	3 716 905	3 810 476	3 905 238	4 001 429	4 098 810	4 197 857	2,5 %
Guinea-Bissau	410 891	421 554	432 309	443 095	454 048	465 238	476 429	487 619	499 048	510 476	522 143	533 810	545 476	557 381	569 286	581 190	593 571	2,3 %
Liberia	1 045 414	1 071 338	1 098 529	1 126 667	1 155 476	1 185 238	1 215 000	1 245 714	1 276 905	1 308 571	1 340 952	1 373 810	1 407 381	1 441 429	1 475 952	1 510 952	1 546 429	2,5 %
Mali	4 038 773	4 159 025	4 284 485	4 414 762	4 549 524	4 687 857	4 829 524	4 974 524	5 122 619	5 274 524	5 430 000	5 589 524	5 752 857	5 919 762	6 090 238	6 264 524	6 442 381	3,0 %
Niger	4 559 100	4 737 373	4 922 140	5 113 810	5 312 381	5 518 333	5 732 143	5 953 810	6 183 571	6 421 905	6 668 333	6 923 333	7 187 143	7 459 762	7 741 429	8 032 143	8 331 905	3,8 %
Nigeria	43 039 147	44 190 669	45 363 327	46 557 805	47 774 634	49 015 366	50 281 220	51 572 439	52 888 780	54 231 463	55 600 976	56 998 049	58 423 415	59 876 341	61 358 049	62 868 049	64 406 829	2,5 %
Senegal	3 463 360	3 565 951	3 669 432	3 773 810	3 879 762	3 986 667	4 095 238	4 205 476	4 317 143	4 430 238	4 545 000	4 661 190	4 779 048	4 898 571	5 019 762	5 142 619	5 267 619	2,6 %
Sierra Leone	1 685 515	1 723 101	1 760 998	1 799 286	1 837 857	1 876 905	1 915 952	1 955 000	1 994 286	2 033 571	2 073 095	2 112 857	2 152 857	2 193 095	2 233 333	2 273 571	2 314 048	2,0 %
Togo	1 721 170	1 765 905	1 811 041	1 856 429	1 902 619	1 949 286	1 996 429	2 044 048	2 092 381	2 141 190	2 190 476	2 240 952	2 291 667	2 343 095	2 395 476	2 448 095	2 501 905	2,3 %
Total	**80 296 906**	**82 493 286**	**84 737 156**	**87 028 741**	**89 367 820**	**91 754 643**	**94 190 300**	**96 674 861**	**99 207 910**	**101 790 429**	**104 424 810**	**107 111 612**	**109 851 157**	**112 642 409**	**115 487 064**	**118 384 091**	**121 336 255**	2,6 %

Grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	719 745	790 337	864 528	990 248	1 122 609	1 261 653	1 407 791	1 560 982	1 721 533	1 889 479	2 064 989	2 240 916	2 368 962	2 500 391	2 634 939	2 772 457	2 913 397	9,1 %
Burkina Faso	723 375	840 130	963 385	1 173 899	1 396 588	1 631 736	1 879 798	2 141 129	2 416 109	2 704 677	3 007 749	3 288 518	3 538 163	3 794 051	4 056 498	4 325 566	4 600 907	11,8 %
Cape Verde	118 115	120 749	123 406	127 027	130 745	133 333	135 000	136 667	138 571	140 000	141 667	143 333	145 000	146 429	148 095	149 524	151 190	1,5 %
Côte d'Ivoire	1 023 632	1 145 979	1 273 991	1 499 308	1 735 686	1 983 670	2 243 782	2 516 304	2 801 478	3 099 741	3 411 371	3 736 557	3 966 749	4 203 294	4 446 308	4 696 006	4 952 244	10,2 %
Gambia	164 683	181 789	199 712	229 450	260 700	293 554	328 089	364 101	401 815	439 537	460 982	482 667	506 155	530 186	554 634	579 525	605 105	8,2 %
Ghana	4 641 309	4 923 789	5 215 366	5 548 023	5 804 675	6 064 535	6 326 883	6 592 193	6 859 992	7 130 199	7 402 891	7 677 896	7 978 961	8 282 644	8 560 000	8 719 286	8 879 524	3,9 %
Guinea	742 782	815 430	892 303	1 025 129	1 165 210	1 312 612	1 467 619	1 629 987	1 800 025	1 978 135	2 164 408	2 358 966	2 516 971	2 679 571	2 846 874	3 018 767	3 195 611	9,5 %
Guinea-Bissau	87 117	95 601	104 428	119 085	134 405	150 450	167 116	184 405	202 454	221 139	240 613	260 639	293 651	328 103	364 061	401 280	440 205	10,8 %
Liberia	103 013	125 567	149 333	194 826	242 682	293 049	345 825	401 277	459 410	520 234	583 945	650 493	751 131	856 646	967 250	1 082 977	1 204 062	16,1 %
Mali	1 046 968	1 156 536	1 272 490	1 463 596	1 666 060	1 879 977	2 105 689	2 343 452	2 593 693	2 856 983	3 133 657	3 424 410	3 686 404	3 958 522	4 240 844	4 533 820	4 837 439	10,0 %
Niger	665 335	762 510	866 780	1 047 817	1 242 407	1 451 408	1 675 728	1 916 245	2 173 898	2 449 879	2 744 875	3 059 963	3 366 961	3 691 229	4 033 043	4 392 923	4 771 226	13,0 %
Nigeria	19 446 924	21 429 921	23 508 442	27 163 997	31 007 494	35 045 118	39 283 233	43 508 776	46 007 952	48 557 561	51 158 498	53 811 825	56 774 328	59 795 878	61 358 049	62 868 049	64 406 829	7,5 %
Senegal	1 898 506	2 026 512	2 159 720	2 366 691	2 528 892	2 673 320	2 822 279	2 975 856	3 133 748	3 296 006	3 462 569	3 633 357	3 822 814	4 016 912	4 215 651	4 418 863	4 626 830	5,6 %
Sierra Leone	84 303	114 958	147 003	210 013	275 844	344 571	416 153	490 609	568 096	648 475	731 969	818 528	968 884	1 125 766	1 289 296	1 459 498	1 636 704	18,8 %
Togo	459 677	503 877	549 973	630 730	715 361	803 833	896 219	992 591	1 093 180	1 197 924	1 306 894	1 420 661	1 544 005	1 672 026	1 805 105	1 942 683	2 085 671	10,0 %
Total	**31 925 484**	**35 033 683**	**38 290 861**	**43 789 837**	**49 429 358**	**55 322 819**	**61 501 205**	**67 754 573**	**72 371 954**	**77 129 970**	**82 017 076**	**87 008 729**	**92 229 141**	**97 581 648**	**101 520 646**	**105 361 222**	**109 306 945**	7,8 %

New grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	0	70 592	74 191	125 720	132 360	139 044	146 138	153 191	160 551	167 947	175 510	175 926	128 047	131 429	134 548	137 518	140 940
Burkina Faso	0	116 754	123 256	210 513	222 690	235 148	248 062	261 331	274 980	288 568	303 072	280 769	249 645	255 888	262 447	269 068	275 341
Cape Verde	0	2 635	2 657	3 620	3 719	2 588	1 667	1 667	1 905	1 429	1 667	1 667	1 667	1 429	1 667	1 429	1 667
Côte d'Ivoire	0	122 347	128 012	225 317	236 378	247 984	260 113	272 521	285 174	298 264	311 629	325 186	230 192	236 545	243 014	249 698	256 238
Gambia	0	17 106	17 923	29 738	31 251	32 853	34 536	36 011	37 714	37 722	21 445	21 684	23 489	24 031	24 447	24 892	25 579
Ghana	0	282 480	291 577	332 657	256 652	259 860	262 348	265 310	267 799	270 206	272 693	275 005	301 065	303 683	277 356	159 286	160 238
Guinea	0	72 648	76 873	132 826	140 081	147 402	155 007	162 368	170 038	178 110	186 274	194 558	158 005	162 600	167 303	171 893	176 845
Guinea-Bissau	0	8 484	8 827	14 656	15 320	16 045	16 667	17 289	18 049	18 685	19 473	20 027	33 012	34 452	35 958	37 219	38 925
Liberia	0	22 554	23 766	45 493	47 856	50 368	52 776	55 453	58 132	60 824	63 711	66 548	100 638	105 515	110 604	115 728	121 085
Mali	0	109 568	115 954	191 106	202 464	213 917	225 713	237 762	250 242	263 289	276 674	290 753	261 994	272 118	282 322	292 976	303 620
Niger	0	97 176	104 269	181 037	194 590	209 001	224 320	240 517	257 653	275 982	294 996	315 088	306 998	324 267	341 815	359 880	378 303
Nigeria	0	1 982 996	2 078 522	3 655 555	3 843 497	4 037 624	4 238 115	4 225 543	2 499 176	2 549 610	2 600 936	2 653 328	2 962 503	3 021 550	1 562 171	1 510 000	1 538 780
Senegal	0	128 006	133 208	206 971	162 201	144 428	148 959	153 576	157 892	162 259	166 563	170 788	189 456	194 098	198 739	203 212	207 968
Sierra Leone	0	30 655	32 045	63 011	65 831	68 727	71 582	74 456	77 487	80 379	83 494	86 559	150 356	156 881	163 530	170 203	177 205
Togo	0	44 199	46 097	80 757	84 631	88 472	92 386	96 373	100 589	104 743	108 970	113 767	123 344	128 021	133 079	137 578	142 989
Total	**0**	**3 108 200**	**3 257 177**	**5 498 976**	**5 639 522**	**5 893 461**	**6 178 386**	**6 253 368**	**4 617 381**	**4 758 016**	**4 887 107**	**4 991 653**	**5 220 412**	**5 352 507**	**3 938 998**	**3 840 576**	**3 945 723**

Off-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	0	142 517	282 900	408 394	521 552	620 960	705 296	772 980	822 388	851 980	860 106	852 859	833 165	810 090	783 607	753 597	720 250	6,9 %
Burkina Faso	0	281 926	561 187	816 542	1 052 082	1 265 230	1 453 669	1 614 699	1 745 569	1 843 387	1 905 486	1 965 600	1 926 138	1 879 923	1 826 820	1 766 920	1 699 851	8,2 %
Cape Verde	0	485	791	689	281	0	0	0	0	0	0	0	0	0	0	0	0	-100,0 %
Côte d'Ivoire	0	238 895	471 050	671 798	846 405	992 583	1 107 979	1 190 018	1 235 997	1 243 073	1 208 375	1 128 866	1 053 174	971 213	882 902	788 222	687 023	2,7 %
Gambia	0	24 167	47 509	67 031	83 254	95 831	104 486	108 753	108 266	104 210	111 351	117 471	113 215	108 505	103 456	98 056	92 114	4,8 %
Ghana	0	132 330	237 619	307 418	373 070	420 328	449 229	459 956	452 629	427 440	384 673	324 493	210 953	95 014	0	0	0	-100,0 %
Guinea	0	169 388	336 189	487 281	625 692	750 104	858 970	950 778	1 023 917	1 076 784	1 107 767	1 115 013	1 071 127	1 022 489	969 269	911 436	849 172	6,8 %
Guinea-Bissau	0	27 390	54 975	81 255	106 561	130 770	153 686	175 151	195 076	213 239	229 555	243 852	225 348	205 442	183 883	160 875	136 459	6,7 %
Liberia	0	80 135	160 416	235 475	306 538	373 235	434 764	490 915	540 955	584 313	620 483	648 744	589 258	524 862	455 371	380 736	300 754	4,6 %
Mali	0	247 216	493 627	721 285	933 868	1 129 233	1 305 123	1 459 266	1 589 067	1 692 268	1 766 102	1 807 917	1 737 277	1 658 171	1 570 572	1 474 357	1 369 400	7,6 %
Niger	0	319 664	648 364	968 699	1 284 125	1 592 747	1 892 529	2 181 067	2 455 799	2 713 946	2 952 171	3 167 256	3 168 562	3 159 418	3 139 661	3 108 750	3 066 303	11,7 %
Nigeria	0	1 904 729	3 633 974	4 790 086	5 453 426	5 582 988	5 136 024	4 207 153	4 059 899	3 726 377	3 207 126	2 502 863	1 298 722	63 447	0	0	0	-100,0 %
Senegal	0	123 665	240 193	330 964	419 349	505 698	583 608	652 547	712 069	761 691	801 196	830 099	779 116	723 967	664 773	601 807	535 380	5,9 %
Sierra Leone	0	134 689	269 353	396 219	517 080	631 386	738 356	837 311	927 669	1 008 665	1 079 699	1 140 113	1 042 811	938 273	826 219	706 636	579 474	5,6 %
Togo	0	105 367	209 745	304 386	391 225	469 409	538 100	596 442	643 614	678 657	700 644	708 824	648 050	582 464	511 985	436 507	356 111	3,9 %
Total	**0**	**3 932 564**	**7 647 892**	**10 587 522**	**12 914 508**	**14 560 502**	**15 461 821**	**15 697 036**	**16 512 915**	**16 926 031**	**16 934 733**	**16 553 969**	**14 696 917**	**12 743 278**	**11 918 517**	**11 187 900**	**10 392 291**	2,2 %

Mini-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	0	8 607	17 268	25 534	33 505	41 145	48 423	55 299	61 726	67 679	73 122	78 021	81 538	84 287	86 230	87 319	87 543	12,3 %
Burkina Faso	0	20 924	41 907	61 894	81 153	99 603	117 198	133 865	149 539	164 152	177 661	189 989	199 248	206 837	212 669	216 684	218 765	12,5 %
Cape Verde	0	72	118	104	43	0	0	0	0	0	0	0	0	0	0	0	0	-100,0 %
Côte d'Ivoire	0	14 065	27 874	40 594	52 468	63 464	73 561	82 729	90 939	98 153	104 346	109 486	112 142	113 414	113 256	111 635	108 491	10,2 %
Gambia	0	1 322	2 639	3 881	5 064	6 186	7 248	8 242	9 161	10 012	10 781	11 463	13 130	14 556	15 742	16 674	17 306	14,4 %
Ghana	0	13 480	26 128	36 307	44 481	50 598	54 603	56 456	56 108	53 516	48 649	41 457	32 207	16 875	0	0	0	-100,0 %
Guinea	0	11 023	22 060	32 562	42 680	52 376	61 595	70 300	78 443	85 981	92 882	99 097	113 947	126 871	137 775	146 538	153 074	14,8 %
Guinea-Bissau	0	993	1 985	2 942	3 874	4 779	5 657	6 505	7 323	8 109	8 862	9 591	11 242	12 808	14 263	15 630	16 908	16,5 %
Liberia	0	2 845	5 699	8 427	11 064	13 605	16 024	18 328	20 495	22 523	24 402	26 124	30 171	33 772	36 891	39 517	41 613	15,3 %
Mali	0	15 005	30 083	44 568	58 642	72 262	85 380	97 959	109 941	121 308	132 008	142 009	165 066	186 063	204 891	221 427	235 542	15,8 %
Niger	0	23 050	47 112	71 224	95 611	120 201	144 918	169 666	194 348	218 860	243 066	266 857	316 877	364 999	410 886	454 145	494 376	18,3 %
Nigeria	0	137 280	265 807	367 612	447 717	505 427	540 050	550 890	537 236	498 378	433 571	342 061	212 448	12 094	0	0	0	-100,0 %
Senegal	0	10 581	21 187	31 075	40 403	49 101	57 109	64 359	70 788	76 328	80 936	84 539	94 380	101 522	105 820	107 151	105 409	12,1 %
Sierra Leone	0	6 609	13 235	19 578	25 706	31 601	37 233	42 581	47 614	52 329	56 687	60 691	70 183	78 700	86 171	92 573	97 870	15,4 %
Togo	0	5 376	10 727	15 722	20 441	24 861	28 958	32 710	36 096	39 095	41 686	43 858	49 516	54 025	57 326	59 370	60 123	13,1 %
Total	**0**	**271 230**	**533 829**	**762 025**	**962 854**	**1 135 209**	**1 277 955**	**1 389 889**	**1 469 758**	**1 516 423**	**1 528 660**	**1 505 242**	**1 502 095**	**1 406 821**	**1 481 921**	**1 568 664**	**1 637 018**	8,3 %

Total connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	719 745	941 461	1 164 697	1 424 176	1 677 666	1 923 758	2 161 510	2 389 261	2 605 647	2 809 138	2 998 217	3 171 796	3 283 665	3 394 767	3 504 776	3 613 374	3 721 190	8,7 %
Burkina Faso	723 375	1 142 979	1 566 480	2 052 335	2 529 823	2 996 570	3 450 665	3 889 693	4 311 218	4 712 217	5 090 896	5 444 107	5 663 550	5 880 811	6 095 987	6 309 170	6 519 524	10,7 %
Cape Verde	118 115	121 306	124 315	127 820	131 070	133 333	135 000	136 667	138 571	140 000	141 667	143 333	145 000	146 429	148 095	149 524	151 190	1,4 %
Côte d'Ivoire	1 023 632	1 398 940	1 772 915	2 211 701	2 634 559	3 039 717	3 425 322	3 789 050	4 128 413	4 440 968	4 724 091	4 974 908	5 132 065	5 287 921	5 442 466	5 595 862	5 747 759	8,8 %
Gambia	164 683	207 278	249 860	300 362	349 018	395 571	439 824	481 096	519 242	553 760	583 115	611 600	632 501	653 248	673 831	694 255	714 524	7,8 %
Ghana	4 641 309	5 069 599	5 479 113	5 891 748	6 222 226	6 535 461	6 830 716	7 108 606	7 368 729	7 611 154	7 836 213	8 043 846	8 222 122	8 394 533	8 560 000	8 719 286	8 879 524	3,5 %
Guinea	742 782	995 841	1 250 552	1 544 972	1 833 582	2 115 092	2 388 184	2 651 065	2 902 385	3 140 899	3 365 057	3 573 076	3 702 045	3 828 931	3 953 917	4 076 741	4 197 857	9,0 %
Guinea-Bissau	87 117	123 985	161 389	203 282	244 839	285 999	326 459	366 061	404 853	442 487	479 029	514 082	530 240	546 353	562 208	577 785	593 571	9,7 %
Liberia	103 013	208 546	315 448	438 728	560 284	679 889	796 613	910 520	1 020 860	1 127 070	1 228 830	1 325 361	1 370 560	1 415 280	1 459 512	1 503 231	1 546 429	12,0 %
Mali	1 046 968	1 418 756	1 796 200	2 229 448	2 658 570	3 081 472	3 496 192	3 900 677	4 292 702	4 670 559	5 031 767	5 374 335	5 588 747	5 802 756	6 016 307	6 229 604	6 442 381	9,6 %
Niger	665 335	1 105 224	1 562 256	2 087 739	2 622 143	3 164 355	3 713 175	4 266 978	4 824 045	5 382 685	5 940 112	6 494 076	6 852 400	7 215 645	7 583 590	7 955 818	8 331 905	12,7 %
Nigeria	19 446 924	23 471 929	27 408 223	32 321 695	36 908 637	41 133 534	44 959 307	48 266 819	50 605 087	52 782 317	54 799 194	56 656 749	58 285 497	59 871 419	61 358 049	62 868 049	64 406 829	6,3 %
Senegal	1 898 506	2 160 758	2 421 099	2 728 730	2 988 644	3 228 119	3 462 996	3 692 761	3 916 604	4 134 025	4 344 701	4 547 995	4 696 310	4 842 402	4 986 244	5 127 821	5 267 619	5,7 %
Sierra Leone	84 303	256 255	429 590	625 811	818 630	1 007 558	1 191 742	1 370 502	1 543 379	1 709 469	1 868 355	2 019 332	2 081 878	2 142 738	2 201 687	2 258 708	2 314 048	12,8 %
Togo	459 677	614 620	770 445	950 838	1 127 028	1 298 103	1 463 277	1 621 743	1 772 891	1 915 676	2 049 224	2 173 343	2 241 572	2 308 515	2 374 416	2 438 559	2 501 905	8,8 %
Total	**31 925 484**	**39 237 477**	**46 472 581**	**55 139 384**	**63 306 720**	**71 018 530**	**78 240 982**	**84 841 499**	**90 354 627**	**95 572 424**	**100 480 469**	**105 067 940**	**108 428 152**	**111 731 748**	**114 921 084**	**118 117 787**	**121 336 255**	7,1 %

Total access rates

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	29 %	37 %	45 %	54 %	61 %	68 %	75 %	81 %	86 %	90 %	94 %	96 %	97 %	98 %	99 %	99 %	100 %
Burkina Faso	17 %	27 %	35 %	45 %	54 %	62 %	69 %	76 %	82 %	87 %	92 %	95 %	97 %	98 %	99 %	99 %	100 %
Cape Verde	94 %	96 %	97 %	98 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Côte d'Ivoire	26 %	35 %	43 %	53 %	61 %	69 %	76 %	82 %	87 %	91 %	95 %	98 %	98 %	99 %	99 %	100 %	100 %
Gambia	36 %	44 %	51 %	60 %	68 %	75 %	81 %	86 %	90 %	93 %	95 %	97 %	98 %	99 %	99 %	100 %	100 %
Ghana	72 %	77 %	82 %	86 %	89 %	91 %	93 %	95 %	97 %	98 %	99 %	99 %	100 %	100 %	100 %	100 %	100 %
Guinea	26 %	35 %	42 %	51 %	59 %	66 %	73 %	79 %	84 %	89 %	93 %	96 %	97 %	98 %	99 %	99 %	100 %
Guinea-Bissau	21 %	29 %	37 %	46 %	54 %	61 %	69 %	75 %	81 %	87 %	92 %	96 %	97 %	98 %	99 %	99 %	100 %
Liberia	10 %	19 %	29 %	39 %	48 %	57 %	66 %	73 %	80 %	86 %	92 %	96 %	97 %	98 %	99 %	99 %	100 %
Mali	26 %	34 %	42 %	50 %	58 %	66 %	72 %	78 %	84 %	89 %	93 %	96 %	97 %	98 %	99 %	99 %	100 %
Niger	15 %	23 %	32 %	41 %	49 %	57 %	65 %	72 %	78 %	84 %	89 %	94 %	95 %	97 %	98 %	99 %	100 %
Nigeria	45 %	53 %	60 %	69 %	77 %	84 %	89 %	94 %	96 %	97 %	99 %	99 %	100 %	100 %	100 %	100 %	100 %
Senegal	55 %	61 %	66 %	72 %	77 %	81 %	85 %	88 %	91 %	93 %	96 %	98 %	98 %	99 %	99 %	100 %	100 %
Sierra Leone	5 %	15 %	24 %	35 %	45 %	54 %	62 %	70 %	77 %	84 %	90 %	96 %	97 %	98 %	99 %	99 %	100 %
Togo	27 %	35 %	43 %	51 %	59 %	67 %	73 %	79 %	85 %	89 %	94 %	97 %	98 %	99 %	99 %	100 %	100 %
Average	**40 %**	**48 %**	**55 %**	**63 %**	**71 %**	**77 %**	**83 %**	**88 %**	**91 %**	**94 %**	**96 %**	**98 %**	**99 %**	**99 %**	**100 %**	**100 %**	**100 %**

Grid access rates

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	29 %	31 %	33 %	37 %	41 %	45 %	49 %	53 %	57 %	60 %	64 %	68 %	70 %	72 %	74 %	76 %	78 %
Burkina Faso	17 %	19 %	22 %	26 %	30 %	34 %	38 %	42 %	46 %	50 %	54 %	58 %	60 %	63 %	66 %	68 %	71 %
Cape Verde	94 %	95 %	96 %	98 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Côte d'Ivoire	26 %	29 %	31 %	36 %	40 %	45 %	50 %	54 %	59 %	64 %	69 %	73 %	76 %	79 %	81 %	84 %	86 %
Gambia	36 %	39 %	41 %	46 %	51 %	55 %	60 %	65 %	70 %	74 %	75 %	77 %	79 %	80 %	82 %	83 %	85 %
Ghana	72 %	75 %	78 %	81 %	83 %	85 %	86 %	88 %	90 %	92 %	93 %	95 %	97 %	99 %	100 %	100 %	100 %
Guinea	26 %	28 %	30 %	34 %	37 %	41 %	45 %	49 %	52 %	56 %	60 %	63 %	66 %	69 %	71 %	74 %	76 %
Guinea-Bissau	21 %	23 %	24 %	27 %	30 %	32 %	35 %	38 %	41 %	43 %	46 %	49 %	54 %	59 %	64 %	69 %	74 %
Liberia	10 %	12 %	14 %	17 %	21 %	25 %	28 %	32 %	36 %	40 %	44 %	47 %	53 %	59 %	66 %	72 %	78 %
Mali	26 %	28 %	30 %	33 %	37 %	40 %	44 %	47 %	51 %	54 %	58 %	61 %	64 %	67 %	70 %	72 %	75 %
Niger	15 %	16 %	18 %	20 %	23 %	26 %	29 %	32 %	35 %	38 %	41 %	44 %	47 %	49 %	52 %	55 %	57 %
Nigeria	45 %	48 %	52 %	58 %	65 %	71 %	78 %	84 %	87 %	90 %	92 %	94 %	97 %	100 %	100 %	100 %	100 %
Senegal	55 %	57 %	59 %	63 %	65 %	67 %	69 %	71 %	73 %	74 %	76 %	78 %	80 %	82 %	84 %	86 %	88 %
Sierra Leone	5 %	7 %	8 %	12 %	15 %	18 %	22 %	25 %	28 %	32 %	35 %	39 %	45 %	51 %	58 %	64 %	71 %
Togo	27 %	29 %	30 %	34 %	38 %	41 %	45 %	49 %	52 %	56 %	60 %	63 %	67 %	71 %	75 %	79 %	83 %
Average	**40 %**	**42 %**	**45 %**	**50 %**	**55 %**	**60 %**	**65 %**	**70 %**	**73 %**	**76 %**	**79 %**	**81 %**	**84 %**	**87 %**	**88 %**	**89 %**	**90 %**

Urban

Households

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	1 065 752	1 106 698	1 149 228	1 193 333	1 239 048	1 286 190	1 335 000	1 385 238	1 437 143	1 490 476	1 545 238	1 601 905	1 660 000	1 719 762	1 780 952	1 843 571	1 907 857	3,7 %
Burkina Faso	1 215 275	1 287 536	1 362 433	1 440 000	1 520 238	1 603 095	1 688 571	1 776 667	1 867 381	1 960 238	2 055 714	2 153 571	2 253 810	2 355 952	2 460 238	2 566 429	2 674 286	4,9 %
Cape Verde	81 272	83 142	85 028	86 905	88 810	90 714	92 619	94 524	96 429	98 095	100 000	101 905	103 571	105 238	106 905	108 571	110 238	1,9 %
Côte d'Ivoire	2 077 507	2 158 650	2 241 675	2 326 724	2 413 621	2 502 759	2 594 310	2 688 103	2 783 966	2 882 069	2 982 241	3 084 310	3 188 276	3 294 138	3 401 897	3 511 552	3 622 931	3,5 %
Gambia	269 481	280 780	292 302	304 048	315 952	328 095	340 476	352 857	365 476	378 333	391 429	404 524	417 619	430 952	444 286	457 619	471 429	3,5 %
Ghana	3 427 584	3 549 121	3 672 382	3 797 381	3 923 810	4 052 143	4 181 905	4 313 333	4 446 190	4 580 476	4 715 952	4 853 095	4 991 190	5 130 476	5 270 952	5 412 857	5 555 714	3,0 %
Guinea	1 031 015	1 069 842	1 111 235	1 155 238	1 201 429	1 249 524	1 299 762	1 351 429	1 404 762	1 460 000	1 516 905	1 575 476	1 635 952	1 698 095	1 761 905	1 827 381	1 894 762	3,9 %
Guinea-Bissau	199 488	207 961	216 561	225 238	234 048	243 095	252 143	261 190	270 476	279 762	289 286	298 571	308 095	317 619	327 381	336 905	346 667	3,4 %
Liberia	515 473	532 466	550 363	569 048	588 333	608 333	628 810	650 000	671 905	694 286	717 381	740 952	765 476	790 476	816 190	842 381	869 286	3,3 %
Mali	1 580 897	1 660 116	1 743 057	1 829 524	1 919 524	2 012 619	2 108 810	2 207 857	2 310 000	2 415 238	2 523 571	2 635 238	2 750 000	2 867 857	2 988 571	3 112 381	3 239 048	4,5 %
Niger	842 020	887 405	935 699	987 143	1 041 905	1 100 238	1 162 381	1 228 571	1 299 048	1 374 286	1 454 286	1 539 286	1 629 762	1 725 714	1 826 905	1 933 571	2 045 714	5,7 %
Nigeria	20 203 436	21 112 534	22 045 216	23 000 976	23 980 000	24 982 683	26 009 512	27 060 000	28 133 659	29 230 732	30 351 463	31 495 366	32 662 195	33 851 707	35 063 659	36 297 561	37 551 707	3,9 %
Senegal	1 502 856	1 559 070	1 616 935	1 676 429	1 738 095	1 801 429	1 866 905	1 934 762	2 004 762	2 077 143	2 151 667	2 228 571	2 308 095	2 390 000	2 474 524	2 561 429	2 650 714	3,6 %
Sierra Leone	667 093	688 241	709 999	732 381	755 476	779 286	803 571	828 333	854 048	880 000	906 905	934 286	962 619	991 429	1 020 952	1 050 952	1 081 667	3,1 %
Togo	679 329	705 726	732 802	760 476	789 048	818 333	848 333	879 048	910 714	943 095	976 190	1 010 476	1 045 476	1 081 190	1 118 095	1 155 476	1 194 048	3,5 %
Total	**35 358 477**	**36 889 288**	**38 464 914**	**40 084 843**	**41 749 335**	**43 458 537**	**45 213 108**	**47 011 913**	**48 855 957**	**50 744 229**	**52 678 229**	**54 657 533**	**56 682 138**	**58 750 607**	**60 863 412**	**63 018 637**	**65 216 067**	3,8 %

Grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	602 150	649 624	699 864	779 214	863 566	952 997	1 047 885	1 148 250	1 254 489	1 366 605	1 484 785	1 601 905	1 660 000	1 719 762	1 780 952	1 843 571	1 907 857	7,4 %
Burkina Faso	681 769	751 672	826 471	939 208	1 060 886	1 191 831	1 332 401	1 482 955	1 643 851	1 815 007	1 997 179	2 153 571	2 253 810	2 355 952	2 460 238	2 566 429	2 674 286	8,7 %
Cape Verde	81 272	83 142	85 028	86 905	88 810	90 714	92 619	94 524	96 429	98 095	100 000	101 905	103 571	105 238	106 905	108 571	110 238	1,9 %
Côte d'Ivoire	880 863	970 521	1 065 228	1 224 754	1 394 055	1 573 662	1 764 037	1 965 425	2 178 034	2 402 326	2 638 493	2 886 691	3 024 852	3 167 500	3 314 710	3 466 553	3 622 931	9,1 %
Gambia	161 689	175 571	190 170	213 195	237 527	263 256	290 416	318 829	348 722	378 333	391 429	404 524	417 619	430 952	444 286	457 619	471 429	6,7 %
Ghana	3 160 232	3 372 697	3 593 725	3 797 381	3 923 810	4 052 143	4 181 905	4 313 333	4 446 190	4 580 476	4 715 952	4 853 095	4 991 190	5 130 476	5 270 952	5 412 857	5 555 714	3,2 %
Guinea	550 562	594 176	640 932	715 727	795 735	881 037	972 057	1 068 504	1 170 760	1 279 248	1 393 993	1 515 208	1 585 887	1 659 120	1 734 945	1 813 400	1 894 762	8,0 %
Guinea-Bissau	74 010	80 240	86 772	96 934	107 672	119 050	130 965	143 416	156 543	170 221	184 602	199 390	226 219	254 313	283 880	314 522	346 667	10,4 %
Liberia	87 115	101 567	116 950	145 671	176 198	208 647	243 020	279 482	318 125	358 920	402 062	447 501	522 945	602 637	686 891	775 657	869 286	15,4 %
Mali	833 133	906 903	985 833	1 105 314	1 233 738	1 371 214	1 518 101	1 674 577	1 841 161	2 018 213	2 206 090	2 405 369	2 558 096	2 717 761	2 884 295	3 058 083	3 239 048	8,9 %
Niger	520 369	564 807	612 828	682 988	759 367	842 526	933 053	1 031 571	1 138 735	1 255 457	1 382 263	1 519 918	1 613 357	1 712 686	1 817 710	1 928 706	2 045 714	9,0 %
Nigeria	11 111 890	12 417 836	13 807 961	16 162 660	18 681 422	21 369 914	24 234 008	27 060 000	28 133 659	29 230 732	30 351 463	31 495 366	32 662 195	33 851 707	35 063 659	36 297 561	37 551 707	7,4 %
Senegal	1 349 564	1 434 735	1 523 963	1 654 639	1 738 095	1 801 429	1 866 905	1 934 762	2 004 762	2 077 143	2 151 667	2 228 571	2 308 095	2 390 000	2 474 524	2 561 429	2 650 714	4,0 %
Sierra Leone	70 045	86 333	103 574	136 778	171 974	209 251	248 621	290 144	334 063	380 188	428 885	480 027	588 191	702 203	822 394	948 756	1 081 667	18,2 %
Togo	237 765	262 501	288 664	332 965	380 128	430 177	483 204	539 305	598 731	661 438	727 522	797 453	869 155	944 432	1 023 811	1 106 758	1 194 048	10,7 %
Total	**20 402 427**	**22 452 325**	**24 627 963**	**28 074 332**	**31 612 982**	**35 357 848**	**39 339 197**	**43 345 077**	**45 664 255**	**48 072 403**	**50 556 387**	**53 090 493**	**55 385 182**	**57 744 741**	**60 170 151**	**62 660 471**	**65 216 067**	7,2 %

New on-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	0	47 474	50 240	79 350	84 352	89 432	94 887	100 365	106 240	112 116	118 180	117 119	58 095	59 762	61 190	62 619	64 286
Burkina Faso	0	69 903	74 798	112 738	121 678	130 945	140 570	150 554	160 896	171 156	182 172	156 392	100 238	102 143	104 286	106 190	107 857
Cape Verde	0	1 870	1 886	1 876	1 905	1 905	1 905	1 905	1 905	1 667	1 905	1 905	1 667	1 667	1 667	1 667	1 667
Côte d'Ivoire	0	89 658	94 706	159 526	169 301	179 607	190 375	201 387	212 609	224 292	236 167	248 198	138 160	142 648	147 210	151 843	156 378
Gambia	0	13 882	14 599	23 025	24 333	25 728	27 160	28 413	29 893	29 611	13 095	13 095	13 095	13 333	13 333	13 333	13 810
Ghana	0	212 465	221 028	203 656	126 429	128 333	129 762	131 429	132 857	134 286	135 476	137 143	138 095	139 286	140 476	141 905	142 857
Guinea	0	43 615	46 756	74 794	80 008	85 303	91 020	96 447	102 256	108 488	114 745	121 216	70 679	73 233	75 825	78 455	81 362
Guinea-Bissau	0	6 230	6 532	10 162	10 738	11 378	11 915	12 452	13 127	13 678	14 381	14 787	26 829	28 095	29 567	30 641	32 145
Liberia	0	14 452	15 383	28 721	30 527	32 449	34 373	36 462	38 643	40 795	43 142	45 439	75 444	79 692	84 254	88 766	93 629
Mali	0	73 770	78 931	119 481	128 424	137 476	146 887	156 476	166 585	177 052	187 877	199 278	152 727	159 665	166 535	173 788	180 965
Niger	0	44 439	48 021	70 160	76 379	83 160	90 527	98 517	107 164	116 722	126 807	137 654	93 439	99 329	105 024	110 996	117 009
Nigeria	0	1 305 946	1 390 125	2 354 699	2 518 763	2 688 491	2 864 094	2 825 992	1 073 659	1 097 073	1 120 732	1 143 902	1 166 829	1 189 512	1 211 951	1 233 902	1 254 146
Senegal	0	85 170	89 229	130 676	83 456	63 333	65 476	67 857	70 000	72 381	74 524	76 905	79 524	81 905	84 524	86 905	89 286
Sierra Leone	0	16 288	17 241	33 204	35 196	37 276	39 370	41 523	43 920	46 125	48 697	51 141	108 164	114 012	120 190	126 362	132 911
Togo	0	24 736	26 163	44 300	47 163	50 049	53 028	56 101	59 425	62 708	66 084	69 931	71 702	75 277	79 379	82 947	87 290
Total	**0**	**2 049 898**	**2 175 638**	**3 446 369**	**3 538 650**	**3 744 865**	**3 981 349**	**4 005 880**	**2 319 178**	**2 408 148**	**2 483 984**	**2 534 107**	**2 294 689**	**2 359 559**	**2 425 410**	**2 490 320**	**2 555 596**

Off-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	0	41 552	81 702	112 942	136 539	151 451	156 608	150 811	132 839	101 349	54 957	0	0	0	0	0	0	-100,0 %
Burkina Faso	0	48 715	97 448	136 580	167 037	186 938	194 275	186 908	162 567	118 825	53 214	0	0	0	0	0	0	-100,0 %
Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
Côte d'Ivoire	0	108 012	213 899	300 537	370 751	422 317	452 876	459 887	440 678	392 517	312 499	197 619	163 424	126 638	87 187	44 999	0	-100,0 %
Gambia	0	9 564	18 569	24 778	28 518	29 472	27 305	21 654	12 185	0	0	0	0	0	0	0	0	-100,0 %
Ghana	0	16 039	14 301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-100,0 %
Guinea	0	43 242	85 510	119 867	147 525	167 494	178 748	180 043	170 183	147 888	111 738	60 268	50 065	38 975	26 960	13 981	0	-100,0 %
Guinea-Bissau	0	11 611	23 598	34 992	45 955	56 384	66 097	74 947	82 860	89 624	95 167	99 182	81 876	63 306	43 501	22 383	0	-100,0 %
Liberia	0	39 173	78 802	115 466	149 868	181 676	210 431	235 784	257 294	274 390	286 654	293 452	242 531	187 839	129 300	66 724	0	-100,0 %
Mali	0	68 474	137 677	197 512	249 377	291 548	322 205	339 360	340 973	324 838	288 619	229 870	191 904	150 096	104 276	54 298	0	-100,0 %
Niger	0	29 327	58 704	82 951	102 741	117 142	125 088	125 364	116 591	97 224	65 475	19 368	16 405	13 028	9 195	4 866	0	-100,0 %
Nigeria	0	790 427	1 497 683	1 864 995	1 926 755	1 642 168	968 457	0	0	0	0	0	0	0	0	0	0	-100,0 %
Senegal	0	11 303	16 904	5 943	0	0	0	0	0	0	0	0	0	0	0	0	0	-100,0 %
Sierra Leone	0	54 719	110 259	162 437	212 182	259 107	302 700	342 484	378 170	408 937	434 563	454 259	374 428	289 225	198 559	102 197	0	-100,0 %
Togo	0	40 293	80 752	116 594	148 698	176 435	199 161	216 200	226 897	230 447	226 062	213 023	176 321	136 759	94 284	48 718	0	-100,0 %
Total	**0**	**1 312 451**	**2 515 809**	**3 275 594**	**3 685 946**	**3 682 131**	**3 203 952**	**2 333 441**	**2 321 238**	**2 186 040**	**1 928 947**	**1 567 040**	**1 296 956**	**1 005 866**	**693 262**	**358 166**	**0**	-100,0 %

Total urban connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	602 150	691 176	781 567	892 156	1 000 105	1 104 449	1 204 493	1 299 061	1 387 328	1 467 954	1 539 742	1 601 905	1 660 000	1 719 762	1 780 952	1 843 571	1 907 857	6,6 %
Burkina Faso	681 769	800 387	923 918	1 075 788	1 227 923	1 378 769	1 526 676	1 669 862	1 806 418	1 933 833	2 050 393	2 153 571	2 253 810	2 355 952	2 460 238	2 566 429	2 674 286	7,9 %
Cape Verde	81 272	83 142	85 028	86 905	88 810	90 714	92 619	94 524	96 429	98 095	100 000	101 905	103 571	105 238	106 905	108 571	110 238	1,9 %
Côte d'Ivoire	880 863	1 078 533	1 279 127	1 525 291	1 764 806	1 995 979	2 216 913	2 425 311	2 618 711	2 794 843	2 950 992	3 084 310	3 188 276	3 294 138	3 401 897	3 511 552	3 622 931	7,7 %
Gambia	161 689	185 135	208 739	237 973	266 046	292 728	317 722	340 483	360 907	378 333	391 429	404 524	417 619	430 952	444 286	457 619	471 429	6,0 %
Ghana	3 160 232	3 388 735	3 608 026	3 797 381	3 923 810	4 052 143	4 181 905	4 313 333	4 446 190	4 580 476	4 715 952	4 853 095	4 991 190	5 130 476	5 270 952	5 412 857	5 555 714	3,1 %
Guinea	550 562	637 419	726 442	835 594	943 260	1 048 531	1 150 805	1 248 547	1 340 943	1 427 136	1 505 731	1 575 476	1 635 952	1 698 095	1 761 905	1 827 381	1 894 762	7,1 %
Guinea-Bissau	74 010	91 851	110 370	131 926	153 627	175 434	197 062	218 364	239 404	259 845	279 769	298 571	308 095	317 619	327 381	336 905	346 667	8,5 %
Liberia	87 115	140 739	195 752	261 137	326 065	390 323	453 451	515 266	575 419	633 310	688 716	740 952	765 476	790 476	816 190	842 381	869 286	11,2 %
Mali	833 133	975 377	1 123 510	1 302 826	1 483 115	1 662 762	1 840 306	2 013 937	2 182 135	2 343 052	2 494 710	2 635 238	2 750 000	2 867 857	2 988 571	3 112 381	3 239 048	7,9 %
Niger	520 369	594 134	671 532	765 939	862 108	959 668	1 058 141	1 156 935	1 255 326	1 352 680	1 447 738	1 539 286	1 629 762	1 725 714	1 826 905	1 933 571	2 045 714	8,3 %
Nigeria	11 111 890	13 208 263	15 305 643	18 027 655	20 608 178	23 012 082	25 202 465	27 060 000	28 133 659	29 230 732	30 351 463	31 495 366	32 662 195	33 851 707	35 063 659	36 297 561	37 551 707	6,6 %
Senegal	1 349 564	1 446 038	1 540 867	1 660 581	1 738 095	1 801 429	1 866 905	1 934 762	2 004 762	2 077 143	2 151 667	2 228 571	2 308 095	2 390 000	2 474 524	2 561 429	2 650 714	4,0 %
Sierra Leone	70 045	141 052	213 833	299 215	384 157	468 358	551 321	632 628	712 234	789 125	863 448	934 286	962 619	991 429	1 020 952	1 050 952	1 081 667	12,3 %
Togo	237 765	302 795	369 416	449 559	528 826	606 611	682 366	755 505	825 628	891 885	953 584	1 010 476	1 045 476	1 081 190	1 118 095	1 155 476	1 194 048	8,7 %
Total	**20 402 427**	**23 764 776**	**27 143 772**	**31 349 926**	**35 298 929**	**39 039 979**	**42 543 149**	**45 678 518**	**47 985 493**	**50 258 443**	**52 485 334**	**54 657 533**	**56 682 138**	**58 750 607**	**60 863 412**	**63 018 637**	**65 216 067**	6,5 %

Urban access rates

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	57 %	62 %	68 %	75 %	81 %	86 %	90 %	94 %	97 %	98 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Burkina Faso	56 %	62 %	68 %	75 %	81 %	86 %	90 %	94 %	97 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Cape Verde	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Côte d'Ivoire	42 %	50 %	57 %	66 %	73 %	80 %	85 %	90 %	94 %	97 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %
Gambia	60 %	66 %	71 %	78 %	84 %	89 %	93 %	96 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Ghana	92 %	95 %	98 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Guinea	53 %	60 %	65 %	72 %	79 %	84 %	89 %	92 %	95 %	98 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %
Guinea-Bissau	37 %	44 %	51 %	59 %	66 %	72 %	78 %	84 %	89 %	93 %	97 %	100 %	100 %	100 %	100 %	100 %	100 %
Liberia	17 %	26 %	36 %	46 %	55 %	64 %	72 %	79 %	86 %	91 %	96 %	100 %	100 %	100 %	100 %	100 %	100 %
Mali	53 %	59 %	64 %	71 %	77 %	83 %	87 %	91 %	94 %	97 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %
Niger	62 %	67 %	72 %	78 %	83 %	87 %	91 %	94 %	97 %	98 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Nigeria	55 %	63 %	69 %	78 %	86 %	92 %	97 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Senegal	90 %	93 %	95 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Sierra Leone	11 %	20 %	30 %	41 %	51 %	60 %	69 %	76 %	83 %	90 %	95 %	100 %	100 %	100 %	100 %	100 %	100 %
Togo	35 %	43 %	50 %	59 %	67 %	74 %	80 %	86 %	91 %	95 %	98 %	100 %	100 %	100 %	100 %	100 %	100 %
Total	**58 %**	**64 %**	**71 %**	**78 %**	**85 %**	**90 %**	**94 %**	**97 %**	**98 %**	**99 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

Rural

Households

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	1 383 465	1 411 386	1 439 415	1 467 619	1 495 714	1 523 571	1 551 429	1 579 048	1 606 190	1 633 095	1 659 762	1 686 190	1 712 143	1 737 857	1 763 333	1 788 333	1 813 333	1,7 %
Burkina Faso	2 971 863	3 024 517	3 077 194	3 129 762	3 182 619	3 235 238	3 288 333	3 341 667	3 395 238	3 449 048	3 503 571	3 558 571	3 614 286	3 670 714	3 727 857	3 786 190	3 845 238	1,6 %
Cape Verde	44 070	43 742	43 438	43 095	42 857	42 619	42 381	42 143	42 143	41 905	41 667	41 429	41 429	41 190	41 190	40 952	40 952	-0,4 %
Côte d'Ivoire	1 807 208	1 825 569	1 843 828	1 862 069	1 880 517	1 899 138	1 918 103	1 937 414	1 957 069	1 976 897	1 997 069	2 017 586	2 038 276	2 059 310	2 080 690	2 102 586	2 124 828	1,0 %
Gambia	187 150	190 075	193 056	196 190	199 286	202 381	205 714	209 048	212 381	215 952	219 524	223 095	226 905	230 714	234 762	239 048	243 095	1,7 %
Ghana	2 992 074	3 018 217	3 043 506	3 067 857	3 091 190	3 113 810	3 135 476	3 156 667	3 177 143	3 196 905	3 216 429	3 235 000	3 253 333	3 271 429	3 289 048	3 306 429	3 323 810	0,6 %
Guinea	1 779 821	1 809 095	1 840 175	1 872 857	1 906 429	1 940 476	1 974 286	2 008 095	2 041 667	2 075 000	2 108 333	2 141 429	2 174 524	2 207 143	2 239 524	2 271 429	2 303 095	1,6 %
Guinea-Bissau	211 404	213 593	215 748	217 857	220 000	222 143	224 286	226 429	228 571	230 714	232 857	235 238	237 381	239 762	241 905	244 286	246 905	1,0 %
Liberia	529 941	538 872	548 166	557 619	567 143	576 905	586 190	595 714	605 000	614 286	623 571	632 857	641 905	650 952	659 762	668 571	677 143	1,5 %
Mali	2 457 876	2 498 909	2 541 428	2 585 238	2 630 000	2 675 238	2 720 714	2 766 667	2 812 619	2 859 286	2 906 429	2 954 286	3 002 857	3 051 905	3 101 667	3 152 143	3 203 333	1,7 %
Niger	3 717 080	3 849 968	3 986 441	4 126 667	4 270 476	4 418 095	4 569 762	4 725 238	4 884 524	5 047 619	5 214 048	5 384 048	5 557 381	5 734 048	5 914 524	6 098 571	6 286 190	3,3 %
Nigeria	22 835 710	23 078 135	23 318 111	23 556 829	23 794 634	24 032 683	24 271 707	24 512 439	24 755 122	25 000 732	25 249 512	25 502 683	25 761 220	26 024 634	26 294 390	26 570 488	26 855 122	1,0 %
Senegal	1 960 504	2 006 881	2 052 497	2 097 381	2 141 667	2 185 238	2 228 333	2 270 714	2 312 381	2 353 095	2 393 333	2 432 619	2 470 952	2 508 571	2 545 238	2 581 190	2 616 905	1,8 %
Sierra Leone	1 018 422	1 034 860	1 050 999	1 066 905	1 082 381	1 097 619	1 112 381	1 126 667	1 140 238	1 153 571	1 166 190	1 178 571	1 190 238	1 201 667	1 212 381	1 222 619	1 232 381	1,1 %
Togo	1 041 842	1 060 179	1 078 240	1 095 952	1 113 571	1 130 952	1 148 095	1 165 000	1 181 667	1 198 095	1 214 286	1 230 476	1 246 190	1 261 905	1 277 381	1 292 619	1 307 857	1,4 %
Total	44 938 429	45 603 999	46 272 241	46 943 898	47 618 485	48 296 107	48 977 192	49 662 948	50 351 953	51 046 200	51 746 581	52 454 079	53 169 019	53 891 802	54 623 651	55 365 455	56 120 188	1,4 %

Grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	117 595	140 713	164 664	211 034	259 043	308 656	359 906	412 732	467 043	522 874	580 204	639 011	708 962	780 629	853 987	928 886	1 005 540	13,8 %
Burkina Faso	41 606	88 457	136 915	234 690	335 703	439 906	547 398	658 174	772 258	889 670	1 010 570	1 134 947	1 284 354	1 438 099	1 596 260	1 759 137	1 926 622	20,8 %
Cape Verde	36 843	37 607	38 378	40 122	41 936	42 619	42 381	42 143	42 143	41 905	41 667	41 429	41 429	41 190	41 190	40 952	40 952	0,5 %
Côte d'Ivoire	142 769	175 458	208 764	274 554	341 631	410 008	479 745	550 879	623 444	697 416	772 878	849 865	941 897	1 035 794	1 131 598	1 229 453	1 329 313	14,1 %
Gambia	2 994	6 218	9 542	16 255	23 173	30 298	37 673	45 271	53 092	61 204	69 554	78 143	88 536	99 234	110 348	121 906	133 676	20,7 %
Ghana	1 481 077	1 551 092	1 621 641	1 750 642	1 880 865	2 012 392	2 144 979	2 278 860	2 413 802	2 549 722	2 686 939	2 824 801	2 987 771	3 152 168	3 289 048	3 306 429	3 323 810	5,3 %
Guinea	192 221	221 254	251 371	309 402	369 475	431 574	495 562	561 483	629 265	698 887	770 416	843 757	931 084	1 020 451	1 111 929	1 205 366	1 300 849	12,5 %
Guinea-Bissau	13 107	15 361	17 656	22 151	26 733	31 400	36 152	40 989	45 911	50 918	56 011	61 250	67 432	73 790	80 181	86 758	93 538	12,6 %
Liberia	15 898	24 000	32 383	49 155	66 484	84 402	102 805	121 796	141 285	161 314	181 883	202 992	228 186	254 009	280 359	307 321	334 777	18,2 %
Mali	213 835	249 633	286 657	358 281	432 322	508 762	587 588	668 875	752 532	838 769	927 566	1 019 041	1 128 308	1 240 761	1 356 549	1 475 737	1 598 392	13,1 %
Niger	144 966	197 703	253 952	364 829	483 040	608 882	742 674	884 674	1 035 162	1 194 422	1 362 611	1 540 045	1 753 604	1 978 542	2 215 333	2 464 217	2 725 511	18,5 %
Nigeria	8 335 034	9 012 085	9 700 482	11 001 337	12 326 072	13 675 204	15 049 225	16 448 776	17 874 293	19 326 830	20 807 034	22 316 459	24 112 133	25 944 171	26 294 390	26 570 488	26 855 122	7,5 %
Senegal	548 941	591 777	635 757	712 052	790 797	871 892	955 374	1 041 094	1 128 986	1 218 864	1 310 903	1 404 786	1 514 719	1 626 912	1 741 127	1 857 434	1 976 116	8,4 %
Sierra Leone	14 258	28 625	43 429	73 235	103 870	135 320	167 532	200 466	234 033	268 287	303 084	338 501	380 693	423 562	466 902	510 743	555 037	20,0 %
Togo	221 912	241 375	261 309	297 765	335 233	373 657	413 014	453 286	494 450	536 486	579 372	623 209	674 851	727 594	781 294	835 925	891 624	9,2 %
Total	11 523 057	12 581 358	13 662 898	15 715 504	17 816 376	19 964 971	22 162 008	24 409 497	26 707 699	29 057 567	31 460 690	33 918 236	36 843 958	39 836 907	41 350 495	42 700 752	44 090 879	8,7 %

New on-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	0	23 118	23 951	46 370	48 009	49 613	51 250	52 826	54 311	55 831	57 330	58 807	69 951	71 667	73 357	74 899	76 655
Burkina Faso	0	46 851	48 458	97 776	101 012	104 203	107 492	110 777	114 083	117 412	120 900	124 377	149 407	153 745	158 162	162 877	167 484
Cape Verde	0	764	771	1 744	1 814	683	-238	-238	0	-238	-238	-238	0	-238	0	-238	0
Côte d'Ivoire	0	32 689	33 305	65 791	67 077	68 377	69 738	71 134	72 565	73 971	75 462	76 988	92 032	93 897	95 804	97 854	99 860
Gambia	0	3 224	3 324	6 713	6 918	7 125	7 375	7 598	7 821	8 111	8 350	8 589	10 394	10 698	11 114	11 558	11 770
Ghana	0	70 015	70 549	129 001	130 224	131 527	132 586	133 881	134 942	135 921	137 217	137 862	162 970	164 397	136 880	17 381	17 381
Guinea	0	29 033	30 117	58 031	60 073	62 099	63 987	65 921	67 782	69 622	71 529	73 342	87 326	89 367	91 478	93 438	95 483
Guinea-Bissau	0	2 254	2 295	4 494	4 582	4 667	4 752	4 837	4 922	5 007	5 092	5 239	6 182	6 357	6 391	6 577	6 780
Liberia	0	8 102	8 383	16 771	17 330	17 918	18 402	18 991	19 489	20 029	20 569	21 109	25 194	25 823	26 350	26 962	27 456
Mali	0	35 798	37 024	71 624	74 041	76 440	78 826	81 287	83 657	86 237	88 797	91 475	109 267	112 453	115 788	119 188	122 655
Niger	0	52 737	56 248	110 877	118 211	125 841	133 793	141 999	150 489	159 260	168 189	177 434	213 559	224 938	236 791	248 884	261 294
Nigeria	0	677 050	688 397	1 300 855	1 324 735	1 349 132	1 374 021	1 399 551	1 425 517	1 452 536	1 480 205	1 509 425	1 795 674	1 832 038	350 219	276 098	284 634
Senegal	0	42 836	43 979	76 295	78 745	81 095	83 483	85 719	87 892	89 878	92 039	93 883	109 933	112 193	114 215	116 307	118 682
Sierra Leone	0	14 367	14 804	29 807	30 634	31 451	32 212	32 934	33 568	34 254	34 797	35 418	42 192	42 869	43 340	43 840	44 294
Togo	0	19 463	19 934	36 456	37 468	38 423	39 358	40 271	41 164	42 036	42 886	43 837	51 642	52 744	53 700	54 631	55 699
Total	0	1 058 302	1 081 539	2 052 606	2 100 872	2 148 595	2 197 037	2 247 488	2 298 202	2 349 868	2 403 123	2 457 546	2 925 723	2 992 949	1 513 588	1 350 256	1 390 127

Off-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	0	100 965	201 197	295 452	385 013	469 508	548 688	622 170	689 550	750 631	805 149	852 859	833 165	810 090	783 607	753 597	720 250	9,5 %
Burkina Faso	0	233 211	463 740	679 963	885 044	1 078 292	1 259 394	1 427 791	1 583 002	1 724 562	1 852 272	1 965 600	1 926 138	1 879 923	1 826 820	1 766 920	1 699 851	9,7 %
Cape Verde	0	485	791	689	281	0	0	0	0	0	0	0	0	0	0	0	0	-100,0 %
Côte d'Ivoire	0	130 884	257 151	371 261	475 654	570 266	655 103	730 131	795 319	850 556	895 876	931 247	889 750	844 575	795 715	743 223	687 023	7,3 %
Gambia	0	14 603	28 940	42 253	54 736	66 359	77 181	87 099	96 082	104 210	111 351	117 471	113 215	108 505	103 456	98 056	92 114	8,6 %
Ghana	0	116 292	223 318	307 418	373 070	420 328	449 229	459 956	452 629	427 440	384 673	324 493	210 953	95 014	0	0	0	-100,0 %
Guinea	0	126 145	250 679	367 414	478 168	582 610	680 222	770 735	853 734	928 895	996 028	1 054 745	1 021 062	983 514	942 309	897 455	849 172	9,1 %
Guinea-Bissau	0	15 779	31 377	46 263	60 606	74 386	87 589	100 203	112 216	123 615	134 388	144 670	143 471	142 136	140 383	138 492	136 459	11,1 %
Liberia	0	40 962	81 613	120 009	156 670	191 559	224 334	255 131	283 661	309 923	333 829	355 292	346 727	337 023	326 071	314 012	300 754	9,8 %
Mali	0	178 742	355 950	523 773	684 491	837 685	982 918	1 119 906	1 248 093	1 367 430	1 477 483	1 578 048	1 545 373	1 508 075	1 466 296	1 420 059	1 369 400	10,1 %
Niger	0	290 337	589 660	885 747	1 181 384	1 475 605	1 767 441	2 055 703	2 339 208	2 616 723	2 886 696	3 147 888	3 152 157	3 146 390	3 130 466	3 103 884	3 066 303	12,5 %
Nigeria	0	1 114 302	2 136 292	2 925 091	3 526 671	3 940 821	4 167 567	4 207 153	4 059 899	3 726 377	3 207 126	2 502 863	1 298 722	63 447	0	0	0	-100,0 %
Senegal	0	112 362	223 289	325 021	419 349	505 698	583 608	652 547	712 069	761 691	801 196	830 099	779 116	723 967	664 773	601 807	535 380	6,4 %
Sierra Leone	0	79 970	159 094	233 782	304 898	372 279	435 656	494 827	549 498	599 728	645 136	685 854	668 383	649 047	627 660	604 440	579 474	9,7 %
Togo	0	65 074	128 993	187 792	242 527	292 974	338 939	380 242	416 717	448 210	474 582	495 800	471 729	445 705	417 701	387 788	356 111	7,5 %
Total	0	2 620 113	5 132 082	7 311 929	9 228 562	10 878 370	12 257 870	13 363 595	14 191 677	14 739 991	15 005 786	14 986 929	13 399 961	11 737 412	11 225 256	10 829 734	10 392 291	5,2 %

Mini-grid connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	0	8 607	17 268	25 534	33 505	41 145	48 423	55 299	61 726	67 679	73 122	78 021	81 538	84 287	86 230	87 319	87 543	12,3 %
Burkina Faso	0	20 924	41 907	61 894	81 153	99 603	117 198	133 865	149 539	164 152	177 661	189 989	199 248	206 837	212 669	216 684	218 765	12,5 %
Cape Verde	0	72	118	104	43	0	0	0	0	0	0	0	0	0	0	0	0	-100,0 %
Côte d'Ivoire	0	14 065	27 874	40 594	52 468	63 464	73 561	82 729	90 939	98 153	104 346	109 486	112 142	113 414	113 256	111 635	108 491	10,2 %
Gambia	0	1 322	2 639	3 881	5 064	6 186	7 248	8 242	9 161	10 012	10 781	11 463	13 130	14 556	15 742	16 674	17 306	14,4 %
Ghana	0	13 480	26 128	36 307	44 481	50 598	54 603	56 456	56 108	53 516	48 649	41 457	32 207	16 875	0	0	0	-100,0 %
Guinea	0	11 023	22 060	32 562	42 680	52 376	61 595	70 300	78 443	85 981	92 882	99 097	113 947	126 871	137 775	146 538	153 074	14,8 %
Guinea-Bissau	0	993	1 985	2 942	3 874	4 779	5 657	6 505	7 323	8 109	8 862	9 591	11 242	12 808	14 263	15 630	16 908	16,5 %
Liberia	0	2 845	5 699	8 427	11 064	13 605	16 024	18 328	20 495	22 523	24 402	26 124	30 171	33 772	36 891	39 517	41 613	15,3 %
Mali	0	15 005	30 083	44 568	58 642	72 262	85 380	97 959	109 941	121 308	132 008	142 009	165 066	186 063	204 891	221 427	235 542	15,8 %
Niger	0	23 050	47 112	71 224	95 611	120 201	144 918	169 666	194 348	218 860	243 066	266 857	316 877	364 999	410 886	454 145	494 376	18,3 %
Nigeria	0	137 280	265 807	367 612	447 717	505 427	540 050	550 890	537 236	498 378	433 571	342 061	212 448	12 094	0	0	0	-100,0 %
Senegal	0	10 581	21 187	31 075	40 403	49 101	57 109	64 359	70 788	76 328	80 936	84 539	94 380	101 522	105 820	107 151	105 409	12,1 %
Sierra Leone	0	6 609	13 235	19 578	25 706	31 601	37 233	42 581	47 614	52 329	56 687	60 691	70 183	78 700	86 171	92 573	97 870	15,4 %
Togo	0	5 376	10 727	15 722	20 441	24 861	28 958	32 710	36 096	39 095	41 686	43 858	49 516	54 025	57 326	59 370	60 123	13,1 %
Total	0	271 230	533 829	762 025	962 854	1 135 209	1 277 955	1 389 889	1 469 758	1 516 423	1 528 660	1 505 242	1 502 095	1 406 821	1 481 921	1 568 664	1 637 018	8,3 %

Total connections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	CAGR
Benin	117 595	250 285	383 130	532 020	677 561	819 309	957 017	1 090 200	1 218 319	1 341 183	1 458 475	1 569 891	1 623 665	1 675 005	1 723 824	1 769 802	1 813 333	11,7 %
Burkina Faso	41 606	342 592	642 561	976 547	1 301 900	1 617 801	1 923 990	2 219 831	2 504 799	2 778 385	3 040 503	3 290 535	3 409 740	3 524 858	3 635 749	3 742 742	3 845 238	13,6 %
Cape Verde	36 843	38 164	39 287	40 915	42 260	42 619	42 381	42 143	42 143	41 905	41 667	41 429	41 429	41 190	41 190	40 952	40 952	0,3 %
Côte d'Ivoire	142 769	320 407	493 788	686 409	869 753	1 043 738	1 208 409	1 363 739	1 509 702	1 646 125	1 773 100	1 890 598	1 943 789	1 993 783	2 040 570	2 084 310	2 124 828	11,0 %
Gambia	2 994	22 143	41 121	62 389	82 973	102 842	122 102	140 612	158 335	175 426	191 686	207 076	214 882	222 296	229 546	236 636	243 095	13,5 %
Ghana	1 481 077	1 680 863	1 871 087	2 094 367	2 298 417	2 483 318	2 648 811	2 795 272	2 922 539	3 030 678	3 120 260	3 190 751	3 230 931	3 264 057	3 289 048	3 306 429	3 323 810	4,2 %
Guinea	192 221	358 422	524 110	709 378	890 323	1 066 561	1 237 378	1 402 518	1 561 441	1 713 763	1 859 326	1 997 600	2 066 092	2 130 836	2 192 012	2 249 360	2 303 095	11,2 %
Guinea-Bissau	13 107	32 134	51 019	71 356	91 212	110 565	129 398	147 697	165 450	182 642	199 260	215 510	222 145	228 734	234 827	240 880	246 905	11,9 %
Liberia	15 898	67 807	119 696	177 591	234 219	289 566	343 162	395 254	445 441	493 760	540 114	584 408	605 084	624 804	643 321	660 850	677 143	13,2 %
Mali	213 835	443 379	672 690	926 622	1 175 456	1 418 710	1 655 886	1 886 740	2 110 567	2 327 507	2 537 058	2 739 097	2 838 747	2 934 899	3 027 736	3 117 223	3 203 333	11,8 %
Niger	144 966	511 090	890 724	1 321 800	1 760 035	2 204 688	2 655 034	3 110 043	3 568 719	4 030 005	4 492 374	4 954 790	5 222 639	5 489 931	5 756 685	6 022 246	6 286 190	15,0 %
Nigeria	8 335 034	10 263 666	12 102 580	14 294 040	16 300 459	18 121 452	19 756 843	21 206 819	22 471 429	23 551 585	24 447 731	25 161 383	25 623 302	26 019 712	26 294 390	26 570 488	26 855 122	5,9 %
Senegal	548 941	714 720	880 232	1 068 148	1 250 549	1 426 691	1 596 091	1 757 999	1 911 842	2 056 882	2 193 034	2 319 424	2 388 214	2 452 402	2 511 720	2 566 392	2 616 905	8,1 %
Sierra Leone	14 258	115 204	215 757	326 596	434 474	539 200	640 421	737 874	831 145	920 344	1 004 906	1 085 046	1 119 259	1 151 310	1 180 734	1 207 756	1 232 381	13,3 %
Togo	221 912	311 825	401 029	501 279	598 201	691 491	780 911	866 238	947 263	1 023 791	1 095 640	1 162 867	1 196 095	1 227 324	1 256 320	1 283 083	1 307 857	8,8 %
Total	11 523 057	15 472 701	19 328 809	23 789 458	28 007 791	31 978 551	35 697 833	39 162 981	42 369 134	45 313 981	47 995 135	50 410 407	51 746 014	52 981 140	54 057 672	55 099 150	56 120 188	7,9 %

Total access rates

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Benin	9 %	18 %	27 %	36 %	45 %	54 %	62 %	69 %	76 %	82 %	88 %	93 %	95 %	96 %	98 %	99 %	100 %
Burkina Faso	1 %	11 %	21 %	31 %	41 %	50 %	59 %	66 %	74 %	81 %	87 %	92 %	94 %	96 %	98 %	99 %	100 %
Cape Verde	84 %	87 %	90 %	95 %	99 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Côte d'Ivoire	8 %	18 %	27 %	37 %	46 %	55 %	63 %	70 %	77 %	83 %	89 %	94 %	95 %	97 %	98 %	99 %	100 %
Gambia	2 %	12 %	21 %	32 %	42 %	51 %	59 %	67 %	75 %	81 %	87 %	93 %	95 %	96 %	98 %	99 %	100 %
Ghana	50 %	56 %	61 %	68 %	74 %	80 %	84 %	89 %	92 %	95 %	97 %	99 %	99 %	100 %	100 %	100 %	100 %
Guinea	11 %	20 %	28 %	38 %	47 %	55 %	63 %	70 %	76 %	83 %	88 %	93 %	95 %	97 %	98 %	99 %	100 %
Guinea-Bissau	6 %	15 %	24 %	33 %	41 %	50 %	58 %	65 %	72 %	79 %	86 %	92 %	94 %	95 %	97 %	99 %	100 %
Liberia	3 %	13 %	22 %	32 %	41 %	50 %	59 %	66 %	74 %	80 %	87 %	92 %	94 %	96 %	98 %	99 %	100 %
Mali	9 %	18 %	26 %	36 %	45 %	53 %	61 %	68 %	75 %	81 %	87 %	93 %	95 %	96 %	98 %	99 %	100 %
Niger	4 %	13 %	22 %	32 %	41 %	50 %	58 %	66 %	73 %	80 %	86 %	92 %	94 %	96 %	97 %	99 %	100 %
Nigeria	37 %	44 %	52 %	61 %	69 %	75 %	81 %	87 %	91 %	94 %	97 %	99 %	99 %	100 %	100 %	100 %	100 %
Senegal	28 %	36 %	43 %	51 %	58 %	65 %	72 %	77 %	83 %	87 %	92 %	95 %	97 %	98 %	99 %	99 %	100 %
Sierra Leone	1 %	11 %	21 %	31 %	40 %	49 %	58 %	65 %	73 %	80 %	86 %	92 %	94 %	96 %	97 %	99 %	100 %
Togo	21 %	29 %	37 %	46 %	54 %	61 %	68 %	74 %	80 %	85 %	90 %	95 %	96 %	97 %	98 %	99 %	100 %
Total	26 %	34 %	42 %	51 %	59 %	66 %	73 %	79 %	84 %	89 %	93 %	96 %	97 %	98 %	99 %	100 %	100 %

Annex III: Tabulated year-by-year net demand for each country

Net on-grid demand per year (GWh)

No	Country		GDP elacticity	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Algeria	Total		49 206	51 437	53 472	54 284	54 595	55 341	56 387	57 822	59 362	61 355	63 839	66 865	70 023	73 321	76 766	80 363	84 121
		% growth			4,5 %	4,0 %	1,5 %	0,6 %	1,4 %	1,9 %	2,5 %	2,7 %	3,4 %	4,0 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %
		Organic growth	1,35	49 206	51 271	53 148	53 812	53 980	54 582	55 484	56 772	58 166	60 009	62 340	65 207	68 206	71 343	74 624	78 056	81 646
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			149	301	450	595	741	888	1 038	1 187	1 339	1 496	1 658	1 821	1 986	2 154	2 323	2 495
		Rural access expansion			17	23	22	20	18	15	12	10	6	3	0	-4	-8	-12	-16	-20
2	Angola	Total		8 096	8 524	8 619	9 078	9 581	10 099	14 666	15 261	15 897	16 718	17 744	22 944	23 947	25 008	26 129	27 315	28 567
		% growth			5,3 %	1,1 %	5,3 %	5,5 %	5,4 %	45,2 %	4,1 %	4,2 %	5,2 %	6,1 %	29,3 %	4,4 %	4,4 %	4,5 %	4,5 %	4,6 %
		Organic growth	1,15	8 096	8 311	8 182	8 260	8 348	8 418	8 498	8 569	8 641	8 831	9 147	9 600	10 075	10 573	11 096	11 645	12 221
		Exogenous demand increase		0	0	0	0	0	0	4 000	4 000	4 000	4 000	4 000	8 000	8 000	8 000	8 000	8 000	8 000
		Urban access expansion			179	370	687	1 034	1 412	1 824	2 270	2 754	3 296	3 910	4 550	4 947	5 370	5 819	6 296	6 800
		Rural access expansion			33	67	131	199	270	344	421	502	590	687	795	925	1 065	1 214	1 374	1 545
3	Benin	Total		1 022	1 109	1 230	1 424	1 647	1 897	2 181	2 503	2 835	3 185	3 554	3 929	4 231	4 552	4 893	5 253	5 636
		% growth			8,6 %	10,9 %	15,8 %	15,6 %	15,2 %	15,0 %	14,8 %	13,2 %	12,4 %	11,6 %	10,5 %	7,7 %	7,6 %	7,5 %	7,4 %	7,3 %
		Organic growth	1,35	1 022	1 043	1 091	1 162	1 246	1 342	1 452	1 579	1 698	1 817	1 935	2 050	2 172	2 301	2 437	2 582	2 735
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			57	120	223	339	470	617	783	964	1 162	1 378	1 600	1 736	1 880	2 032	2 193	2 365
		Rural access expansion			9	19	39	61	85	112	141	172	205	241	278	323	372	423	478	536
4	Botswana	Total		3 650	3 575	3 758	3 979	4 227	4 446	4 654	4 871	5 092	5 299	5 486	5 650	5 819	5 991	6 169	6 352	6 539
		% growth			-2,1 %	5,1 %	5,9 %	6,2 %	5,2 %	4,7 %	4,7 %	4,5 %	4,1 %	3,5 %	3,0 %	3,0 %	3,0 %	3,0 %	3,0 %	3,0 %
		Organic growth	1,2	3 650	3 549	3 703	3 874	4 066	4 258	4 443	4 637	4 834	5 016	5 181	5 326	5 476	5 630	5 788	5 951	6 119
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			23	48	92	141	161	175	191	206	222	238	254	271	288	306	324	343
		Rural access expansion			3	7	13	20	28	35	44	52	61	67	69	71	73	75	76	78
5	Burkina Faso	Total		1 192	1 350	1 556	1 855	2 190	2 562	2 975	3 432	3 919	4 440	4 997	5 527	6 004	6 509	7 046	7 615	8 218
		% growth			13,3 %	15,2 %	19,2 %	18,1 %	17,0 %	16,1 %	15,4 %	14,2 %	13,3 %	12,5 %	10,6 %	8,6 %	8,4 %	8,2 %	8,1 %	7,9 %
		Organic growth	1,35	1 192	1 247	1 336	1 440	1 554	1 678	1 811	1 955	2 098	2 241	2 384	2 526	2 676	2 834	3 003	3 181	3 370
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			85	181	332	505	702	924	1 175	1 453	1 760	2 098	2 406	2 634	2 875	3 131	3 401	3 685
		Rural access expansion			19	40	83	131	183	239	301	368	439	515	596	694	800	912	1 033	1 162
6	Burundi	Total		381	402	436	510	590	678	774	876	985	1 115	1 268	1 451	1 618	1 799	1 994	2 205	2 433
		% growth			5,6 %	8,4 %	17,0 %	15,8 %	14,9 %	14,0 %	13,2 %	12,5 %	13,1 %	13,8 %	14,4 %	11,5 %	11,2 %	10,9 %	10,6 %	10,3 %
		Organic growth	0,85	381	365	359	357	354	353	351	350	349	353	363	379	395	412	430	448	467
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			17	36	70	107	149	195	245	299	362	436	522	574	630	691	757	829
		Rural access expansion			20	41	84	129	177	228	281	337	399	470	550	649	757	873	1 000	1 137
7	Cameroon	Total		6 084	6 669	7 216	7 867	8 481	9 073	9 709	10 421	11 176	11 958	12 764	17 593	18 478	19 409	20 391	21 425	22 513
		% growth			9,6 %	8,2 %	9,0 %	7,8 %	7,0 %	7,0 %	7,3 %	7,2 %	7,0 %	6,7 %	37,8 %	5,0 %	5,0 %	5,1 %	5,1 %	5,1 %
		Organic growth	1,15	6 084	6 441	6 737	6 993	7 307	7 669	8 057	8 501	8 970	9 448	9 934	10 425	10 941	11 482	12 050	12 646	13 271
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	4 000	4 000	4 000	4 000	4 000	4 000
		Urban access expansion			209	437	790	1 045	1 229	1 425	1 637	1 863	2 103	2 356	2 622	2 905	3 204	3 520	3 854	4 207
		Rural access expansion			20	41	83	128	176	227	283	343	407	474	546	632	724	822	925	1 036
8	Cape Verde	Total		326	329	344	361	379	397	416	435	455	474	491	507	524	540	557	575	593
		% growth			1,2 %	4,5 %	4,9 %	5,0 %	4,8 %	4,7 %	4,6 %	4,6 %	4,1 %	3,7 %	3,3 %	3,2 %	3,2 %	3,2 %	3,2 %	3,2 %
		Organic growth	1,2	326	327	339	353	367	382	398	415	432	448	462	475	489	502	516	531	546
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			2	5	7	10	12	15	18	21	24	27	30	33	36	39	42	45
		Rural access expansion			0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	Central African	Total		158	172	187	213	241	273	307	345	387	432	483	538	712	906	1 121	1 361	1 626
		% growth			9,0 %	8,6 %	13,7 %	13,3 %	12,9 %	12,7 %	12,4 %	12,0 %	11,8 %	11,6 %	11,5 %	32,3 %	27,2 %	23,8 %	21,3 %	19,5 %
		Organic growth	0,85	158	163	168	174	180	186	193	201	209	218	227	236	247	257	268	280	292
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			7	14	30	47	66	88	111	138	167	200	237	389	561	753	967	1 206
		Rural access expansion			2	5	9	15	20	26	33	40	48	56	65	76	88	100	114	128
10	Chad	Total		186	223	248	319	401	491	592	702	823	958	1 111	1 284	1 573	1 895	2 254	2 653	3 095
		% growth			20,1 %	10,9 %	28,9 %	25,5 %	22,6 %	20,6 %	18,5 %	17,1 %	16,4 %	16,0 %	15,6 %	22,5 %	20,5 %	18,9 %	17,7 %	16,7 %
		Organic growth	0,85	186	187	176	175	178	181	186	190	194	200	207	216	226	235	245	256	267
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			22	44	88	135	188	247	313	385	466	559	664	871	1 104	1 368	1 664	1 996
		Rural access expansion			14	27	56	88	122	159	200	243	291	345	404	476	555	641	733	833
11	Côte d'Ivoire	Total		5 825	6 343	6 841	7 466	8 126	8 829	9 576	10 360	11 197	12 086	13 026	14 019	14 874	15 778	16 736	17 748	18 819
		% growth			8,9 %	7,9 %	9,1 %	8,8 %	8,6 %	8,5 %	8,2 %	8,1 %	7,9 %	7,8 %	7,6 %	6,1 %	6,1 %	6,1 %	6,1 %	6,0 %
		Organic growth	0,85	5 825	6 218	6 574	6 946	7 321	7 704	8 094	8 483	8 883	9 290	9 703	10 120	10 556	11 010	11 483	11 977	12 492
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			112	238	461	713	997	1 315	1 668	2 060	2 492	2 968	3 489	3 841	4 219	4 626	5 062	5 529
		Rural access expansion			14	28	59	92	128	167	209	254	303	355	410	477	549	626	709	798
12	Comoros	Total		41	49	57	66	75	83	91	101	107	115	122	131	140	149	159	169	181
		% growth			18,8 %	16,9 %	15,8 %	13,5 %	10,8 %	10,0 %	10,5 %	6,8 %	6,6 %	6,8 %	6,7 %	6,9 %	6,4 %	6,7 %	6,7 %	7,0 %
		Organic growth	1,35	41	42	43	44	46	47	47	48	50	52	54	57	60	62	65	69	73
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			4	9	12	15	17	19	22	25	28	31	35	39	43	47	52	57
		Rural access expansion			2	5	9	14	19	25	31	33	35	37	39	41	44	46	49	51
13	Congo	Total		904	968	977	1 006	1 108	1 169	1 253	1 344	1 437	1 547	1 633	1 744	1 863	1 988	2 121	2 261	2 409
		% growth			7,1 %	0,9 %	3,0 %	10,1 %	5,5 %	7,2 %	7,3 %	6,9 %	7,7 %	5,5 %	6,8 %	6,8 %	6,7 %	6,7 %	6,6 %	6,6 %
		Organic growth	1,15	904	924	887	844	864	844	841	840	836	848	875	918	963	1 011	1 061	1 113	1 169
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			41	83	149	223	297	377	462	551	641	690	748	808	873	941	1 014	1 090
		Rural access expansion			3	7	13	20	27	35	42	50	58	68	78	91	104	119	134	150
14	Djibouti	Total		372	398	425	461	501	542	583	626	672	716	750	786	824	864	905	948	992
		% growth			6,9 %	6,8 %	8,7 %	8,5 %	8,4 %	7,4 %	7,4 %	7,3 %	6,6 %	4,8 %	4,8 %	4,8 %	4,8 %	4,7 %	4,8 %	4,7 %
		Organic growth	0,85	372	390	408	429	451	474	495	516	538	561	585	611	637	664	693	723	754
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			8	16	31	47	65	84	104	127	146	155	165	175	185	195	207	218
		Rural access expansion			0	1	2	3	4	5	6	7	8	9	11	13	14	16	18	20
15	Democratic Republic of	Total		9 311	10 061	10 489	11 200	11 988	12 868	13 860	14 996	16 272	17 707	19 321	21 136	24 415	28 052	32 077	36 523	41 423
		% growth			8,0 %	4,3 %	6,8 %	7,0 %	7,3 %	7,7 %	8,2 %	8,5 %	8,8 %	9,1 %	9,4 %	15,5 %	14,9 %	14,3 %	13,9 %	13,4 %
		Organic growth	0,85	9 311	9 783	9 906	10 065	10 243	10 450	10 697	11 004	11 357	11 762	12 225	12 751	13 299	13 871	14 468	15 090	15 739
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			231	484	933	1 431	1 983	2 598	3 286	4 055	4 917	5 884	6 970	9 454	12 252	15 391	18 902	22 817
		Rural access expansion			48	99	202	314	434	565	706	860	1 029	1 213	1 415	1 662	1 929	2 218	2 530	2 867
16	Egypt	Total		142 700	150 428	158 307	166 150	175 246	186 686	200 091	214 962	230 909	245 965	259 802	272 100	284 964	298 422	312 500	327 231	342 645
		% growth			5,4 %	5,2 %	5,0 %	5,5 %	6,5 %	7,2 %	7,4 %	7,4 %	6,5 %	5,6 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %
		Organic growth	1,35	142 700	150 027	157 530	164 986	173 678	184 691	197 638	212 023	227 455	241 979	255 269	267 008	279 288	292 132	305 567	319 620	334 320
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			263	537	824	1 126	1 452	1 804	2 183	2 590	3 017	3 462	3 924	4 413	4 932	5 482	6 069	6 694
		Rural access expansion			137	239	340	441	544	649	756	864	969	1 071	1 168	1 264	1 358	1 450	1 542	1 632
17	Eritrea	Total		300	335	369	414	463	515	573	629	682	742	809	884	967	1 057	1 152	1 256	1 366
		% growth			11,6 %	10,4 %	12,1 %	11,7 %	11,3 %	11,2 %	9,9 %	8,4 %	8,7 %	9,0 %	9,4 %	9,4 %	9,2 %	9,1 %	8,9 %	8,8 %
		Organic growth	0,85	300	310	317	324	331	339	347	356	365	376	391	407	425	443	462	482	503
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			22	46	79	113	152	194	236	273	314	360	412	469	532	601	676	759
		Rural access expansion			3	6	12	19	25	32	38	45	51	58	65	73	82	90	97	104
18	Ethiopia	Total		6 693	8 086	9 420	11 266	13 340	15 281	17 304	19 465	21 827	24 209	26 571	28 868	31 396	34 081	36 933	39 957	43 162
		% growth			20,8 %	16,5 %	19,6 %	18,4 %	14,5 %	13,2 %	12,5 %	12,1 %	10,9 %	9,8 %	8,6 %	8,8 %	8,6 %	8,4 %	8,2 %	8,0 %
		Organic growth	1,35	6 693	7 575	8 330	9 215	10 194	11 223	12 310	13 454	14 703	15 905	17 027	18 038	19 109	20 244	21 447	22 720	24 069
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			369	791	1 435	2 176	2 696	3 201	3 748	4 346	4 978	5 640	6 325	7 055	7 832	8 661	9 540	10 473
		Rural access expansion			141	299	616	970	1 362	1 793	2 263	2 778	3 326	3 904	4 505	5 231	6 004	6 825	7 697	8 620
19	Equatorial Guinea	Total		359	335	306	290	275	273	273	283	289	299	312	333	354	377	401	426	452
		% growth			-6,8 %	-8,5 %	-5,3 %	-5,3 %	-0,5 %	-0,1 %	3,5 %	2,1 %	3,5 %	4,5 %	6,6 %	6,5 %	6,4 %	6,3 %	6,2 %	6,2 %
		Organic growth	1,15	359	319	281	255	231	219	209	208	203	203	208	218	229	240	252	265	278
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			12	18	23	27	32	36	41	46	52	58	66	73	82	90	99	109
		Rural access expansion			3	6	12	17	22	27	33	39	44	46	49	52	55	58	61	65
20	Gabon	Total		2 096	2 218	2 278	2 306	2 384	2 509	2 655	2 817	2 999	3 191	3 393	3 605	3 830	4 065	4 315	4 578	4 858
		% growth			5,8 %	2,7 %	1,2 %	3,4 %	5,2 %	5,8 %	6,1 %	6,5 %	6,4 %	6,3 %	6,3 %	6,2 %	6,2 %	6,1 %	6,1 %	6,1 %
		Organic growth	1,35	2 096	2 190	2 235	2 248	2 312	2 422	2 552	2 697	2 861	3 033	3 215	3 406	3 608	3 822	4 049	4 290	4 545
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			28	42	55	67	81	95	110	126	143	161	180	200	220	242	264	288
		Rural access expansion			1	2	3	5	6	8	10	12	14	17	19	22	23	24	25	25
21	Gambia	Total		279	305	328	365	407	453	505	562	623	689	736	787	841	899	959	1 023	1 090
		% growth			9,4 %	7,4 %	11,4 %	11,4 %	11,4 %	11,4 %	11,3 %	11,0 %	10,5 %	6,8 %	6,9 %	6,9 %	6,8 %	6,7 %	6,6 %	6,6 %
		Organic growth	0,85	279	287	290	295	302	310	319	330	340	353	367	382	399	416	434	453	472
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			17	35	64	96	132	171	213	260	309	337	366	398	431	466	503	542
		Rural access expansion			1	3	6	9	12	15	19	23	28	33	38	44	51	59	67	76
22	Guinea	Total		911	1 012	1 162	1 372	1 591	1 832	2 100	2 394	2 695	3 021	3 372	3 751	4 073	4 416	4 782	5 172	5 587
		% growth			11,0 %	14,8 %	18,1 %	15,9 %	15,2 %	14,6 %	14,0 %	12,6 %	12,1 %	11,6 %	11,2 %	8,6 %	8,4 %	8,3 %	8,2 %	8,0 %
		Organic growth	1,35	911	947	1 024	1 108	1 186	1 270	1 363	1 462	1 553	1 648	1 747	1 851	1 961	2 077	2 200	2 331	2 469
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			53	113	214	326	453	595	753	925	1 115	1 323	1 551	1 706	1 873	2 051	2 241	2 445
		Rural access expansion			12	25	51	79	109	143	179	217	258	302	349	406	466	531	599	672
23	Guinea-Bissau	Total		32	41	52	68	87	107	128	152	177	205	236	270	326	387	454	527	606
		% growth			30,5 %	25,5 %	32,0 %	26,6 %	23,1 %	20,4 %	18,3 %	16,9 %	15,8 %	15,1 %	14,3 %	20,6 %	18,7 %	17,3 %	16,0 %	15,1 %
		Organic growth	0,85	32	33	34	35	36	38	39	40	42	43	45	47	49	51	53	55	58
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			8	16	29	44	61	79	98	120	143	170	198	248	302	362	428	499
		Rural access expansion			1	2	4	6	8	11	13	16	19	22	25	29	34	39	44	49
24	Ghana	Total		9 206	9 891	10 575	11 619	13 080	14 199	15 254	16 391	17 638	18 935	20 279	21 670	23 154	24 723	26 365	28 031	29 791
		% growth			7,4 %	6,9 %	9,9 %	12,6 %	8,6 %	7,4 %	7,5 %	7,6 %	7,3 %	7,1 %	6,9 %	6,8 %	6,8 %	6,6 %	6,3 %	6,3 %
		Organic growth	1,35	9 206	9 604	9 982	10 695	11 889	12 738	13 512	14 350	15 280	16 242	17 235	18 259	19 343	20 492	21 709	22 998	24 364
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			258	535	810	1 014	1 219	1 432	1 658	1 899	2 153	2 419	2 698	2 991	3 299	3 623	3 963	4 319
		Rural access expansion			28	58	114	177	242	310	382	459	540	625	714	820	933	1 034	1 070	1 108
25	Kenya	Total		7 570	8 337	9 179	10 165	11 297	12 597	14 044	15 673	17 453	19 252	20 797	22 330	23 998	25 769	27 649	29 644	31 760
		% growth			10,1 %	10,1 %	10,7 %	11,1 %	11,5 %	11,5 %	11,6 %	11,4 %	10,3 %	8,0 %	7,4 %	7,5 %	7,4 %	7,3 %	7,2 %	7,1 %
		Organic growth	1,35	7 570	8 091	8 658	9 172	9 778	10 490	11 282	12 178	13 146	14 103	15 035	15 928	16 874	17 876	18 938	20 062	21 254
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			182	386	717	1 089	1 508	1 979	2 509	3 101	3 709	4 072	4 450	4 854	5 283	5 740	6 226	6 742
		Rural access expansion			64	135	276	430	599	784	986	1 205	1 440	1 690	1 952	2 270	2 610	2 972	3 356	3 765
26	Lesotho	Total		765	789	814	866	905	961	1 020	1 090	1 170	1 244	1 310	1 366	1 425	1 486	1 549	1 615	1 683
		% growth			3,2 %	3,1 %	6,4 %	4,6 %	6,1 %	6,2 %	6,8 %	7,4 %	6,3 %	5,3 %	4,3 %	4,3 %	4,3 %	4,3 %	4,3 %	4,2 %
		Organic growth	1,2	765	782	798	836	861	899	940	990	1 049	1 100	1 142	1 175	1 208	1 242	1 276	1 312	1 349
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			5	11	22	32	44	58	72	88	105	123	142	160	180	201	224	247
		Rural access expansion			2	4	8	13	17	22	27	33	39	44	50	57	64	72	79	87
27	Liberia	Total		298	316	331	377	430	492	563	642	731	828	932	1 044	1 211	1 394	1 595	1 815	2 055
		% growth			6,1 %	4,8 %	13,8 %	14,2 %	14,3 %	14,4 %	14,1 %	13,9 %	13,2 %	12,6 %	12,0 %	16,0 %	15,1 %	14,4 %	13,8 %	13,2 %
		Organic growth	0,85	298	295	289	293	301	311	325	340	356	373	390	407	425	443	462	482	502
		Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Urban access expansion			17	35	70	109	152	201	256	318	386	461	543	677	825	988	1 168	1 367
		Rural access expansion			3	6	13	21	29	37	47	57	69	81	94	110	127	145	165	186

28 Libya	Total		9 258	7 922	7 562	13 092	20 090	19 761	20 281	20 838	21 439	22 186	23 094	24 179	25 314	26 499	27 739	29 034	30 389
	% growth			-14,4 %	-4,5 %	73,1 %	53,5 %	-1,6 %	2,6 %	2,8 %	2,9 %	3,5 %	4,1 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %
	Organic growth	1,35	9 258	7 910	7 532	13 035	20 000	19 634	20 116	20 637	21 199	21 908	22 779	23 827	24 922	26 069	27 267	28 521	29 833
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			11	29	55	88	124	161	198	236	273	311	349	388	428	469	511	555
	Rural access expansion			1	1	1	2	3	4	4	4	4	4	3	3	3	2	1	1
29 Madagascar	Total		1 343	1 475	1 639	1 868	2 141	2 454	2 786	3 140	3 517	3 927	4 371	4 852	5 617	6 455	7 371	8 371	9 459
	% growth			9,9 %	11,1 %	14,0 %	14,6 %	14,6 %	13,5 %	12,7 %	12,0 %	11,7 %	11,3 %	11,0 %	15,8 %	14,9 %	14,2 %	13,6 %	13,0 %
	Organic growth	1,35	1 343	1 388	1 456	1 529	1 626	1 742	1 857	1 972	2 089	2 214	2 345	2 484	2 632	2 788	2 954	3 129	3 315
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			73	153	279	420	580	757	952	1 167	1 404	1 664	1 949	2 499	3 108	3 781	4 523	5 337
	Rural access expansion			14	30	61	95	132	172	215	260	310	362	418	486	559	637	719	807
30 Malawi	Total		1 928	2 024	2 112	2 296	2 507	2 749	3 011	3 294	3 602	3 928	4 275	4 642	5 079	5 551	6 062	6 615	7 213
	% growth			5,0 %	4,3 %	8,7 %	9,2 %	9,6 %	9,5 %	9,4 %	9,3 %	9,1 %	8,8 %	8,6 %	9,4 %	9,3 %	9,2 %	9,1 %	9,0 %
	Organic growth	1,15	1 928	1 977	2 014	2 102	2 206	2 328	2 456	2 592	2 735	2 880	3 028	3 178	3 335	3 500	3 673	3 855	4 046
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			27	56	107	165	231	304	387	480	583	698	825	994	1 182	1 392	1 626	1 885
	Rural access expansion			20	42	87	136	191	250	316	387	465	549	639	749	868	997	1 134	1 282
31 Mali	Total		1 415	1 624	1 848	2 143	2 459	2 797	3 165	3 566	4 002	4 479	5 002	5 574	6 110	6 685	7 302	7 964	8 673
	% growth			14,7 %	13,8 %	15,9 %	14,8 %	13,7 %	13,2 %	12,7 %	12,2 %	11,9 %	11,7 %	11,4 %	9,6 %	9,4 %	9,2 %	9,1 %	8,9 %
	Organic growth	1,35	1 415	1 518	1 625	1 728	1 831	1 932	2 039	2 152	2 271	2 400	2 539	2 690	2 850	3 019	3 198	3 388	3 589
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			90	193	353	532	731	953	1 198	1 469	1 768	2 099	2 464	2 771	3 103	3 461	3 849	4 266
	Rural access expansion			15	31	62	97	134	173	216	262	311	364	421	490	564	643	728	818
32 Mauritania	Total		788	824	870	965	1 056	1 175	1 310	1 447	1 585	1 738	1 908	2 097	2 251	2 414	2 587	2 770	2 965
	% growth			4,6 %	5,7 %	10,8 %	9,5 %	11,2 %	11,6 %	10,4 %	9,6 %	9,7 %	9,8 %	9,9 %	7,3 %	7,2 %	7,2 %	7,1 %	7,0 %
	Organic growth	1,35	788	791	803	838	865	912	969	1 020	1 067	1 120	1 182	1 252	1 327	1 405	1 489	1 577	1 671
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			30	62	116	174	239	311	389	473	564	664	773	841	913	990	1 071	1 157
	Rural access expansion			3	5	11	17	23	30	38	45	53	62	72	83	96	109	122	137
33 Mauritius	Total		2 586	2 674	2 778	2 886	3 002	3 126	3 255	3 390	3 530	3 661	3 780	3 887	3 997	4 110	4 226	4 346	4 469
	% growth			3,4 %	3,9 %	3,9 %	4,0 %	4,1 %	4,1 %	4,1 %	4,1 %	3,7 %	3,3 %	2,8 %	2,8 %	2,8 %	2,8 %	2,8 %	2,8 %
	Organic growth	1,2	2 586	2 674	2 778	2 886	3 001	3 125	3 254	3 388	3 527	3 658	3 776	3 883	3 992	4 104	4 219	4 338	4 460
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			0	0	0	0	0	0	0	1	1	1	2	3	4	4	5	6
	Rural access expansion			0	0	1	1	1	2	2	2	2	3	3	3	3	3	2	2
34 Morocco	Total		28 875	30 531	30 902	32 757	33 928	35 588	37 416	39 479	41 700	43 928	46 150	48 356	50 660	53 066	55 579	58 203	60 945
	% growth			5,7 %	1,2 %	6,0 %	3,6 %	4,9 %	5,1 %	5,5 %	5,6 %	5,3 %	5,1 %	4,8 %	4,8 %	4,7 %	4,7 %	4,7 %	4,7 %
	Organic growth	1,35	28 875	30 396	30 654	32 392	33 448	34 986	36 689	38 622	40 709	42 799	44 882	46 946	49 105	51 364	53 726	56 197	58 781
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			108	217	332	447	568	693	824	960	1 099	1 241	1 385	1 533	1 685	1 841	1 999	2 162
	Rural access expansion			26	31	33	33	34	33	33	32	30	28	25	21	17	13	7	2
35 Mozambique	Total		4 692	5 201	5 561	6 068	6 660	7 359	8 164	9 092	10 110	11 144	12 183	17 212	18 253	19 366	20 557	21 830	23 190
	% growth			10,8 %	6,9 %	9,1 %	9,8 %	10,5 %	10,9 %	11,4 %	11,2 %	10,2 %	9,3 %	41,3 %	6,0 %	6,1 %	6,1 %	6,2 %	6,2 %
	Organic growth	1,35	4 692	5 071	5 291	5 584	5 938	6 370	6 876	7 469	8 113	8 739	9 336	9 891	10 478	11 101	11 760	12 458	13 198
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	4 000	4 000	4 000	4 000	4 000	4 000
	Urban access expansion			100	211	373	554	758	988	1 248	1 539	1 858	2 206	2 581	2 917	3 283	3 680	4 112	4 580
	Rural access expansion			29	60	111	168	230	299	375	458	547	641	740	857	983	1 117	1 259	1 411
36 Namibia	Total		3 700	3 957	4 000	4 045	4 173	4 351	4 542	4 746	4 960	5 166	5 342	5 511	5 686	5 866	6 051	6 242	6 437
	% growth			6,9 %	1,1 %	1,1 %	3,2 %	4,3 %	4,4 %	4,5 %	4,5 %	4,1 %	3,4 %	3,2 %	3,2 %	3,2 %	3,2 %	3,1 %	3,1 %
	Organic growth	1,2	3 700	3 936	3 958	3 966	4 053	4 187	4 329	4 482	4 640	4 793	4 939	5 078	5 221	5 368	5 519	5 674	5 833
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			18	37	68	103	141	183	228	278	323	346	369	393	417	442	467	493
	Rural access expansion			3	6	11	17	23	29	36	43	49	57	64	73	82	91	101	111
37 Niger	Total		1 191	1 321	1 480	1 684	1 918	2 188	2 523	2 880	3 280	3 711	4 173	4 666	5 131	5 635	6 181	6 771	7 408
	% growth			10,9 %	12,0 %	13,8 %	13,9 %	14,1 %	15,3 %	14,2 %	13,9 %	13,1 %	12,4 %	11,8 %	10,0 %	9,8 %	9,7 %	9,5 %	9,4 %
	Organic growth	1,35	1 191	1 246	1 320	1 384	1 460	1 551	1 679	1 803	1 939	2 075	2 209	2 340	2 479	2 627	2 783	2 948	3 123
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			54	115	207	311	430	569	727	906	1 109	1 335	1 587	1 779	1 989	2 218	2 468	2 740
	Rural access expansion			21	45	93	147	206	275	351	435	528	629	738	873	1 020	1 180	1 355	1 545
38 Nigeria	Total		23 939	26 344	27 635	31 038	35 035	39 253	43 768	48 320	50 758	53 744	57 340	61 624	66 264	71 164	75 609	80 246	85 123
	% growth			10,0 %	4,9 %	12,3 %	12,9 %	12,0 %	11,5 %	10,4 %	5,0 %	5,9 %	6,7 %	7,5 %	7,5 %	7,4 %	6,2 %	6,1 %	6,1 %
	Organic growth	1,15	23 939	24 495	23 862	23 898	24 235	24 521	24 810	25 103	25 399	26 018	26 978	28 312	29 713	31 183	32 725	34 344	36 042
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			1 576	3 228	6 071	9 186	12 554	16 196	19 851	21 367	23 063	24 967	27 113	29 381	31 778	34 309	36 978	39 790
	Rural access expansion			272	545	1 068	1 614	2 178	2 762	3 366	3 992	4 664	5 395	6 199	7 170	8 203	8 575	8 925	9 290
39 Rwanda	Total		520	681	839	1 091	1 379	1 699	1 942	2 204	2 488	2 776	3 065	3 350	3 665	3 996	4 345	4 712	5 099
	% growth			31,0 %	23,1 %	30,1 %	26,5 %	23,2 %	14,3 %	13,5 %	12,9 %	11,6 %	10,4 %	9,3 %	9,4 %	9,0 %	8,7 %	8,4 %	8,2 %
	Organic growth	1,35	520	578	619	666	721	787	860	939	1 027	1 111	1 189	1 259	1 334	1 414	1 497	1 586	1 681
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			80	171	324	500	693	794	903	1 020	1 141	1 265	1 390	1 521	1 658	1 801	1 951	2 107
	Rural access expansion			23	49	101	158	220	288	361	441	524	611	701	810	925	1 046	1 175	1 311
40 Sao Tome and Principe	Total		65	70	76	84	93	103	113	122	131	140	149	159	170	181	193	205	217
	% growth			7,8 %	7,8 %	10,7 %	11,1 %	10,7 %	10,0 %	7,4 %	7,6 %	7,0 %	6,7 %	6,5 %	6,8 %	6,4 %	6,4 %	6,5 %	6,0 %
	Organic growth	1,35	65	68	71	76	81	86	92	98	104	111	118	124	132	140	148	157	166
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			2	4	8	11	16	20	22	24	26	28	31	33	36	38	41	44
	Rural access expansion			0	0	1	1	1	2	2	3	3	4	4	5	6	6	7	7
41 Senegal	Total		2 985	3 344	3 745	4 250	4 741	5 250	5 805	6 409	7 012	7 625	8 240	8 853	9 512	10 212	10 957	11 746	12 585
	% growth			12,0 %	12,0 %	13,5 %	11,6 %	10,7 %	10,6 %	10,4 %	9,4 %	8,7 %	8,1 %	7,4 %	7,4 %	7,4 %	7,3 %	7,2 %	7,1 %
	Organic growth	1,35	2 985	3 222	3 487	3 778	4 103	4 462	4 853	5 278	5 690	6 099	6 500	6 885	7 294	7 728	8 187	8 673	9 188
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			105	222	401	528	636	754	884	1 021	1 167	1 322	1 485	1 660	1 847	2 047	2 260	2 487
	Rural access expansion			18	37	71	110	152	198	248	301	358	419	482	558	638	723	813	909
42 Seychelles	Total		326	343	360	374	387	399	412	429	446	463	477	491	505	519	534	549	565
	% growth			5,5 %	4,7 %	4,2 %	3,3 %	3,2 %	3,2 %	4,1 %	4,0 %	3,6 %	3,2 %	2,9 %	2,8 %	2,9 %	2,8 %	2,8 %	2,9 %
	Organic growth	1,2	326	342	358	373	385	397	410	427	444	460	475	488	502	516	530	545	561
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			1	1	1	1	2	2	2	2	3	3	3	3	3	3	4	4
	Rural access expansion			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43 Sierra Leone	Total		246	224	258	318	384	458	540	631	733	843	961	1 087	1 310	1 555	1 823	2 117	2 438
	% growth			-8,9 %	15,1 %	23,0 %	20,7 %	19,4 %	17,9 %	16,9 %	16,2 %	15,0 %	14,0 %	13,1 %	20,5 %	18,7 %	17,3 %	16,1 %	15,2 %
	Organic growth	0,85	246	202	211	220	230	241	253	266	281	295	309	322	336	350	366	381	398
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			17	37	76	119	168	223	285	354	431	514	605	788	990	1 214	1 460	1 732
	Rural access expansion			5	11	22	35	49	64	80	98	118	138	160	186	214	243	275	309
44 Somalia	Total		316	368	424	507	602	706	819	945	1 081	1 235	1 409	1 605	2 034	2 514	3 050	3 647	4 311
	% growth			16,5 %	15,0 %	19,7 %	18,8 %	17,2 %	16,0 %	15,3 %	14,4 %	14,2 %	14,1 %	14,0 %	26,7 %	23,6 %	21,3 %	19,6 %	18,2 %
	Organic growth	0,85	316	323	330	334	341	349	356	365	374	385	400	417	435	453	473	493	514
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			39	81	148	221	302	392	491	599	721	858	1 013	1 393	1 822	2 302	2 841	3 442
	Rural access expansion			6	13	26	40	55	71	89	108	128	151	176	206	239	275	313	355
45 South Africa	Total		211 837	213 786	213 269	213 596	214 425	216 516	220 063	223 559	227 105	231 405	236 499	242 429	248 495	254 702	261 051	267 545	274 188
	% growth			0,9 %	-0,2 %	0,2 %	0,4 %	1,0 %	1,6 %	1,6 %	1,6 %	1,9 %	2,2 %	2,5 %	2,5 %	2,5 %	2,5 %	2,5 %	2,5 %
	Organic growth	1,2	211 837	212 560	210 766	209 986	210 204	211 669	214 650	217 673	220 739	224 546	229 128	234 528	240 055	245 713	251 504	257 431	263 498
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			1 134	2 317	3 249	3 685	4 132	4 598	5 070	5 549	6 042	6 552	7 081	7 619	8 169	8 727	9 296	9 874
	Rural access expansion			92	186	361	536	714	815	816	817	818	819	820	821	820	820	818	815
46 South Sudan	Total		671	689	632	649	688	752	850	995	1 106	1 232	1 373	1 530	1 797	2 093	2 421	2 782	3 181
	% growth			2,7 %	-8,3 %	2,7 %	5,9 %	9,3 %	13,1 %	17,0 %	11,2 %	11,4 %	11,4 %	11,4 %	17,5 %	16,5 %	15,6 %	14,9 %	14,3 %
	Organic growth	0,85	671	665	582	547	527	525	547	600	615	634	658	686	715	746	778	812	847
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			13	25	49	74	103	137	182	224	273	327	389	546	722	922	1 146	1 398
	Rural access expansion			12	25	54	86	123	166	213	267	326	388	455	536	625	721	825	937
47 Sudan	Total		9 272	9 938	10 431	11 184	11 973	12 812	13 704	14 654	15 649	16 616	17 601	18 726	19 942	21 228	22 589	24 027	25 547
	% growth			7,2 %	5,0 %	7,2 %	7,1 %	7,0 %	7,0 %	6,9 %	6,8 %	6,2 %	5,9 %	6,4 %	6,5 %	6,4 %	6,4 %	6,4 %	6,3 %
	Organic growth	1,15	9 272	9 720	9 979	10 325	10 670	11 028	11 397	11 778	12 159	12 622	13 174	13 826	14 510	15 228	15 981	16 771	17 601
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			165	343	644	974	1 335	1 728	2 158	2 626	2 972	3 234	3 523	3 832	4 164	4 519	4 900	5 307
	Rural access expansion			53	109	215	328	450	579	717	864	1 022	1 192	1 378	1 600	1 836	2 088	2 356	2 640
48 Swaziland	Total		1 468	1 482	1 476	1 481	1 466	1 468	1 491	1 526	1 567	1 614	1 667	1 724	1 781	1 839	1 899	1 961	2 025
	% growth			0,9 %	-0,4 %	0,3 %	-1,1 %	0,2 %	1,6 %	2,3 %	2,7 %	3,0 %	3,3 %	3,4 %	3,3 %	3,3 %	3,3 %	3,3 %	3,3 %
	Organic growth	1,2	1 468	1 476	1 465	1 459	1 432	1 423	1 434	1 456	1 483	1 515	1 553	1 597	1 642	1 688	1 735	1 784	1 834
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			3	6	12	18	25	32	39	47	55	64	71	74	78	81	85	89
	Rural access expansion			3	5	10	15	20	25	31	37	43	50	57	65	73	82	92	101
49 Tanzania	Total		5 030	5 766	6 581	7 601	8 759	10 043	11 462	13 005	14 650	16 065	17 500	18 939	20 504	22 170	23 945	25 833	27 841
	% growth			14,6 %	14,1 %	15,5 %	15,2 %	14,7 %	14,1 %	13,5 %	12,7 %	9,7 %	8,9 %	8,2 %	8,3 %	8,1 %	8,0 %	7,9 %	7,8 %
	Organic growth	1,35	5 030	5 463	5 934	6 406	6 940	7 520	8 148	8 807	9 518	10 220	10 899	11 547	12 233	12 959	13 729	14 544	15 408
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			255	546	986	1 489	2 059	2 705	3 430	4 189	4 716	5 271	5 853	6 475	7 140	7 850	8 607	9 414
	Rural access expansion			48	101	210	330	463	609	769	943	1 130	1 329	1 539	1 796	2 071	2 366	2 682	3 019
50 Togo	Total		1 102	1 181	1 263	1 378	1 506	1 646	1 799	1 965	2 144	2 340	2 553	2 786	3 038	3 310	3 604	3 919	4 259
	% growth			7,2 %	6,9 %	9,1 %	9,3 %	9,3 %	9,3 %	9,2 %	9,1 %	9,1 %	9,1 %	9,1 %	9,1 %	8,9 %	8,9 %	8,8 %	8,7 %
	Organic growth	0,85	1 102	1 143	1 182	1 223	1 269	1 317	1 369	1 423	1 480	1 540	1 605	1 674	1 746	1 821	1 899	1 981	2 066
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			30	64	122	188	261	342	431	531	641	763	898	1 043	1 203	1 378	1 569	1 778
	Rural access expansion			8	16	32	50	68	89	110	134	159	186	215	249	287	327	370	415
51 Tunisia	Total		14 815	14 954	15 075	15 459	15 996	16 657	17 476	18 379	19 325	20 292	21 278	22 281	23 328	24 422	25 565	26 759	28 006
	% growth			0,9 %	0,8 %	2,5 %	3,5 %	4,1 %	4,9 %	5,2 %	5,2 %	5,0 %	4,9 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %	4,7 %
	Organic growth	1,35	14 815	14 920	15 007	15 355	15 856	16 479	17 259	18 122	19 028	19 954	20 899	21 860	22 865	23 917	25 017	26 167	27 370
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			32	64	98	133	169	207	245	285	325	366	408	451	494	538	583	628
	Rural access expansion			2	4	6	8	9	10	12	12	13	13	13	12	12	11	9	7
52 Uganda	Total		2 739	3 092	3 339	3 816	4 377	5 020	5 758	6 593	7 574	8 503	9 360	10 215	11 173	12 202	13 306	14 489	15 755
	% growth			12,9 %	8,0 %	14,3 %	14,7 %	14,7 %	14,7 %	14,5 %	14,9 %	12,3 %	10,1 %	9,1 %	9,4 %	9,2 %	9,0 %	8,9 %	8,7 %
	Organic growth	1,35	2 739	2 928	2 996	3 149	3 345	3 575	3 845	4 150	4 525	4 886	5 227	5 537	5 866	6 214	6 583	6 974	7 388
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Urban access expansion			100	210	392	601	841	1 116	1 430	1 794	2 099	2 333	2 578	2 842	3 127	3 434	3 764	4 120
	Rural access expansion			64	134	275	431	604	798	1 013	1 255	1 518	1 800	2 099	2 465	2 861	3 289	3 750	4 247
53 Zambia	Total		10 522	10 855	11 262	11 801	12 435	13 105	17 812	18 558	19 347	20 208	21 148	26 175	27 292	28 479	29 739	31 077	32 498
	% growth			3,2 %	3,8 %	4,8 %	5,4 %	5,4 %	35,9 %	4,2 %	4,2 %	4,4 %	4,7 %	23,8 %	4,3 %	4,3 %	4,4 %	4,5 %	4,6 %
	Organic growth	1,15	10 522	10 790	11 127	11 550	12 056	12 583	13 134	13 709	14 308	14 962	15 673	16 449	17 262	18 116	19 012	19 952	20 939
	Exogenous demand increase		0	0	0	0	0	0	4 000	4 000	4 000	4 000	4 000	8 000	8 000	8 000	8 000	8 000	8 000
	Urban access expansion			54	113	208	313	430	559	702	859	1 032	1 225	1 437	1 693	1 975	2 284	2 623	2 994
	Rural access expansion			11	22	43	67	92	119	148	180	213	250	290	337	388	443	502	564
54 Zimbabwe	Total		7 955	8 066	8 133	8 399	8 535	8 643	8 626	8 566	8 495	8 586	8 842	13 273	13 727	14 204	14 706	15 235	15 792
	% growth			1,4 %	0,8 %	3,3 %	1,6 %	1,3 %	-0,2 %	-0,7 %	-0,8 %	1,1 %	3,0 %	50,1 %	3,4 %	3,5 %	3,5 %	3,6 %	3,7 %
	Organic growth	0,85	7 955	7 989	7 975	8 103	8 096	8 055	7 973	7 866	7 746	7 779	7 962	8 305	8 662	9 035	9 423	9 829	10 251
	Exogenous demand increase		0	0	0	0	0	0	0	0	0	0	0	4 000	4 000	4 000	4 000	4 000	4 000
	Urban access expansion			58	118	222	329	441	489	525	562	606	660	726	798	877	962	1 055	1 155
	Rural access expansion			19	39	74	110	147	163	175	187	202	220	242	266	292	321	352	385

Annex IV: Study methodology and basis for analysis

This annex presents the full methodology applied in the study, organized stepwise in the following order:

A. Access Expansion
B. Demand Projections
C. Transmission, distribution and inter-connector costs
D. Generation Expansion
E. Scenarios

A. Access Expansion

a) Macro level ambitions and assumptions

The starting point for the access expansion targets applied in this study is the AfDB's overarching strategy of universal access by 2025, specifically:

- 100 percent access in urban areas
- 95 percent access in rural areas

Further, the AfDB strategy embraces the multi-tier access framework with regards to access, and thus opens for both mini-grid and off-grid solutions. The strategy foresees:

- 140 million new connections to centralized (national) grids
- 75 million new connections to either mini-grids or off-grid solutions

Annex table A 2014 rural and urban access rates, and 2025 targets

	2014 - actual	2025 - target
Urban	68.4 %	100 %
Rural	27 %	95 %

Following the AfDB strategy, it is assumed that most of this increase will happen by means of grid-connection. However, it is also assumed that, particularly for the poor and marginalized, a number of households will gain access by means of mini-grid and off-grid solutions (e.g. Solar Home Systems). The assumed break-down of the 2025 target is presented in the table below.

Annex table B 2025 access targets broken down on type of connection

	Urban	Rural
Grid connections	93 %	55 %
Mini-grid connections		5 %
Off-grid connections	7 %	35 %

Finally, it is assumed that only a very marginal percentage of the population had access to off- or mini-grid solutions in 2014.

b) Country specific base year data and assumptions

The access expansion builds on year-by-year projections of number of urban and rural inhabitants in each of the 54 countries prepared by the World Bank [22].

While it is difficult to encounter credible country specific data for number of households in Africa, the ARC GIS software applied in this study does give a continent wide average of 4.2 persons/household. Further, it provides country specific numbers for a few countries, as presented in the table below. Where available, these have been applied. In the remaining countries, the average has been applied. The average number of persons per household is kept constant over the forecast period.

Annex table C People per household

Country	People per household
Algeria	6.3
Botswana	3.7
Côte d´Ivoire	5.8
Kenya	4.1
Lesotho	4.4
Morocco	5.2
Nigeria	4.1
South Africa	2.2
Tanzania	4.8
Tunisia	4.1
Uganda	4.7
Zambia	5.2
All other countries	4.2

Finally, the base-year (2014) electrification rates, as found in the International Energy Agency´s 2015 World Energy Outlook 2015 are applied in the model. The numbers can be found in the table below.

[22] Finally, the base-year (2014) electrification rates, as found in the International Energy Agency´s 2015 World Energy Outlook 2015 are applied in the model. The numbers can be found in the table below.

Annex table D 2014 grid-access

Country	Urban	Rural
Algeria	100 %	97 %
Angola	46 %	18 %
Benin	57 %	9 %
Botswana	75 %	54 %
Burkina Faso	56 %	1 %
Burundi	28 %	2 %
Cameroon	88 %	17 %
Cape Verde	100 %	84 %
CAR	5 %	1 %
Chad	14 %	1 %
Côte d´Ivoire	42 %	8 %
Comoros	89 %	62 %
Congo	62 %	5 %
Djibouti	61 %	14 %
DRC	19 %	2 %
Egypt	100 %	99 %
Eritrea	86 %	17 %
Ethiopia	85 %	10 %
Eq Guinea	93 %	48 %

Country	Urban	Rural
Gabon	97 %	38 %
Gambia	60 %	2 %
Guinea	53 %	11 %
Guinea-Bissau	37 %	6 %
Ghana	92 %	50 %
Kenya	60 %	7 %
Lesotho	43 %	8 %
Liberia	17 %	3 %
Libya	100 %	99 %
Madagascar	37 %	4 %
Malawi	32 %	4 %
Mali	53 %	9 %
Mauritania	47 %	2 %
Mauritius	100 %	100 %
Morocco	100 %	97 %
Mozambique	66 %	27 %
Namibia	50 %	17 %
Niger	62 %	4 %
Nigeria	55 %	37 %

Country	Urban	Rural
Rwanda	67 %	5 %
STP	70 %	40 %
Senegal	90 %	28 %
Seychelles	97 %	97 %
Sierra Leone	11 %	1 %
Somalia	33 %	%
South Africa	90 %	77 %
South Sudan	4 %	0 %
Sudan	63 %	21 %
Swaziland	40 %	24 %
Tanzania	71 %	4 %
Togo	35 %	21 %
Tunisia	100 %	100 %
Uganda	55 %	7 %
Zambia	45 %	14 %
Zimbabwe	80 %	21 %

c) Access expansion algorithm

While the AfDB strategy emphasizes the importance of prioritization and "value-for-money" it does not attempt to assess how these new connections will, or should be, distributed between countries. That is;

- In which countries can we expect grid-connection rates to reach 100 percent during the period?

- In which countries can we expect mini-grid or off-grid solutions to play an important role?
- In which countries should AfDB (and other partners) prioritize grid-connections versus off-grid?
- In which countries can AfDB best leverage country-specific conditions to achieve high access rates?
- In which countries can AfDB expect to significant challenges to achieve high access rates?

In order to account for these policy-related questions, the Team has developed an innovative access expansion algorithm to project access rates across the three technologies. This is done in a manner which; i) holds true to the overarching universal access by 2025 target, ii) reflects the country-specific starting point in terms of access and other relevant contextual factors, and iii) allows for both scenario testing and prioritization considerations for the AfDB with regards to level of effort and relevant strategies for access expansion in the various regions and countries. In practice, each country is given a "score" according to its geospatial and macro-economic starting point. The relative country scores are designed to account for the following indicators:

- Income level: GDP/capita
- Poverty level: % of population living on >1.9USD
- Geospatial: Population density
- Investment attractiveness: Doing Business score
- Public investment opportunity: GDP/public debt

Specific data applied are found in the table below.

Annex table E Geospatial and macro-economic base-year (2014) indicators applied in the access expansion scoring

	Population density	Pov (%>1.9)	Doing Business Score	GDP/ Debt	GDP/Capita
Algeria	16.70	0.70	47.76	5.95	5 471
Angola	20.10	0.70	38.41	1.74	4 709
Benin	96.60	0.47	48.52	2.49	944
Botswana	3.80	0.82	65.55	4.76	7 498
Burkina Faso	66.00	0.56	51.33	3.53	705
Burundi	401.70	0.29	47.37	2.30	313
Cameroon	49.10	0.76	45.27	3.22	1 441
Cape Verde	129.20	0.92	55.28	0.86	3 530
Central African Republic	7.90	0.34	36.25	2.39	377
Chad	10.90	0.62	39.07	2.82	1 026

	Population density	Pov (%>1.9)	Doing Business Score	GDP/ Debt	GDP/Capita
Côte d´Ivoire	70.40	0.71	52.31	1.96	1 570
Comoros	363.10	0.87	48.69	5.01	853
Congo	13.50	0.71	40.58	2.03	2 911
Djibouti	38.60	0.78	44.50	2.59	1 741
Democratic Republic of Congo	32.90	0.23	37.57	5.49	462
Egypt	91.40	0.75	56.64	1.08	3 328
Eritrea	43.10	0.34	28.05	0.83	583
Ethiopia	88.20	0.66	47.25	1.85	571
Equatorial Guinea	30.10	0.56	39.83	4.12	19 003
Gabon	6.40	0.92	45.88	2.30	9 692
Gambia	176.20	0.52	51.70	1.30	443
Guinea	51.30	0.65	46.23	2.33	561
Guinea-Bissau	51.10	0.33	41.63	1.67	643
Ghana	114.50	0.75	58.82	1.36	1 432
Kenya	79.00	0.66	61.22	1.98	1 335
Lesotho	70.30	0.41	60.37	1.87	1 175
Liberia	40.40	0.32	41.41	8.47	458
Libya	3.60	0.67	33.19	10.00	5 603
Madagascar	41.30	0.22	45.10	2.61	452
Malawi	145.30	0.29	54.39	1.63	355
Mali	14.20	0.51	52.96	3.66	826
Mauritania	3.90	0.94	47.21	1.25	1 327
Mauritius	624.00	1.00	72.27	1.52	10 154

	Population density	Pov (%>1.9)	Doing Business Score	GDP/ Debt	GDP/Capita
Morocco	77.00	0.97	67.50	1.30	3 155
Mozambique	34.90	0.31	53.78	1.00	623
Namibia	3.00	0.77	58.82	2.81	5 421
Niger	15.70	0.54	49.57	3.22	431
Nigeria	197.20	0.47	44.63	7.58	3 222
Rwanda	440.80	0.40	69.81	2.73	707
Sao Tome and Principe	189.80	0.68	46.75	1.12	1 822
Senegal	77.10	0.62	50.68	1.12	1 052
Seychelles	211.00	0.99	61.21	1.80	15 571
Sierra Leone	89.90	0.48	50.23	1.69	708
Somalia	16.90	0.31	20.29	2.31	418
South Africa	44.70	0.84	65.20	2.31	6 480
South Sudan	19.20	0.57	33.48	2.28	1 152
Sudan	21.60	0.85	44.76	1.45	2 177
Swaziland	74.10	0.58	58.34	5.25	3 464
Tanzania	56.60	0.53	54.48	2.73	950
Togo	128.60	0.46	48.57	1.58	620
Tunisia	68.80	0.98	64.89	1.75	4 272
Uganda	165.40	0.65	57.77	2.82	719
Zambia	21.50	0.36	60.54	1.75	1 738
Zimbabwe	39.90	0.79	47.10	2.20	1 027
Average	92.38	0.61	49.83	2.74	2 726

Each country is then awarded a score that reflects these factors, in light of the average scores. A higher than average score indicates a "better" starting point for both grid-connections in urban and rural areas, and mini-grids in rural areas. The score is calculated in the following sequence:

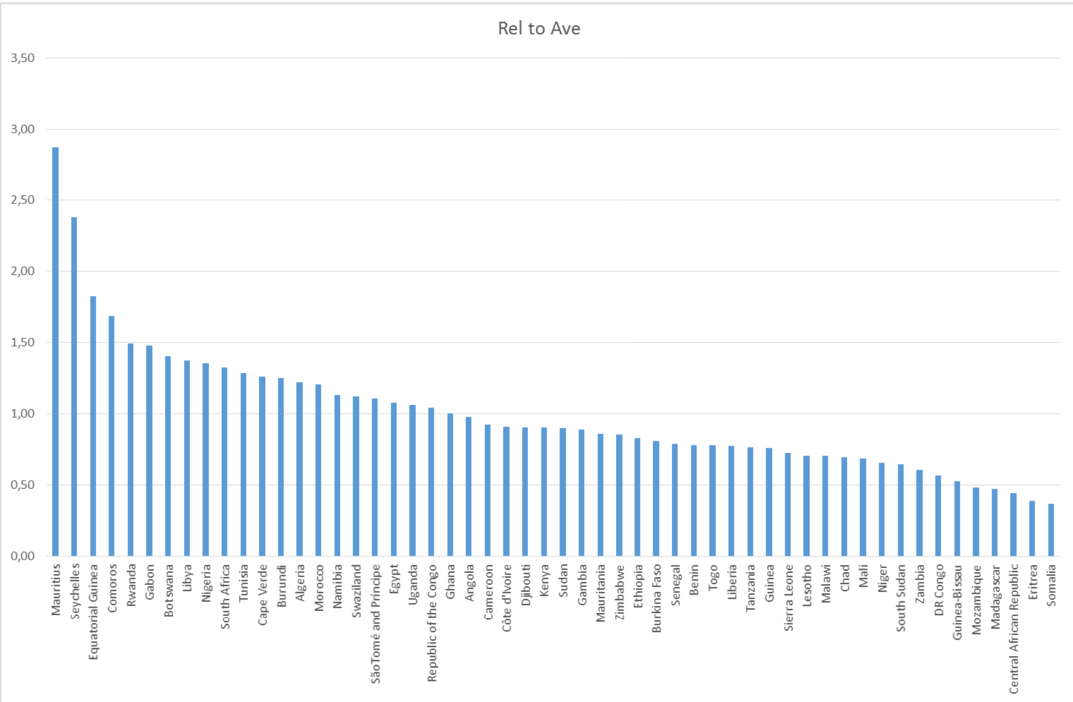
1) For each country the relative score for all indicators are summed up and multiplied by weights found in the table below. The summed weighted relative score gives the country´s ***summed weighted relative score***.

Annex table F Weights applied for Access Score calculations (higher weight implies greater importance of the factor in terms of determining pace and target for the relative access type)

	Population density	Pov (%>1.9)	Doing Business Score	GDP/ Debt	GDP/Capita
Weights - Grid	0.5	1	0.3	0.3	0.5
Weights - Mini-grid	0.2	1	0.8	0.1	0.7

2) This summed weighted relative score is again divided by the average summed weighted relative score for all 54 countries to arrive at the ***Access Score***. Thus for a country with a "summed weighted relative score" which is double the average, it will have an Access Score of 2.

This scoring approach was applied to all 54 countries, with the results illustrated in the figure below. The countries to the left can expect to "out-perform" the average when it comes to the rate of grid expansion, while the countries to the right can expect to "under-perform".



Annex figure A Access Score for all 54 countries relative to average

The Access Score only accounts for the rate of access expansion, and does not account for the access rate in the base year – 2014. Thus, in order to complete the projections, the following is done:

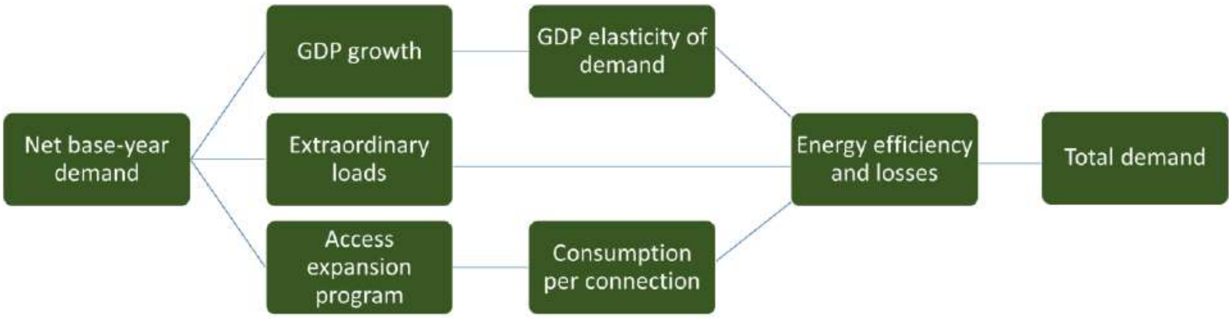
1) Annex table D above, serve as the starting points.
2) The score is used to adjust the access expansion rates (up and down) relative to the Africa-wide average ex pansion rate required to achieve the 2025 and 2030 targets presented in Annex table B.
3) The access expansion rates are increased to account for those countries achieving 100 percent grid connections before 2025, until the overall AfDB targets are achieved.

The overall results of the projections are such that the grid-access targets for urban and rural populations in Africa is achieved and the relative contribution of each country corresponds to its starting point and its geospatial and macro-economic context.

In order to complete the projections, the population not gaining access to grid or mini-grid will get access through off-grid solutions.

B. Demand Projections

The applied total demand projections are, as outlined in the figure below, an aggregate of forecasted demand resulting from i) economic growth and industrialization, ii) the extraordinary access expansion program, and iii) other extraordinary loads.



Annex figure B High-level presentation of the load forecast exercise

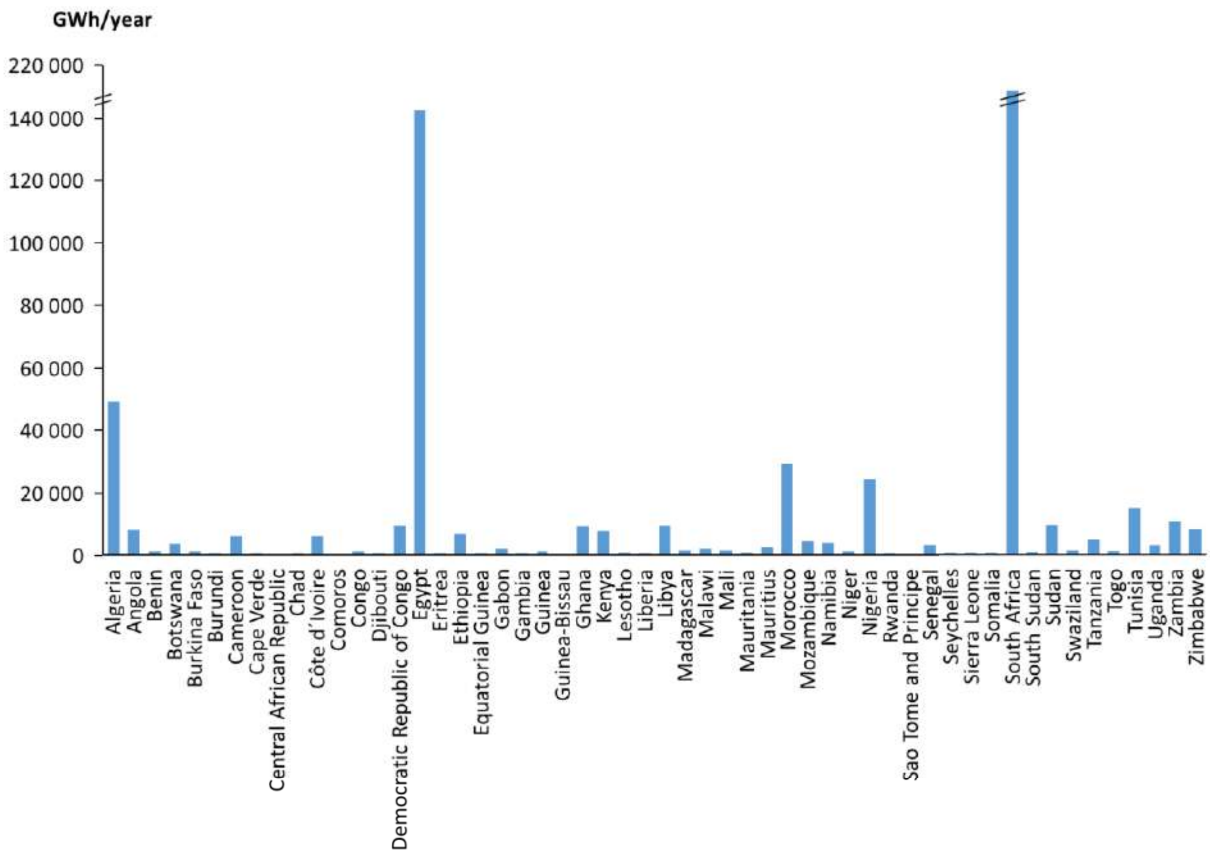
The key assumptions and data underlying the load forecast exercise are presented and discussed one-by-one below. A number of the assumptions are given for groups of similar countries, which are found to have similar characteristics in terms of their electricity demand. The grouping, which is presented in the table below, builds on an econometric exercise conducted for the Africa Energy Sector Outlook 2040 report prepared for the Programme for Infrastructure Development in Africa (PIDA).

Annex table G Grouping of countries (source: Africa Energy Outlook 2040)

Country	Group
Fragile Low-income countries	Burundi, Central African Republic, Chad, Côte d´Ivoire, Djibouti, Democratic Republic of Congo, Eritrea, Gambia, Guinea-Bissau, Liberia, Mali, Sierra Leone, Somalia, South Sudan, Togo, and Zimbabwe
Non-Fragile Low-income countries	Benin, Burkina Faso, Comoros, Ethiopia, Gabon, Guinea, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Senegal, Tanzania, and Uganda
Intermediate Income Countries	Botswana, Cape Verde, Mauritius, Namibia, Seychelles, South Africa, and Swaziland
Resource Rich Countries	Angola, Cameroon, Congo, Equatorial Guinea, Malawi, Nigeria, Sudan, and Zambia
North Africa	Algeria, Egypt, Libya, Morocco, and Tunisia

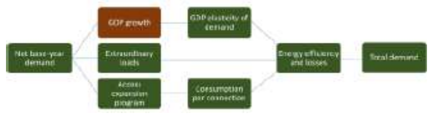
a) Base year demand

The applied base-year (2014) net demand (excluding losses) for each of the 54 countries is based on numbers presented in the IEA World Energy Outlook 2015. Where several credible sources, as well as the initial modelling conducted under this assignment, contradict the data provided by WEO 2015, the numbers have been modified. This is the case for Equatorial Guinea and Mozambique. The applied demand is found in the figure below.



Annex figure C Base year (2014) net grid demand

b) GDP growth



The applied GDP growth numbers from 2014 to 2025 are obtained on a country-by-country basis from the International Monetary Fund (IMF) on-line DataMapper . From 2026 to 2030, the long-run GDP growth numbers found in the table below are applied.

Annex table H Long term (after 2025) GDP growth-numbers

Group	Long-run GDP growth (from 2025)
Fragile Low-income countries	6.0 %
Non-Fragile Low-income countries	5.0 %
Intermediate Income Countries	3.0 %
Resource Rich Countries	5.0 %
North Africa	4.0 %

[23] Found at: http://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD

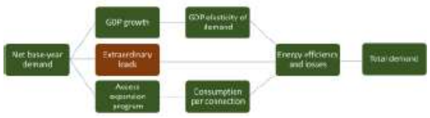
c) GDP elasticity of demand

For numbers on how demand for electricity changes as the economy grows, the GDP elasticity of demand, this study relies on the approximate results of the econometric exercise conducted by PIDA (2015). The applied numbers are found in the table below.

Annex table I GDP elasticities of demand for the different country groupings

Group	Elasticities of demand
Fragile Low-income countries	0.85
Non-Fragile Low-income countries	1.35
Intermediate Income Countries	1.20
Resource Rich Countries	1.15
North Africa	1.35

d) Extraordinary loads (exogenous demand shocks)



In a few cases, the Team has, based on available information, found that the projected GDP growth does not fully account for the potential within energy intensive industries. In these cases, presented in the table below, exogenous demand shocks are introduced into the model to reflect this potential.

Annex table J Exogenous demand shocks

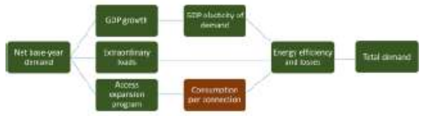
	2020-2025	2025-2030
Angola	4 000 GWh/year	8 000 GWh/year
Mozambique		4 000 GWh/year
Zambia	4 000 GWh/year	8 000 GWh/year
Zimbabwe		4 000 GWh/year

e) Access expansion program

The GDP elasticity of demand captures the access expansion that has taken place historically. However, it is clear that any program setting out to meet the access ambitions of the AfDB will entail a radical break with this historical development. Therefore, it is deemed appropriate to add the increased demand from access expansion to the forecasted organic demand growth. For a number of poor countries with low current access rates, the expansion program actually contributes the largest relative share of demand growth.

f) Average consumption per household

The applied numbers for consumption per new connection in the base-year is based on numbers from McKinsey´s 2015 Powering Africa report [24], and presented in the table below. It is assumed that demand per connection has a GDP elasticity of 1, and so grows at the same rate as the economy as a whole.

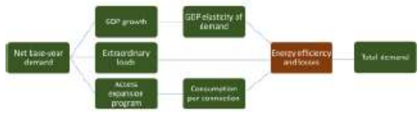


Annex table K Assumed average consumption per household in the base-year

	kWh/connection
Urban	1 200
Rural	400

g) Energy efficiency

It is assumed that the countries are able to improve the energy efficiency of their economies equal to approximately one percent of total consumption each year, applying improved technologies.



h) Transmission and distribution losses

Transmission and distribution (T&D) losses are added to the total demand. Due to the lack of credible country-specific data, the simplified loss assumption presented in the table below are applied.

Annex table L Transmission and distribution losses in 2016

Categories	T&D losses in 2016
Fragile Low-income countries	30 %
Non-Fragile Low-income countries	25 %
Intermediate Income Countries	20 %
Resource Rich Countries [25]	20 %
North Africa	15 %

In keeping with the expectations of losses being reduced as T&D investments increase and the grid is modernized, it is assumed that losses are reduced by 0.5 percentage points per year until they level out at 10 percent.

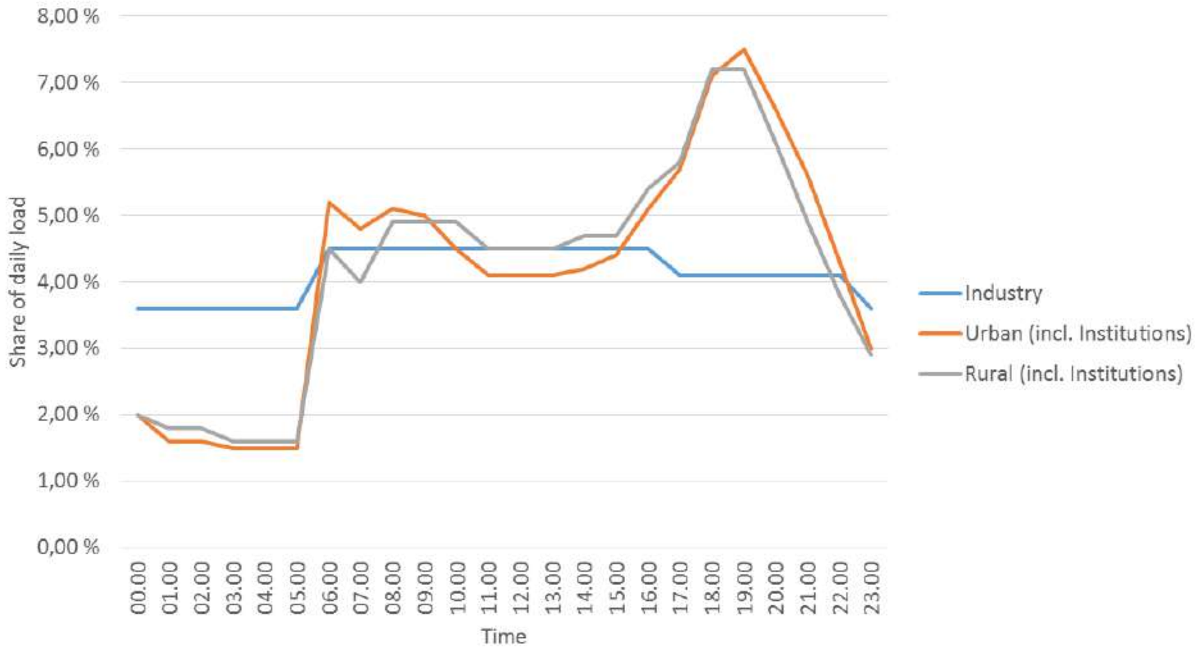
[24] Available at: http://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/powering-africa
[25] Congo is assumed to have 30 % of T&D losses in 2016 based on the team's review of a range of sources including https://data.worldbank.org/indicator/EG.ELC.LOSS.ZS

Finally, five percent inter-connector loss is assumed for flow of electricity between countries.

C. Transmission and Distribution

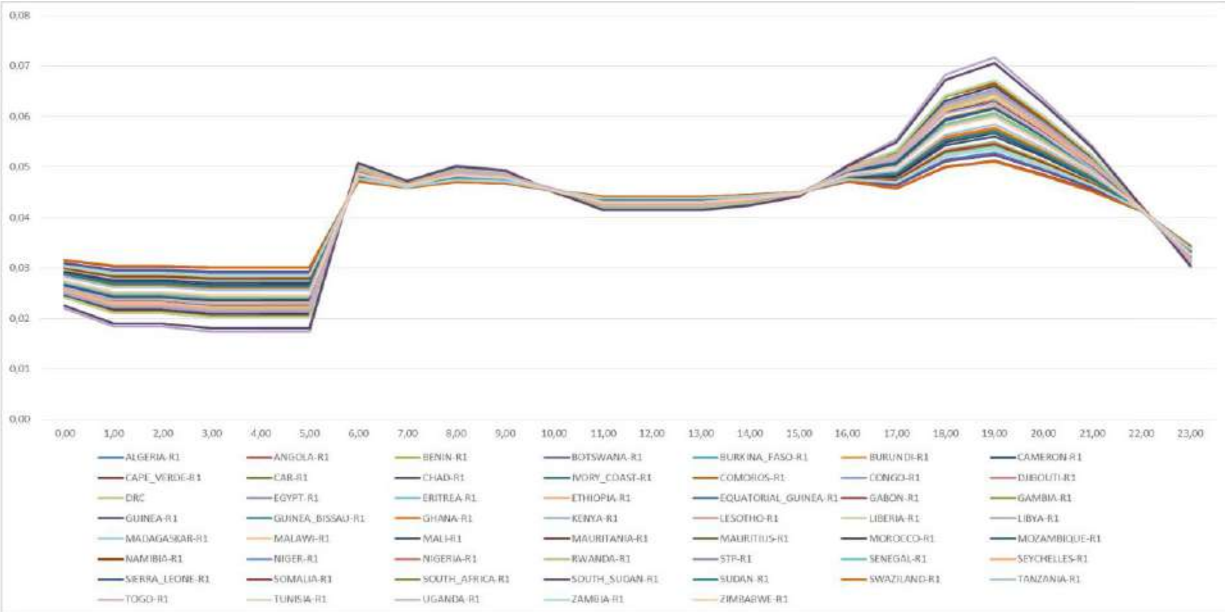
a) Daily load profiles

The daily load curves for each country are based on the generic load profiles for different consumer groups presented in the figure below.



Annex figure D Applied generic load profiles

The daily load profile applied for each country, based on their relative share of industrial, and urban/rural household/commercial/institutional consumption respectively, are found in the table below.



Annex figure E Applied daily load curves

Due to insufficient data, it has not been possible to assemble weekly/monthly/seasonal differentiated load curves.

b) Transmission and distribution costs

Investment costs in transmission and distribution infrastructure is calculated as the number of new connections per year in each country, multiplied by the assumed costs per connection. Cost per connection numbers have been arrived at following a literature review.

For urban connections, as well as rural off- and mini-grid connection, distances will not have a major impact on the cost per connection. These are therefore treated separately, as presented in Annex table N below.

Annex table M Assumed cost per connection (except rural grid-connections)

	Urban	Rural
Grid	400	See table below
Off-grid	300	300
Mini-grid	N/A	600

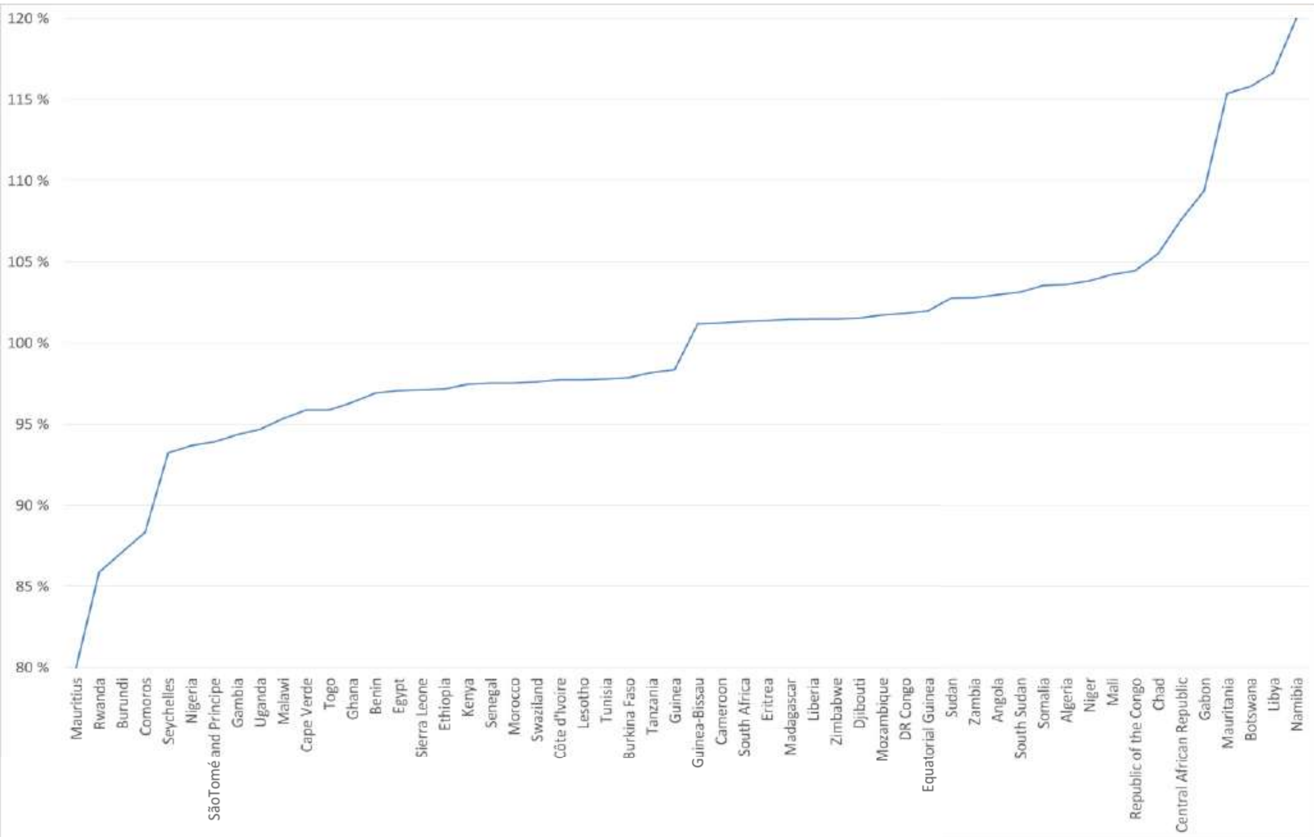
Due to the larger distances, and greater variance in population density, the marginal cost per rural grid connection will increase, building on the logic that the cheapest/easiest to reach connections are made first. Also, the population density of each country will have an impact on the cost of connection rural populations. Thus, the cost per rural grid connection is calculated separately for each country, applying a two-step approach.

First the average cost of each connection is established and applied following the generic values presented in the table below.

Annex table N Rural connection costs

Rural electrification rate	Rural electrification cost (USD)
0.0 % - 19.9 %	500
20.0 % - 39.9 %	550
40.0 % - 54.5 %	600
55.0 % - 69.9 %	650
70.0 % - 74.9 %	700
75.0 % - 79.9 %	800
80.0 % - 84.9 %	900
85.0 % - 89.9 %	1 100
90.0 % - 94.9 %	1 300
95.0 % - 100.0 %	1 500

To take account of how the population density of each country impacts the cost of connecting new rural consumers, the generic values are adjusted for each country, with +/- 20 percent depending on how they fall relative to the median population density. The actual adjustments applied are found in the figure below.



Annex figure F Adjustments of rural grid connection costs to reflect the population density of each country

Finally, T&D costs of two million USD per year is added for each country, to account for a minimal levels of investment in existing grids.

c) Inter-connector costs

Rough cost estimates for inter-connectors between countries are estimated based on costs for planned inter-connectors presented in Eastern Africa Power Pool Master Plan (2014), and the distances between the national grids of the respective neighbouring countries. The applied figures are found in the tables below.

Annex table O Rough cost estimates for inter-connectors by distance between neighbouring countries

Distance between neighbouring countries (km)	Capital expenditures (thousand USD per MWkm)
0-150	5.19
151-250	3.28
251-350	1.17
351-550	0.74
551-850	0.83
851-1750	0.62
1751-6000	0.42

Annex table P Rough investment costs for inter-connectors between neighbouring countries (million USD/MW, INF indicates that the two countries share no land boarder)

	BURUNDI	COMOROS	DRC_EAST	DRC_WEST	DRC_SOUTH	DJIBOUTI	EGYPT	ERITREA	ETHIOPIA	KENYA	MADAGASCAR	MAURITIUS	RWANDA	SEYCHELLES	SOMALIA	SOUTH_SUDAN	SUDAN	TANZANIA	UGANDA	ANGOLA	BOTSWANA	LESOTHO	MALAWI	MOZAMBIQUE	NAMIBIA	SOUTH_AFRICA	SWAZILAND	ZAMBIA	ZIMBABWE	BENIN	BURKINA_FASO	CAPE_VERDE	IVORY_COAST	GAMBIA	GHANA	GUINEA	GUINEA_BISSAU	LIBERIA	MALI	MAURITANIA	NIGER	NIGERIA	SENEGAL	SIERRA_LEONE	TOGO	CAMEROON	CAR	CHAD	CONGO	EQ_GUINEA	GABON	STP	ALGERIA	LIBYA	MOROCCO	TUNISIA
BURUNDI																																																								
COMOROS	INF																																																							
DRC_EAST	0,87	INF																																																						
DRC_WEST	INF	INF	0,34																																																					
DRC_SOUTH	INF	INF	0,39	0,66																																																				
DJIBOUTI	INF	INF	INF	INF	INF																																																			
EGYPT	INF	INF	INF	INF	INF	INF																																																		
ERITREA	INF	INF	INF	INF	INF	0,38	INF																																																	
ETHIOPIA	INF	INF	INF	INF	INF	0,34	INF	0,73																																																
KENYA	INF	INF	INF	INF	INF	INF	INF	INF	0,66																																															
MADAGASCAR	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																																														
MAURITIUS	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																																													
RWANDA	0,19	INF	0,31	INF	INF	INF	INF	INF	INF	INF	INF	INF																																												
SEYCHELLES	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																																											
SOMALIA	INF	INF	INF	INF	INF	0,57	INF	INF	0,54	0,64	INF	INF	INF	INF																																										
SOUTH_SUDAN	INF	INF	0,57	INF	INF	INF	INF	INF	0,36	0,55	INF	INF	INF	INF	INF																																									
SUDAN	INF	INF	INF	INF	INF	INF	0,59	0,33	0,23	INF	INF	INF	INF	INF	INF	0,49																																								
TANZANIA	1,73	INF	0,79	INF	0,54	INF	INF	INF	INF	0,17	INF	INF	0,16	INF	INF	INF	INF																																							
UGANDA	INF	INF	0,23	INF	INF	INF	INF	INF	INF	0,16	INF	INF	0,10	INF	INF	0,13	INF	0,45																																						
ANGOLA	INF	INF	INF	0,38	0,54	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																																					
BOTSWANA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																																				
LESOTHO	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																																			
MALAWI	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,39	INF	INF	INF	INF																																		
MOZAMBIQUE	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,50	INF	INF	INF	INF	0,18																																	
NAMIBIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,35	0,49	INF	INF	INF																																
SOUTH_AFRICA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,25	0,33	INF	0,35	0,18																															
SWAZILAND	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,51	INF	0,18																														
ZAMBIA	INF	INF	INF	INF	0,67	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,46	INF	0,70	0,35	INF	0,66	0,77	0,18	INF	INF																													
ZIMBABWE	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,52	INF	INF	0,70	0,59	0,16	INF	0,36																												
BENIN	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																											
BURKINA_FASO	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,62																										
CAPE_VERDE	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																									
IVORY_COAST	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,55	INF																								
GAMBIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF																							
GHANA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,17	INF	0,52	INF																						
GUINEA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,58	INF	INF																					
GUINEA_BISSAU	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,82																				
LIBERIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,72	INF	INF	0,53	INF																			
MALI	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,40	INF	0,74	INF	INF	0,47	INF	INF																		
MAURITANIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,52																	
NIGER	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,37	0,36	INF	INF	INF	INF	INF	INF	INF	0,57	INF																
NIGERIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,36	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,36															
SENEGAL	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,66	INF	0,33	0,27	INF	0,72	0,21	INF	INF														
SIERRA_LEONE	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,70	INF	0,30	INF	INF	INF	INF	INF													
TOGO	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,30	0,70	INF	INF	INF	0,74	INF	INF	INF	INF	INF	INF	INF	INF	INF												
CAMEROON	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,76	INF	INF	INF											
CAR	INF	INF	0,95	0,72	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,75	0,78	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,65										
CHAD	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,77	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,65	0,59	INF	INF	INF	0,93	0,59									
CONGO	INF	INF	INF	0,16	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,71	0,70	INF								
EQ_GUINEA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,33	INF	INF	INF							
GABON	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,28	INF	INF	0,49	0,55						
STP	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF					
ALGERIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	1,00	1,07	0,90	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF				
LIBYA	INF	INF	INF	INF	INF	INF	0,66	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,70	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,69	INF	INF	INF	INF	INF	INF	0,77	INF	INF	INF	INF	0,28			
MOROCCO	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,78	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,22	INF		
TUNISIA	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	0,33	0,37	INF	

D. Generation Expansion

a) Balmorel model

The Balmorel model was originally developed as part of the Danish Energy Research Program, and has been used and developed further by several European research institutions. The model is an optimization model for analysis of the power sector on a national or international level, with a high temporal and spatial resolution. Balmorel is a partial equilibrium model, simulating generation, transmission and consumption of electricity. The model calculates the electricity generation per technology, time unit and region, maximizing a consumer's utility function minus the cost of electricity generation, transmission and distribution.

The Balmorel model enables both (user-defined) high temporal and spatial detail levels, detailed modelling of thermal and hydropower, as well as modelling of endogenous investments in new power capacities, inter-connectors and storage technologies. Key aspects of the Balmorel power model are:

1. Balmorel optimises production and inter-connector possibilities for one or several regions, enabling detailed modelling of different pathways for the African power sector.
2. Balmorel includes a detailed investment module, which makes it well suited for investigating and optimizing investment needs in a specific country or region.
3. Balmorel has a high resolution in time, enabling it to capture the multiple time series of a power system, including the short-term variation in demand and the supply from variable renewable energy sources like wind and solar, as well as the hydro reservoir dynamics.
4. The structure of the Balmorel model is highly flexible. It can be used on a regional, national and international level, and can easily be extended with new regions and countries.
5. Balmorel is particularly well adapted for and has been used in several analyses of integration of renewable power and the effect of renewable energy sources on the power sector.
6. The model inputs and optimization are particularly transparent and thus well placed as a model for an institution as the AfDB.
7. The model is well adapted to import large amount of data for different regions in an excel-format. The gathering of data in the format of excel sheets gives a useful database, open for everyone, not demanding special licences or advanced computer skills.
8. Balmorel is a proven, tested and internationally recognized model. It has previously been applied to a wide range of energy system analyses. Some applications of Balmorel that focus on investment optimization in clude: detailed analyses of wind power investments in Europe, optimal investments in new production capa city in a multi-regional electricity markets, optimization of investment and production costs for waste conver sion technologies, and modelling of the Norwegian-Swedish tradeable green certificates market.
9. The application of the Balmorel model enables comprehensive high-resolution modelling of the African power system, ensuring that the AfDB contributes to new insights and value added to this arena.

b) Assumptions applied in the investment model

Because the optimization model is designed to minimize total system costs, it does not inherently reflect certain technical or practical restrictions that may exist. To reflect reality the following restrictions on investments were applied:

1. Investments in 2020

In 2020 investments in any type of resources (solar, wind, natural gas, coal etc.) for all countries, except island countries, are limited to 20% of their installed capacity in 2016. For countries with installed capacity below 250 MW in 2016, the maximum limit on the investments in 2020 is set to 50 MW.

2. Investments in solar power

In all modelled years, investments in solar power are limited to 8,000 MW in countries such as Egypt, South Africa, Algeria, Libya and Morocco. Gross investments for every island country except Madagascar are limited to 500 MW. All other countries could invest in a maximum of 3,000 MW in 2025 and 4,000 MW in 2030.

3. Investments in wind power

In all modelled years, investments in wind power are limited to 5,000 MW in countries such as Egypt, South Africa, Algeria, Libya and Morocco. Investments are eliminated in countries with small territories (Burundi, Rwanda, Lesotho and Swaziland). Moreover, gross investments for every island country except Madagascar, as well as for countries with small territories but a coastline, are limited to 50 MW. All other countries could invest in a maximum of 2,000 MW in 2025 and 2030.

4. Share of solar and wind power

Share of power produced from solar and wind power plants out of total domestic power production is assumed to not exceed 20% in 2020, 25% in 2025 and 30% in 2030.

5. Investments in thermal power plants

Investments in geothermal power plants in Kenya are limited to 2,000 MW in 2025 and 2030. For Ethiopia investments in geothermal power plants are limited to 1,500 MW in 2025 and to 1,800 MW in 2030. Angola and Mozambique are assumed to have zero investments in natural gas until 2025. In Egypt, investments in coal in 2020 are limited to 2,000 MW. In South Africa investments in coal are eliminated in 2020 and limited to 6,580 MW in 2025. Furthermore, South Africa is assumed to have a nuclear potential of 9,600 MW with a maximum investment of 1,800 MW in 2020.

6. Investments in inter-connectors

Minimum allowed investment in inter-connectors is set to 100 MW. Maximum allowed investment in inter-connectors is 1,000 MW in 2020 and 2,000 MW in 2025 and 2030.

7. Minimum possible investments

Minimum investment allowed in onshore wind is set to 20 MW, in biomass power plants – 10 MW, in coal power plants – 100 MW and in natural gas power plants (except simple cycle gas turbines) – 30 MW.

8. Storage share of batteries

It is assumed that batteries can be used for storing a maximum of 25% of power generated from wind, solar and hydro run-of-the-river in 2025 and a maximum of 40% of power generated from wind, solar and hydro-run-of-the-river in 2030.

9. Regulating reserves

Regulating reserves introduced in the model are split into two categories – spinning and non-spinning reserves. Both types of reserves could be covered by power from hydro reservoirs, diesel, fuel oil and natural gas power plants. It is assumed that in every hour a country requires spinning reserves equal to a sum of 3% of demand including T&D losses and 5% of power produced from solar, wind and hydro run-of-the river. At the same time, non-spinning reserves are equal to a sum of 13% of demand including T&D losses and 5% of power produced from solar, wind and hydro run-of-the river.

c) Generation technologies

It is assumed that all thermal generation technologies that exist and are under construction (existing power plants) except those that are run on diesel have a 90% availability factor. Existing power plants have the same operating and maintenance (O&M) costs as future power plants presented in the table below. Low speed diesel engines, gas turbines run on diesel and fuel oil as well as combined cycle gas turbines run on diesel are included in the model as an existing technologies.

Existing power plants are split into three equal groups with different fuel efficiencies. Medium speed diesel power plants are assumed to have fuel efficiency that are 10%, 20% and 30% lower than efficiency of future power plants of the same type. Existing biomass power plants have fuel efficiency 10% lower than for future biomass power plants. Existing geothermal and nuclear power plants have the same efficiency as future power plants. All other existing thermal power plants are assumed to have fuel efficiencies that are 5%, 15% and 25% lower than efficiency of future power plants.

Annex table Q Applied costs and fuel efficiency of future thermal generation technologies [26]

	Fuel type	Fuel efficiency (%)	Capital expenditures (million USD/MW)	Fixed O&M costs (thousand USD/MW)	Variable O&M costs (USD/MWh)
Medium speed diesel engine	Diesel, fuel oil	45 %	1.67	22.78	1.90
Steam thermal power plant	Diesel, fuel oil, natural gas	44 %	1.49	46.90	3.91
	Methane	44 %	2.20	46.90	3.91
	Biomass	38 %	3.00	46.90	3.91
Simple cycle gas turbine	Natural gas	38 %	0.63	21.32	1.78
Combined cycle gas turbine	Natural gas	59 %	1.20	26.65	2.23
Subcritical steam coal	Coal	35 %	1.88	46.90	3.91
Supercritical steam coal	Coal	40 %	2.30	65.84	5.54
Nuclear power	Uranium	33 %	10.41	146.30	0.00
Geothermal	Heat	35 %	4.49	45.20	3.23

[26] Based on Eastern Africa Power Pool Master Plan (2014), West African Power Pool: Planning and Prospects for Renewable Energy by IRENA (2013), Construction Intelligence Center (2017), Efficiency in Electricity Generation by EURELECTRIC & VGB (2003).

Hydro potential (in MW) for each country is split into three equal groups with different cost levels. The first group of projects is assumed to have the lowest capital expenditures (cost level 1), and the costs are assumed to increase by 15% (cost level 2) and 25% (cost level 3) for the second and third groups. Moreover, there are three groups of countries that have different initial levels of capital expenditures, as displayed in the table below.

Existing hydro power plants, as well as those under construction, are assumed to have the same operating and maintenance (O&M) costs as future hydro projects presented in the table below. Hydro reservoirs in most of the countries are assumed to have an active storage of 2 weeks. Among countries that have reservoirs with 4 weeks of active storage are Ethiopia, Mozambique and Zambia. Hydro reservoirs in Democratic Republic of Congo (West) are assumed to have 1 week of active storage.

Annex table R Applied costs of future hydro power plants[27]

Country group	Cost level	Capital expenditures (million USD/MW)	Fixed O&M costs (thousand USD/MW)	Variable O&M costs (USD/MWh)
Angola	1	2.09	47.58	3.40
	2	2.40	47.58	3.40
	3	3.00	47.58	3.40
Cameroon, Democratic Republic of Congo (West), Ethiopia, Mozambique, Zambia	1	2.55	47.58	3.40
	2	2.93	47.58	3.40
	3	3.67	47.58	3.40
Other African countries	1	3.00	47.58	3.40
	2	3.45	47.58	3.40
	3	4.31	47.58	3.40

Solar and wind power plants have zero variable O&M costs. Future concentrated solar projects are assumed to have efficiency of 98% and storage capacity of 7 hours. Data on hourly viability of solar and wind power is extracted from Renewables.ninja.

Existing solar photovoltaic projects have O&M costs of 26.05 thousand USD per MW, and existing wind power plants have 48.60 thousand USD per MW. Existing concentrated solar power plants have either no storage capacity or project-specific storage capacity ranging from 2 to 9.3 hours. O&M costs of existing concentrated solar power plants range from 35.20 to 39.20 thousand USD per MW.

[27] Based on Eastern Africa Power Pool Master Plan (2014) and Construction Intelligence Center (2017).

Annex table S Applied costs of future solar and wind power plants[28]

	Capital expenditures (million USD/MW)	Fixed O&M costs (thousand USD/MW)
Solar photovoltaic 2020	0.85	18.06
Solar photovoltaic 2025	0.69	18.06
Solar photovoltaic 2030	0.60	18.06
Concentrated solar power 2020	3.87	36.00
Concentrated solar power 2025	3.37	34.00
Concentrated solar power 2030	3.13	32.00
Onshore wind 2020	1.33	47.52
Onshore wind 2025	1.28	46.19
Onshore wind 2030	1.23	44.91

Investments in battery technologies presented in the table below are allowed in 2025 and 2030. The battery technologies have a degradation rate of 10% over 5 years and zero O&M costs.
Existing hydro pumped storages are modelled in the same way as the battery technologies. Hydro pumped storages in Southern Africa have efficiency of 74%, while hydro pumped storages in Morocco have efficiency of 76%. Operating and maintenance costs for hydro pumped storage are assumed to be the same as for other hydro projects.

Annex table T Applied costs and efficiency of future battery technologies[29]

	Efficiency (%)	Capital expenditures (million USD/MW)	Hours to load/unload storage
Lead-acid 2025	83 %	0.14	3, 5, 8
Lead-acid 2030	84 %	0.10	3, 5, 8
Lithium-ion 2025	96 %	0.38	3, 5, 8
Lithium-ion 2030	97 %	0.25	3, 5, 8

[28] Based on Bloomberg New Energy Finance (2016), Solar Thermal Electricity Global Outlook by Solar PACES, Greenpeace, ESTELA (2016), Forecasting Wind Energy Costs & Cost Drivers by IEA Wind (2016).

[29] Based on Electricity Storage and Renewables: Costs and Markets to 2030 by IRENA (2017).

d) Fuel prices [30]

There are two groups of countries that are assumed to have lower price for natural gas than the price presented in the table below. The first group consists of countries that produce natural gas and therefore are assumed to have twice lower natural gas price. Among them are Algeria, Angola, Cameroon, Côte d'Ivoire, Egypt, Equatorial Guinea, Ghana, Libya, Mozambique, Nigeria, Congo, Tanzania and Tunisia. Countries categorized in the second group are assumed to have a medium price level for natural gas. Among them are Benin, Morocco and Togo, countries that have a good existing infrastructure for supply of natural gas, as well as Mauritania, which has potential for natural gas production yet lacks facilities.

Annex table U Applied fuel prices (USD/MWh)

	Fuel oil	Natural gas	Coal	Diesel	Methane	Biomass	Nuclear
2016	35.4	33.4	8.2	83.2	0.0	5.9	3.9
2017	39.2	33.2	8.5	89.5	0.0	5.9	3.9
2018	42.9	33.1	8.7	95.8	0.0	5.9	3.9
2019	46.6	32.9	9.0	102.1	0.0	5.9	3.9
2020	50.4	32.8	9.2	108.4	0.0	5.9	3.9
2021	53.2	33.8	9.4	111.4	0.0	5.9	3.9
2022	56.1	34.9	9.6	114.4	0.0	5.9	3.9
2023	58.9	35.9	9.8	117.3	0.0	5.9	3.9
2024	61.8	36.9	10.0	120.3	0.0	5.9	3.9
2025	64.7	38.0	10.3	123.3	0.0	5.9	3.9
2026	67.5	39.0	10.5	126.3	0.0	5.9	3.9
2027	70.4	40.1	10.7	129.2	0.0	5.9	3.9
2028	73.3	41.1	10.9	132.2	0.0	5.9	3.9
2029	76.1	42.1	11.1	135.2	0.0	5.9	3.9
2030	79.0	43.2	11.3	138.2	0.0	5.9	3.9

[30] Based on IEA World Energy Outlook (2016), Harnessing African Natural Gas by Economic Consulting Associates (2016), West African Power Pool by IRENA (2017), http://www.globalpetrolprices.com/

e) Hydropower potential (MW)

The hydropower potential of different countries is established using Construction Intelligence Center (2017), Eastern Africa Power Pool Master Plan (2014), West and South African Power Pools: Planning and Prospects for Renewable Energy by IRENA (2013) and other country-specific sources.

Annex table V Economic hydropower potential applied in the study

	Reservoir	Run-of-river
Algeria	124	130
Angola	3 356	255
Benin	160	
Burkina Faso	166	140
Burundi	154	32
Cameroon	2 918	3 068
Central African Republic		2 000
Congo		2 500
Democratic Republic of Congo	96	41 216
Equatorial Guinea		400
Ethiopia	12 438	22 573
Gabon		453
Gambia	25	42
Ghana	462	
Guinea-Bissau	5	9
Guinea	3 326	15
Ivory Coast	2 377	242
Kenya	90	151
Lesotho	100	110
Liberia	200	

	Reservoir	Run-of-river
Madagascar	712	1 921
Malawi	227	950
Mali	303	54
Mauritius	17	1
Morocco	233	92
Mozambique	2 575	1 500
Namibia	600	220
Nigeria	1 618	3 500
Niger	278	
Rwanda	114	12
Senegal	335	141
Sierra Leone	749	6
South Africa	2 240	
South Sudan	2 147	25
São Tomé and Príncipe	12	2
Sudan	2 272	
Swaziland	15	
Tanzania	3 163	522
Togo	50	2
Tunisia	19	10
Uganda	1 928	154

	Reservoir	Run-of-river
Zambia	1 410	1 750

	Reservoir	Run-of-river
Zimbabwe		1 100

f) Thermal potential (MW)

The thermal potential of different countries is established using Construction Intelligence Center (2017), Eastern Africa Power Pool Master Plan (2014), West and South African Power Pools: Planning and Prospects for Renewable Energy by IRENA (2013) and other country-specific sources.

Annex table W Thermal potential of different countries

	Methane	Heat	Natural gas	Coal	Biomass
Algeria					150
Angola			2 000		27
Benin			760	200	42
Botswana				2 695	15
Burkina Faso					109
Burundi					11
Cameroon			729		63
Cape Verde					
Chad					45
Comoros		40			
Djibouti		50			
Democratic Republic of Congo	100			500	54
Egypt				14 000	799
Equatorial Guinea			100		
Ethiopia		4 995			594
Gambia					
Ghana			2 317	2 400	73
Guinea				340	43
Guinea Bissau					

	Methane	Heat	Natural gas	Coal	Biomass
Ivory Coast			2 592	700	83
Kenya		8 799	358	960	102
Liberia				350	
Libya				230	
Madagascar				100	127
Malawi				220	69
Mali					107
Mauritania			350		
Mauritius					60
Morocco			2 400	1 320	323
Mozambique			4 000	5 470	75
Namibia			885	300	60
Niger					100
Nigeria				7 980	854
Rwanda	206	310		100	92
São Tomé and Príncipe					
Senegal			433	960	41
Seychelles					
Sierra Leone					12
South Africa			2 000	11 980	463
South Sudan					100
Sudan			900	534	37
Swaziland				1 000	
Tanzania		200	3 945	1 670	188
Togo					30
Tunisia			1 750		81
Uganda		296	50		98
Zambia				600	51

	Methane	Heat	Natural gas	Coal	Biomass
Zimbabwe				5 500	31

g) Full load hours

Annex table X Full load hours applied for hydro, solar and wind power plants (existing and new) [31]

	Hydro reservoir		Hydro run-of-the-river		Solar	Wind
	Existing	New	Existing	New	Existing & new	Existing & new
Algeria	1 455	1 455	2 064	2 064	2 010	3 500
Angola	5 448	5 448	5 448	5 448	1 900	2 500
Benin	0	3 063	0	0	1 600	2 500
Botswana	0	0	0	0	1 950	3 000
Burkina Faso	4 335	2 500	2 389	2 389	1 700	2 500
Burundi	4 802	4 879	5 515	4 422	1 600	2 500
Cameroon	4 740	4 896	0	6 030	1 675	2 500
Cape Verde	0	0	0	0	1 710	3 000
Central African Republic	6 414	6 414	0	6 414	1 710	2 500
Chad	0	0	0	0	2 060	3 500
Comoros	0	0	0	0	1 650	3 000
Congo	5 725	5 725	5 725	5 725	1 470	2 500
Côte d’Ivoire	4 143	4 964	3 800	4 216	1 600	2 500
Djibouti	0	0	0	0	1 810	3 500
DRC East	5 410	4 892	5 585	5 545	1 570	2 250
DRC South	5 286	0	3 327	6 185	1 760	2 250
DRC West	3 686	0	6 240	6 841	1 500	2 250
Egypt	4 869	4 869	0	0	2 080	3 500
Equatorial Guinea	4 347	4 347	4 347	4 347	1 370	2 500
Eritrea	0	0	0	0	1 920	3 000

[31] Based on Eastern Africa Power Pool Master Plan (2014), West and South African Power Pools: Planning and Prospects for Renewable Energy by IRENA (2013), global solar and wind atlases from the World Bank.

	Hydro reservoir		Hydro run-of-the-river		Solar	Wind
	Existing	New	Existing	New	Existing & new	Existing & new
Ethiopia	2 984	4 759	4 262	5 002	1 940	3 000
Gabon	4 834	4 834	4 834	4 834	1 340	2 500
Gambia	0	3 528	0	3 629	1 660	2 500
Ghana	4 128	4 283	6 111	6 111	1 570	2 500
Guinea	3 788	4 272	4 059	6 582	1 650	2 500
Guinea-Bissau	0	3 540	0	3 563	1 610	2 500
Kenya	4 808	2 615	6 023	5 075	1 820	3 000
Lesotho	5 750	5 750	4 000	4 000	1 890	3 000
Liberia	0	5 500	4 872	4 872	1 460	2 500
Libya	0	0	0	0	2 030	3 500
Madagascar	2 500	2 500	5 746	5 746	1 880	3 000
Malawi	5 539	5 539	2 250	5 539	1 780	3 000
Mali	4 317	3 583	5 997	5 151	1 820	3 000
Mauritania	4 031	4 031	0	0	1 860	3 500
Mauritius	1 170	1 292	2 787	3 400	1 700	3 000
Morocco	1 506	1 772	1 136	1 141	1 970	3 500
Mozambique	6 024	6 024	6 468	6 468	1 690	3 000
Namibia	5 813	5 813	0	5 813	2 050	3 000
Niger	0	4 565	0	0	1 990	3 000
Nigeria	4 720	4 720	0	4 720	1 740	2 750
Rwanda	5 293	4 756	6 786	6 786	1 500	2 500
São Tomé & Príncipe	0	4 136	4 136	4 136	1 410	2 500
Senegal	4 028	3 672	5 833	3 604	1 710	2 500
Seychelles	0	0	0	0	1 560	3 000
Sierra Leone	5 800	5 524	5 133	5 133	1 560	2 500
Somalia	0	0	0	0	1 940	3 500
South Africa	3 035	3 035	3 035	3 035	2 020	3 000

	Hydro reservoir		Hydro run-of-the-river		Solar	Wind
	Existing	New	Existing	New	Existing & new	Existing & new
South Sudan	0	4 484	0	4 489	1 700	2 500
Sudan	4 403	4 321	0	0	2 010	3 000
Swaziland	3 258	2 976	0	0	1 630	3 000
Tanzania	4 851	4 282	4 925	4 925	1 880	3 000
Togo	2 657	2 960	3 194	3 194	1 560	2 500
Tunisia	1 109	1 109	1 176	1 176	1 830	3 500
Uganda	5 266	5 967	5 019	5 882	1 750	2 500
Zambia	5 714	5 714	5 962	5 962	1 800	2 500
Zimbabwe	5 333	5 333	0	5 333	1 860	2 500

h) Climate gas emissions

The technology specific climate gas emissions assumed in the modelling are presented in the table below.

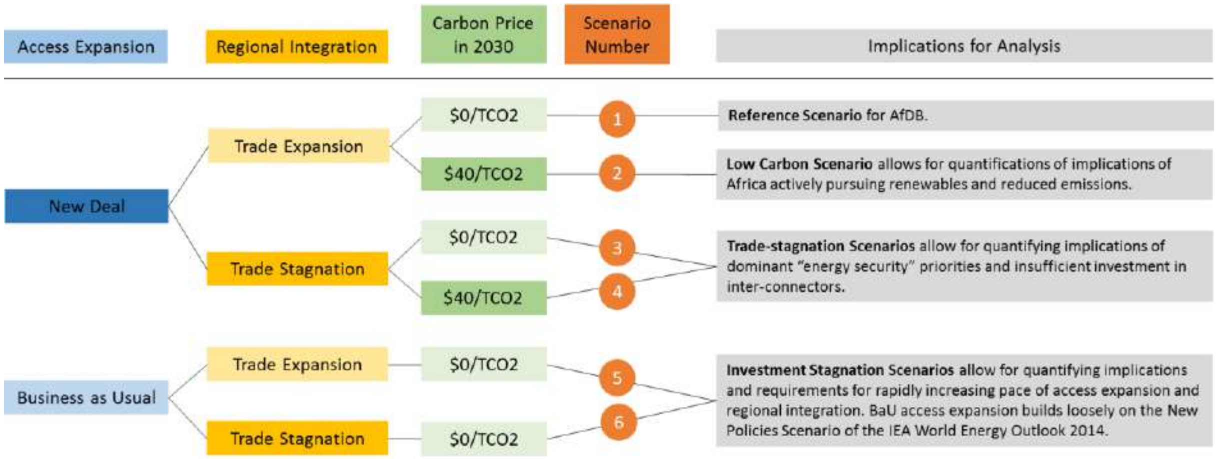
Annex table Y Applied climate gas emissions for different generation technologies[32]

	Kilo of CO_2-equivalent per Giga Joule
Coal	95
Fuel oil	78
Diesel	74
Natural gas	57
Methane	49
Biomass	0
Nuclear	0

[32] Based on Eastern Africa Power Pool Master Plan (2014), West and South African Power Pools: Planning and Prospects for Renewable Energy by IRENA (2013), global solar and wind atlases from the World Bank.

i) Scenarios modelled in the study

As depicted in the figure below, six scenarios in total are modelled in this study. Four of the scenarios are deemed to be the most representative when analysing effect of trade stagnation, the low carbon development and the business-as-usual path. For that reason, scenarios number 1-3, and 5 are outlined and discussed in detail in the report.



Annex figure G Scenarios analysed in the study