SUSTAINABLE ENERGY FOR ALL

Assessing Grids in Africa

Supporting data-driven decision making to drive implementation of the COP29 Global Energy Storage and Grids Pledge.

March 2025

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1 | Background & Purpose

Background

At COP28 in December 2023, 123 signatories signed the Global Renewables and Energy Efficiency Pledge, promising tripling renewable energy and the doubling of energy efficiency by 2030.

A pre-requisite for achieving the pledge includes a rapid development of electricity grid infrastructure and transformation of the existing grids to accommodate higher capacity of fluctuating outputs from solar and wind energy projects. The need for resilient grid stems from the sheer scale and pace necessary to achieve the tripling renewable energy capacity, which will increase global renewable energy capacity from 3,870 GW in 2023[1] to reach at least 11,000 GW by 2030 or an average of more than 1,000 GW of renewable energy additions per year. This scale requires more than twice the record high 473 GW of renewable energy annual capacity additions in 2023, which was already a 60% increase from the 295 GW additions in 2022.

However, transmission and distribution networks, which are the backbone of power systems, are increasingly limiting the timely delivery of renewable energy and causing new renewable energy generation to wait for grid connection in many parts of the world. While no curtailment issues are reported in the African countries reviewed in this project, building resilient and efficient grid systems at speed will expedite renewable energy deployments to deliver on climate and development goals. Investing in grid and mini-grid infrastructure can future proof energy systems for extreme weather events and shifting energy demand needs, while also flexible enough to adapt to variable renewable energy.

Countries have an opportunity to provide leadership on resilient and efficient electricity grids by committing to the Global Energy Storage and Grids Pledge. Initially only 2 countries from Africa committed to the pledge at COP29, while there are now there are 7 out of the 54 countries from Africa committed to the pledge. By making more data and information available, our goal is to support more country commitments to the Pledge and support an action agenda on grids through COP30.

Note: IRENA (2024), Renewable capacity statistics 2024, International Renewable Energy Agency, Abu Dhabi.
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf

Purpose of the Project

A new impetus on grids is emerging in the climate and energy community under the realization as mentioned above. Governments, industry and financiers are all ramping up efforts. However, to support such efforts, understanding and tracking the state of electricity grids is essential for policy and investment decision making and the first step toward developing resilient and efficient power grid. Establishing an assessment methodology and identifying and collecting useful data for the assessment are critical for such decision making.

This project aims at developing an initial assessment concept and framework, identifying critical indicators, finding data gaps, testing the pilot examination, and learning lessons that can inform future assessments. Learning and insight gained from this project will be fed into the future methodology improvement and indicator selections / categorization based on stakeholder perspectives. In long-term, the learning from this project supports providing a diagnostic that would help policymakers and development organizations focusing on removing major bottlenecks towards green and resilient grids and support investors / financiers and private sector players identifying opportunities.

This project focuses on initial data examination of a selection of countries in Africa with economic, institutional, environmental, social and technical indicators, considering data availability mainly through publicly available, open-source datasets. The aim is to develop an assessment framework that can be consistent but evolve and be replicable across regions and countries globally while enabling better data definition, data collection.

The same assessments are tested in Asian context by the United Nation’s Economic and Social Commission for Asia and the Pacific (UN ESCAP) and in Latin American context by PSR in Brazil.

Objectives of the Project

- The main objective of this project is to develop a grid assessment methodology and framework that is ***consistent, easily scalable, adjustable and replicable*** **1) across different countries and regions**; and **2) over time to track the advancement of each country's grid status** related to clean energy transition, including variable renewable energy (VRE) integration to the grid.
- Another objective of the project is to test data availability, level of robustness of indicators, and consistency and replicability of assessments across countries with diverse backgrounds and contexts in different regions.
- Another objective of the project is to test the use of **macro-level and publicly available open-source data and indicators to test their usability and usefulness** for assessing grids.
- The project was also conducted to **learn lessons** in terms of framework implementation and **identify issues in data collection and application**.

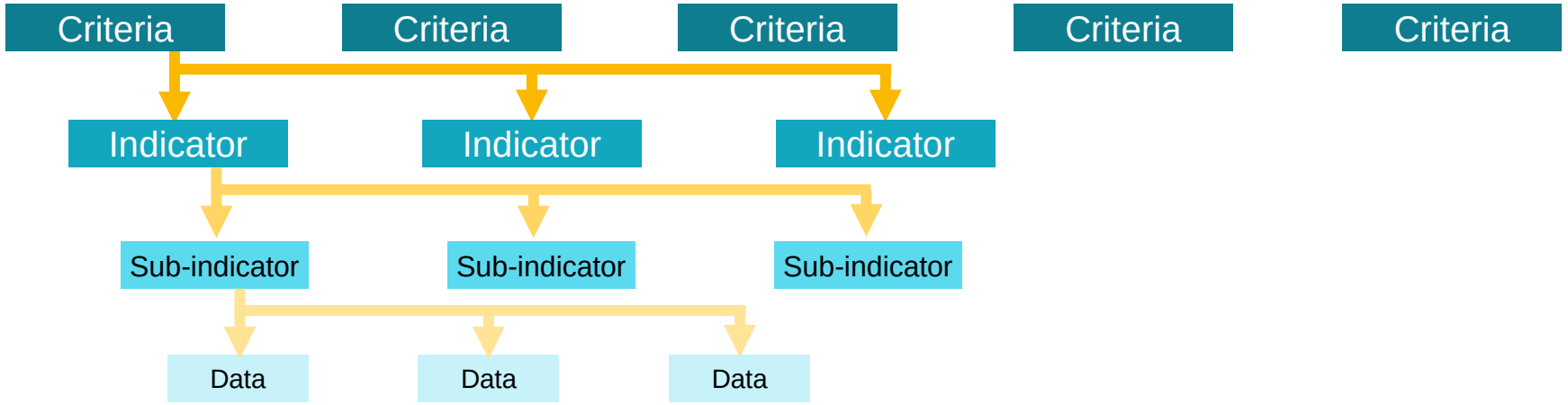
2 | Methodology

Methodology – Grid Assessment Framework Concept

The country grid assessment framework uses a hierarchy of **1) a set of criteria** and **2) indicators and data to assess the criteria.**

- **Consistency:** the set of assessment criteria provides clear consistency for objectives and category of assessment even if different indicators are applied for different countries.
- **Scalability:** the number of indicators in each criteria can be easily expanded, considering each country's institutional settings although it the scalability is subject to data availability.
- **Adjustability:** the choice of indicators can be easily adjusted to country and regional contexts, considering data availability, data definitions and methodology, and appropriateness to country and region –specific conditions, as assessment criteria keeps consistency and objectives intact.
- **Replicability:** Utilizing consistent assessment criteria and reliable multi-year country data from both international and national sources make the assessment replicable across countries and over multi-year time frame.

Hierarchy



Methodology – Grid Assessment Framework Concept (cont'd)

- To simplify the assessment, **five assessment criteria** are chosen for the assessment to cover the current institutional and enabling environment as well as the status / characteristics of physical assets and operational status of the transmission network / grid.
  - **The five areas cover the basic aspects** that impact the transmission power grid regarding renewable energy integration and clean energy transition.
  - The criteria covers the power sector's general characteristics in physical and institutional aspects, supply side aspects (grid development and grid operation), demand side aspects (consumer services) and environmental and social impacts of grid development and utilization.
- **Criteria categorization can be flexible** and modified and related indicators can be re-categorized based on criteria categorization that are **based on stakeholder / assessment user perspectives**.
  - The criteria and indicator groupings can be changed and tailor-made for assessment for policy makers and regulators, development organizations, and investors / financiers, and private sector players who seek opportunities for grid project involvement.
- Some sub-indicators and data can be used for multiple criteria and indicator assessment.

Methodology – Five Grid Assessment Criteria Categories

The following five assessment criteria categories are selected as the essential criteria to assess the power and transmission status and readiness for projects and investment.

Policy and Market Structure	*Grid Development Ecosystem*	*Grid Operations*	*Grid Services to Consumers*	*Sustainability and Just Transition*
• Political commitment • Institutional structure • Electricity markets and regulations • Electricity capacity and generation mix • Variable & non-synchronous assets • Energy security & system flexibility	• Grid mix: mini-grid, transmission, distribution • Regional interconnectors • Grid planning and procedures • Investment ecosystem for grid development • Timeline, tariffs, transparency risks • Private sector participation	• Institutional setting and procedures for grid's technical operation • Grid reliability and efficiency • Economic dispatch: grid utilization, renewable energy evacuation • Grid digitalization	• Service quantity - provision of electricity access and consumption • Service quality - reliability of services • Affordability of power	• Environmental law and regulations • Inclusive development – public engagement • Carbon intensity of sector

Methodology – Grid Assessment Key Indicators by Criteria Category

The following primary indicators are used to examine the **status and readiness of electricity grids toward a clean energy transition** and to show the status and trends (in both speed and direction of change for the future) relevant to renewable energy integration in power system. They are also chosen because of their universality for **regions and countries with different contexts and levels of grid, institutional and developmental status.**

Criteria	List of Key Indicators
Policy & Market Structure	▪ Renewable energy (RE) share ▪ Variable renewable energy (VRE) share in power system (%, installed capacity) ▪ Annual average growth ratio of VRE installed capacity (%, installed capacity, over 5 years) ▪ Annual average growth ratio of electricity demand (%, electricity energy consumption, over 5 years) ▪ Power flexibility (total) (World Economic Forum (WEF) Energy Transition Index –Flexibility in electricity system) ▪ Demand projection (2030) based on a country's system plans / projections ▪ Supply target (2030) based on a country's system plans / projections ▪ Existence of transmission grid target / strategy in national policy / planning documents or NDC ▪ Existence of independent regulatory body / regulated status (Y/N)
Grid Development Ecosystem	▪ Transmission transformer capacity (MVA) ▪ Transmission circuit length (km) ▪ Average annual growth ratio of transmission circuit length (%, over 5 years) ▪ Current interconnections capacity (MW, known) ▪ VRE in transmission connection queue (MW) ▪ Economic regulation – clear grid tariff determination method & its cost reflectiveness ▪ Private participation / investment status in transmission asset development (Y/N)
Grid Operations	▪ Grid loss (total - transmission and distribution combined, %) ▪ RE curtailment ratio in transmission (%) ▪ RE priority dispatch (Y/N)
Grid Services to Consumers	▪ Electricity access (% of population) ▪ SAIFI (System Average Interruption Frequency Index) ▪ SAIDI (System Average Interruption Duration Index) ▪ Existence of consumer tariff subsidy / pricing support (Y/N)
Sustainability & Just Transition	▪ Environmental and Social impact Assessment (ESIA) process for transmission grid projects (Y/N) ▪ Established public consultation / compensation framework and procedure (Y/N) ▪ Carbon intensity of power sector (g CO2eq/Wh/yr)

Methodology – Africa Regional Key Indicators & Distribution Grid Indicators

Regional key indicators

In addition to the primary Indicators, the following indicators are selected **as primary regional indicators for Africa,** as they are important for African context. They are selected because many African countries are still aiming at achieving universal electricity access while Asia and other regions have largely achieved this goal. They are important as the advancement of electricity access and per capita electricity consumption, leading to enhanced economic and social development in Africa, is directly contingent on grid expansion and its service affordability.

Criteria	Key Indicators for Africa
Grid Services to Consumers	▪ Electricity consumption per capita (kWh/yr/capita) ▪ Average residential tariff (USD/kWh)

Distribution grid indicators

Although this project focuses on testing the concept on transmission network data, distribution network is increasing its significance in building resiliency and efficiency of the future grid. Distribution grid has been essential as it is the network that delivers electricity services to final consumers. However, the significance of distribution grid is rapidly growing because small-scale distributed renewable power plants, demand-side management assets and small-scale energy storage including electric vehicles are all connected to and need to be operated on distribution grid, in collaboration with transmission grid for VRE integration. Considering these dimensions and the future expansion possibility of the project concept and framework, the following indicator data are shown in each country profile.

Criteria	Distribution Grid Indicators
Grid Development Ecosystem	▪ Distribution transformer capacity (MVA) ▪ Distribution overhead and cable length (km) ▪ Annual average growth ratio of distribution line length (%) ▪ Distribution grid loss (% of power generation, technical and commercial)

Project Learnings on Data and Indicator Framework in Africa (1/3)

Utilization of open-source data

- Setting a common set of assessment criteria and indicators helps to examine countries in a relatively consistent manner both quantitatively and qualitatively.
- Relatively good open-source international and global datasets are available for many indicators (in particular, quantitative data) through trustworthy organizations with the consistent and clear definitions and data / indicator constructing methods. They provided excellent and consistent data across countries.

Limited scope and coverage of criteria and indicators

- Due to time limitation, this current project heavily relied on publicly available, open-source datasets and documents, and the scope and coverage of indicators / assessed dimensions, thus, may need to be further strengthened and expanded in the future.

Limitation of macro-level indicator examination

- Macro-level indicators cannot capture the reality of a country's power system and grid conditions and the enabling environment. Therefore, this type of method should be considered as additional layer of assessment within more comprehensive assessment that also requires engineering-based power flow analysis and deeper institutional assessment to consider each country's setting / context.

Criticality of detailed qualitative examination

- For assessment of policy, regulatory, and institutional enabling environment, it is important to examine the scope / coverage as well as the detailed contents. Each country has different ways and levels of elaboration of economic regulations (e.g., tariff setting methodologies and grid codes). These aspects cannot be easily quantified. Moreover, policy and regulatory environment is always in progress. Although a snapshot cannot describe some progresses in making, such advancement should also be considered in the assessment. All these issues strongly necessitate qualitative assessment.

Robustness of examination

- Time limitation to cover many relevant aspects of the power system in each country and missing data and indicators, the limited scope and coverage of indicators and assessed dimensions, and missing information on policy and regulatory implementation reduce the robustness of the overview / examination, making it inappropriate / undesirable to make value judgement and recommendations based on the limited information base.

Project Learnings on Data and Indicator Framework in Africa (2/3)

Africa data gaps and discrepancies

- There are various data gaps identified for each country, while the global databases are not always updated as often as desired.
- Internationally available open-source data was immensely valuable, but they need to be checked against national data from each country to fill data gaps, update obsoleteness, and find discrepancy for further investigation.
    - There are discrepancies in system size / power installed capacity data between international data sources and national statistics/ documents.
        - ✓ Large discrepancies need special attention and examination of the causes, as examined in the Nigeria's power system size discrepancy found in US EIA data between 2020 and 2021 as well as US EIA data and national document / statistics data.
        - ✓ Similar but much smaller discrepancies are also found in other countries. These small discrepancies do not cause strong concern as they stem from small definition difference, system boundary issues or data period. For example, some countries use firm capacity listing, instead of name-plate installed capacity. They often explicitly list the two data showing the difference between firm and installed capacities. However, the discrepancy between firm and installed capacity seems larger in African context than developed economies' systems, as maintenance issues in both power plants and network assets may have caused lower firm capacity in African countries. Due to time limitation, these discrepancies are not examined deeply in the current project. However, in case of large discrepancies seen between firm capacity and (name-plate) installed capacity data, additional investigation is warranted.
- Policy and regulatory environment cannot be assessed only by their existence. How they are implemented determines the status of the enabling environment. Although this aspect requires careful data gathering from stakeholders, the time limitation of the current project prevented this from being properly conducted.
- There are data gaps on grid development funding, power sector cost of capital/finance, and time required for domestic grid and interconnector grid development.

Project Learnings on Data and Indicator Framework in Africa (3/3)

Africa data gaps and discrepancies (continued)

- Some data and information were difficult to obtain through international and national publicly-available open sources.

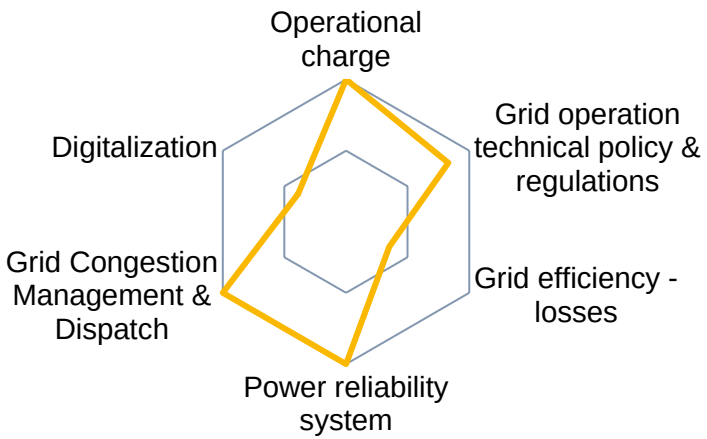
  For most countries, the following data were missing or difficult to find.
  - Average age of transmission infrastructure / assets;
  - Consistent interconnector information and data (existing and planned);
  - Mini-grid capacity data (existing and planned);
  - National funding / budget spent on transmission grid development and operation;
  - Financial cost of power sector projects and network sector projects;
  - Time necessary for transmission and interconnector projects (regulatory and administrative clearance, construction)
  - Grid utilization ratio / network availability;
  - Explicit and clear RE curtailment report data;
  - Explicit and clear RE capacity in connection queue;

  For some countries, the following data were also missing or not publicly available.
  - Transmission line length and transformer transfer capacity;
  - Distribution line length and transformer transfer capacity
  - Consistent future demand and supply projections;
  - Published and / or most updated system plan;
  - Part or all economic regulations (tariff / network charge rate setting methodologies);
  - Parts or all of transmission grid codes;
  - System performance data - published SAIFI and SAIDI

Project Learnings on Index Assessments in Africa (1/2)

Spider chart visualization assessments and traffic light visualization of index scores is feasible, however concerns on the comparison of calculated index scores resulted in the removal of these assessments in the final project outputs. The following are examples of what could be done with a more in-depth country or regional assessment project.

An example of spider chart visualization



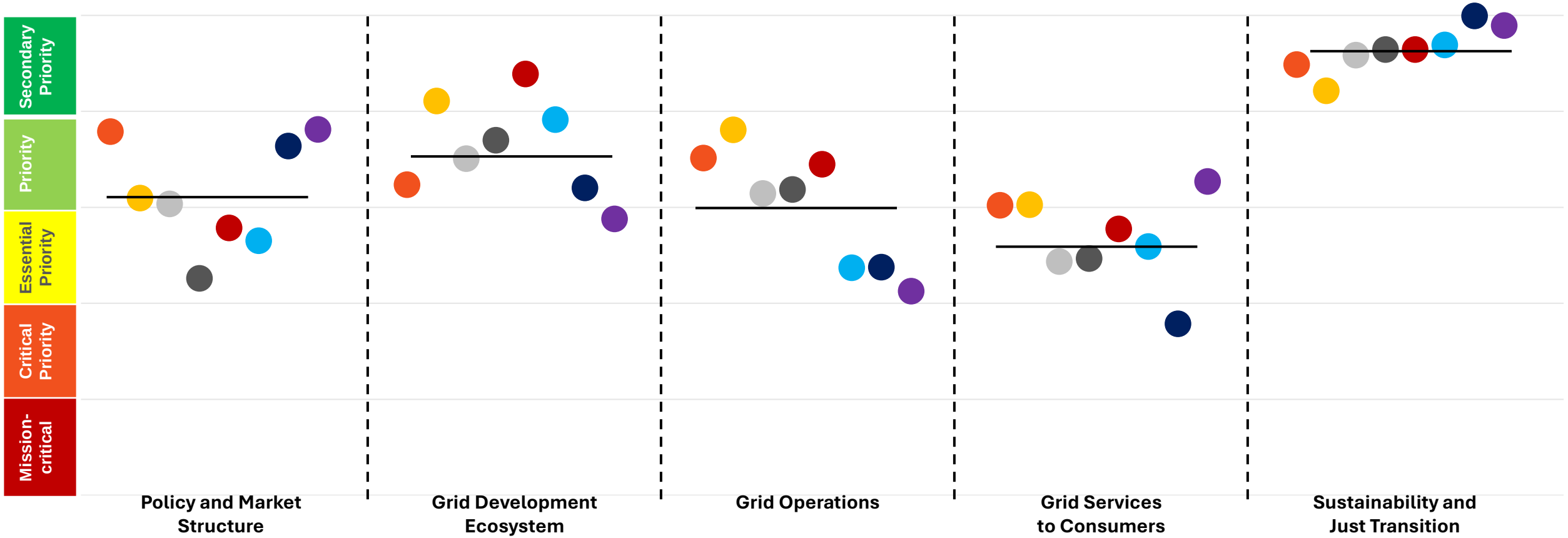
An example of traffic-light assessment table

Ready	Priority	Essential Priority	Critical Priority	Mission-critical

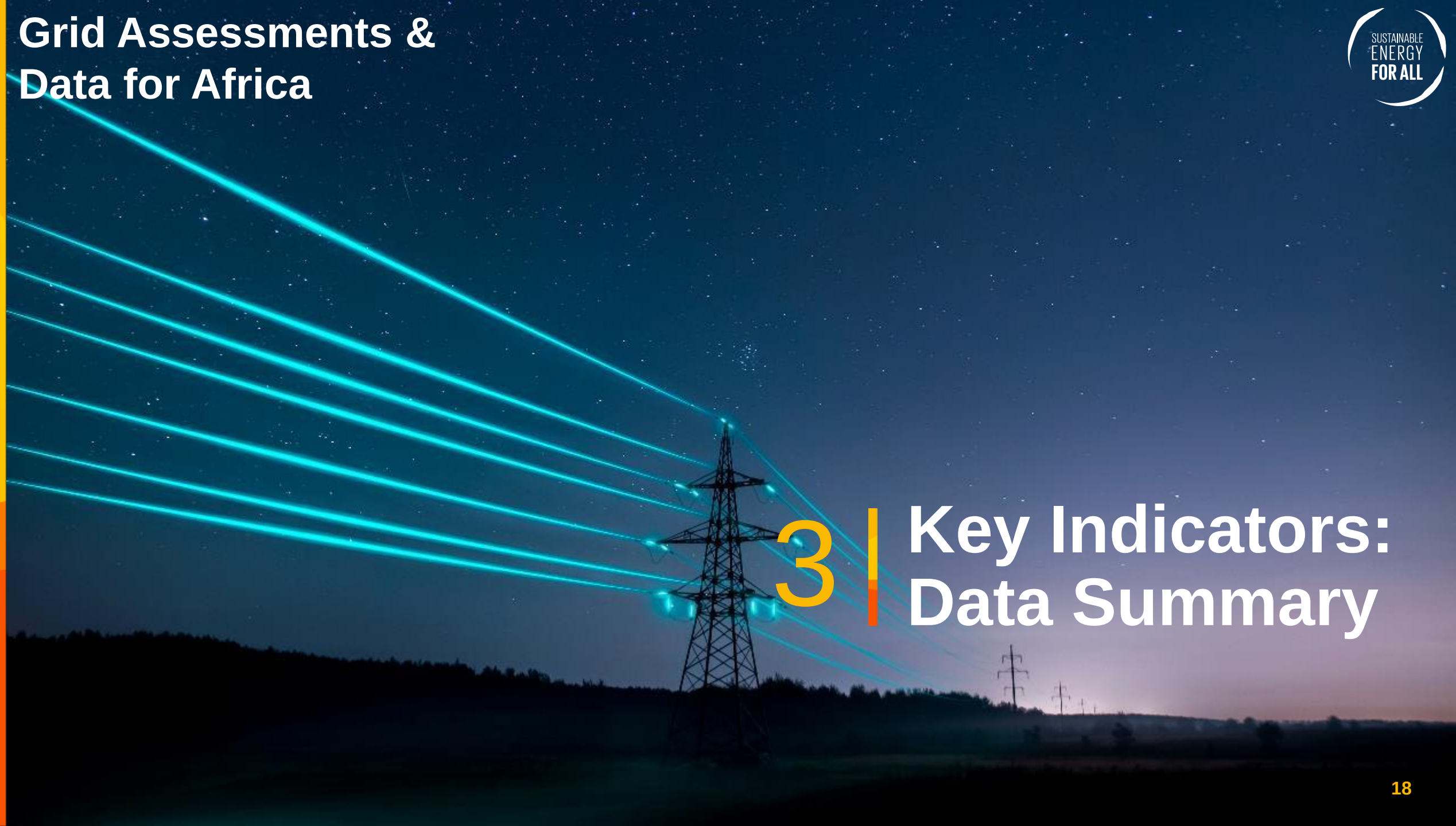
Criteria	Rating	Assessment
Network Operational charge		▪ The country has clear rules and allocation methodology that recover the cost for network operations, approved by the regulator. Operational changes are applied to unit of electricity basis without discrimination
Operation - Technical policy, regulations		▪ The country has the dedicated renewable energy sub-codes since 2015 that consider specific operational needs of variable renewables to supplement the original 2008 grid codes. Regular assessment of flexibility is also in place. ▪ Ancillary services and adequacy reserve procurement is within bilateral agreement with the TSO, frequency reserves and voltage support are within the discretion of the TSO. The TSO began working on the set up of capacity market.
Grid efficiency – loss		▪ Total loss of grid system is around 30%, which is high in global comparison. The loss mostly coming from distribution.
Power reliability system		▪ The grid codes define system quality and security standards extensively and good measurement system is also in place.
Congestion management & dispatch		▪ The country' has renewable priority access to grid and economic dispatch and real-time dispatch are implemented with spot market operation. ▪ It also use high quality VRE forecasting for dispatch operation and practice and curtailment compensation for renewables
Digitalization		▪ Digital infrastructure need to be improved to enable and take advantage of network operation that enable variable renewable integration further.

Project Learnings on Index Assessments in Africa (2/2)

Pilot country blended “index” assessments show valuable regional trends, however, can cause confusion with country comparisons, can vary based on data availability or data weighting processes. These outputs were removed from the final project outputs for each country, but can be useful.



Example: African grids have favorable policy environment and grid development ecosystem; however, priorities include digitized grid operations and massive expansion to un-served and under-served population which will enable improved grid utilization, efficiency, economic dispatch, and reliability.



3 | Key Indicators: Data Summary

Key Indicators: Electricity grid policy and market structure

	Global High/Low	Egypt	Ethiopia	Ghana	Kenya	Nigeria	Rwanda	South Africa	Tanzania	Uganda	Zambia
Power system size (MW, 2022)	N/A	59,301	5,734	5,519	3,747	12,036 (2020)	295	65,871	1,818	1,450	3,948
RE share in power mix (2022)	97.7% DRC / 2.7% Algeria	10.5%	91.5%	30.5%	42.2%	65.4%	50.2%	15.5%	32.5%	77.4%	82.6%
VRE share in power mix (2022)	58.4% Netherlands / near 0%	5.7%	7.4%	1.8%	19.8%	3.1%	8.6%	14.1%	1.0%	6.5%	2.4%
Annual average growth of VRE installed capacity (over 5 years, 2017-2022)	295.3% Zambia / -7.6% Dominica	29.2%	4.8%	-8.9%	59.2%	14.1%	8.5%	11.3%	5.9%	16.2%	295.3%
Average annual growth in electricity demand (over 5 years, 2017-2022)	37.5% Bhutan / -14.0% Lebanon	1.7%	3.9%	8.8%	1.1%	3.6%	9.4%	-2.0%	5.6%	10.3%	3.5%
System flexibility (sub-indicator of WEF ETI, 0-100)	100 Gabon / 1.1 Mongolia	95.5	95.6	99.7	84.0	98.1	N/A	3.2	99.3	N/A	94.2
Demand projection (2030)	N/A	N/A	N/A	5479 MW (peak)	3320 MW	192 TWh (IRENA)	397 MW (peak)	34-5 GW	4878 MW (peak)	1644 MW	5422 MW (peak)
Generation supply target (2030)	N/A	N/A	17500 MW	7606 MW	4689 MW (3650 MW firm capacity)	56 GW (total) 43 GW (on-grid) (IRENA)	547-562 MW	90.9 GW	6390 MW	2300MW	10013 MW
Grid target / strategy in national policy / planning or NDC	Yes / No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Independent regulatory body	Yes / No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: RE renewable energy; VRE variable renewable energy; RE share in power mix high and low are high and low for Africa only.
Data sources: US EIA; WEF; National documents of respective countries (See each country profile and Appendix 2 in the full report)

Key Indicators: Electricity grid development ecosystem

	Global High/Low	Egypt	Ethiopia	Ghana	Kenya	Nigeria	Rwanda	South Africa	Tanzania	Uganda	Zambia
Transmission circuit length (km, 2022)	N/A	54507 km	21397 km	6472 km	8739 km	8229 MW	1158 km (June 2023)	33 194 km	6139 km	N/A	N/A
Transformer capacity (MVA, 2022)	N/A	199517 MVA	N/A	9642 MVA	5455 MVA	N/A	N/A	155 820 MVA (March 2023)	6519 MVA	6445.5 MVA	10407 MVA
Annual average growth ratio of transmission line length (over 5 years)	N/A	3.3% (2019-2024)	4.2% (2017-2022)	2.2% (2018-2023)	4.6% (2019-2024)	N/A	7.0% (3 years, 2021-2024)	0.32% (2019-2024)	6.4% (2019-2024)	N/A	9.6% (one year, 2022-2023)
VRE in transmission connection queue (MW)	N/A	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported	Not reported
Current interconnections capacity (MW, known)	15965 Germany / 0 many countries	840	6000	438	2145	872	257 (?)	7180	100	2400 (?)	2090
Distribution Transformer capacity (MVA)	N/A	100344 MVA (June 2023)	N/A	N/A	15149 MVA (FY 2023/24)	N/A	N/A	146927 MVA (2024)	N/A	N/A	N/A
Distribution overhead and cable length (km)	N/A	578588 km (June 2023)	N/A	N/A	310312 km (FY2023/24)	N/A	29504 km (2023)	375760 km (2024)	163804 km (2023)	70565 km (2024)	12500 km (2022)
Annual average growth in distribution line length (over 5 years)	N/A	2.6%	N/A	N/A	6.4%	N/A	3.9%	1.2%	9.6%	6.0%	N/A
Economic regulations - grid tariff determination / its cost reflectiveness (Y/N)	Yes/Yes / No/No	Yes / Yes	Yes / No	Yes / Yes	No / No	Yes / Yes	Yes / Yes	Yes / Yes	Yes / Yes	No / No	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes / No	Yes (limited with EPC)	Yes (limited with EPC & consultancy)	Yes (limited with EPC)	Yes (with multiple biz models)	Yes (limited with EPC but changes in progress)	Yes (with multiple biz models)	Yes (limited with EPC but changes in progress)	Yes (limited with EPC but changes in progress)	Yes (with EPC and IPT models)	Yes

Note: RE renewable energy; VRE variable renewable energy; EPC Engineering, Procurement & Construction; IPT Independent Power Transmission.
Data sources: US EIA; National documents of respective countries (See each country profile and Appendix 2 in the full report)

Key Indicators: Electricity grid operations

	Global High/Low	Egypt	Ethiopia	Ghana	Kenya	Nigeria	Rwanda	South Africa	Tanzania	Uganda	Zambia
Transmission grid loss (total, %, 2022)	86.4% Palestine / 0.3% Cayman Isl.	17.9%	18.1%	29.3%	22.7%	14.2%	13.6%	11.0%	12.9%	19.2%	10.3%
Distribution grid loss (% of power generation)	N/A	22.5% (2021)	N/A	30.0% (2022)	18.0% (2023)	25.0% (2022)	N/A	9.7% (2023)	N/A	17.6% (2022)	N/A
RE curtailment ratio in transmission (%)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RE Priority dispatch (Y/N)	Yes / No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No

Note: RE renewable energy.
Data sources: US EIA; National documents of respective countries (See each country profile and Appendix 2 in the full report)

Key Indicators: Electricity grid services to consumers

	Global High/Low	Egypt	Ethiopia	Ghana	Kenya	Nigeria	Rwanda	South Africa	Tanzania	Uganda	Zambia
Electricity access (2022)	100% many / 5.4% South Sudan	100%	55.4%	85.1%	76.0%	60.5%	50.6%	86.5%	45.8%	47.1%	47.8%
SAIFI (2023)	81.65 Pakistan / 0.02 Japan	3	N/A	36.3	6.9	N/A	21.7 (2022-23)	6.0	46.8	N/A	4.9
SAIDI (2023)	243.6 Zimbabwe / 0.04 Japan	2.0	N/A	55.9	12.0	N/A	N/A	30.5	20.9	N/A	51.2
Electricity consumption per capita (kWh/yr/capita, 2022)	50,512.9 Iceland / 14.2 Sierra Leone	1592.2	85.9	571.8	178.1	144.5	62.5	3348.7	121.1	84.0	747.7
Average residential tariff (USD/kWh)	0.704 Jamaica / 0.002 Cote d'Ivoire	0.048	0.039	0.138	0.102	0.91	0.215	0.154	0.081	0.217	0.054
Consumer tariff subsidy / pricing support (Y/N)	Yes / No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

Note: SAIFI System Average Interruption Frequency Index; SAIDI System Average Interruption Duration Index.
Data sources: US EIA; WEF; National documents of respective countries (See each country profile and Appendix 2 in the full report)

Key Indicators: Electricity grid sustainability and just transition

	Global High/Low	Egypt	Ethiopia	Ghana	Kenya	Nigeria	Rwanda	South Africa	Tanzania	Uganda	Zambia
ESIA process for transmission projects (Y/N)	Yes / No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes / No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Carbon intensity of power sector (g CO2eq/Wh/yr)	8373 Montenegro / 0 Many	426.6	0.24	331.2	88.1	319.9	319.4	882.16	277.4	7.3	96.8

Note: ESIA environmental and social impact assessment.
Data sources: US EIA; National documents of respective countries (See each country profile and Appendix 2 in the full report)

Key indicator data availability by category and country

	Egypt	Ethiopia	Ghana	Kenya	Nigeria	Rwanda	South Africa	Tanzania	Uganda	Zambia
1. Electricity grid policy and market structure	8/10 80%	9/10 90%	10/10 100%	10/10 100%	10/10 100%	9/10 90%	10/10 100%	10/10 100%	9/10 90%	10/10 100%
2. Electricity grid development ecosystem	9/10 90%	6/10 60%	6/10 60%	9/10 90%	4/10 40%	7/10 70%	9/10 90%	9/10 90%	6/10 60%	6/10 60%
3. Electricity grid operations	3/4 75%	2/4 50%	3/4 75%	3/4 75%	3/4 75%	2/4 50%	3/4 75%	2/4 50%	3/4 75%	2/4 50%
4. Electricity grid services to consumers	6/6 100%	4/6 67%	6/6 100%	6/6 100%	4/6 67%	5/6 83%	6/6 100%	6/6 100%	4/6 67%	6/6 100%
5. Electricity grid sustainability and just transition	3/3 100%	3/3 100%	3/3 100%	3/3 100%	3/3 100%	3/3 100%	3/3 100%	3/3 100%	3/3 100%	3/3 100%
Total by country	**29/33 88%**	**24/33 73%**	**28/33 85%**	**28/33 85%**	**24/33 73%**	**26/33 79%**	**31/33 94%**	**30/33 91%**	**25/33 76%**	**27/33 82%**

Note: Further data may be available in country data and information repositories but were not discovered during this pilot project.

4 | Key Indicators: Country Data by Category

Category: Policy and Market Structure (1/2)

Indicator category		Sub-indicators used for assessment	Egypt	Ethiopia	Ghana	Kenya	Nigeria
Political Environment	Commitment of grid importance / grid target	Grid target / strategy in national policy / planning or NDC	No	No	No	No	No
	Climate Change	Official domestic or international net zero goal / target	No	Yes (2050)	Yes (2060)	Yes (2050)	Yes (2060)
	RE Electricity Target	Official RE electricity goal / target	Yes	Yes	Yes	Yes	Yes
	Equal access to grid	Legal or regulatory guarantee for equal third-party access	Yes	No	Yes	Yes	Yes
Power - Security of supply	Reserve margin at peak load - % of system load (2022)		42.3%	N/A	31.7%	28.9%	-73.4%
	Power Net Import (% of net consumption, 2022)		-0.81%	-15.71%	-9.08%	2.12%	0.00%
Power generation - Clean energy status	% of fossil fuel in installed power capacity (2022)		89.3%	2.5%	68.1%	29.0%	33.2%
	% of fossil fuel in electricity generation (2022)		91.0%	0.04%	63.9%	7.7%	75.3%
	% of RE power capacity (2022)		10.5%	91.5%	30.5%	42.2%	65.4%
VRE & Non-synchronous assets	% of VRE in power installed capacity mix (solar & wind electricity, 2022)		5.7%	7.4%	1.8%	19.8%	1.1%
	% of VRE in electricity generation mix (solar & wind electricity generation, 2022)		5.2%	3.6%	0.6%	19.5%	0.1%
Power flexibility	Total (WEF Flexibility Index)		95.54	95.58	99.71	83.98	98.07
	Regional interconnection	Total existing capacity of interconnectors to neighboring systems (MW, known)	840	6000	438	2145	872
		Regional pool participation (number)	1	1	1	1	1
	Power generation sources	% of hydro power in installed capacity (w/o pumped hydro, 2022)	4.8%	85.0%	28.0%	26.0%	16.3%
		% of gas power in installed capacity (2022)	87.3%	0.0%	62.6%	0.0%	83.1%
	Energy storage	% of pumped hydro in installed capacity (2022)	0.0%	0.0%	0.0%	0.0%	0.0%
		% of utility-scale battery storage vs installed power generation capacity (2022)	0%	0%	0%	0%	0%

Note: RE – Renewable Energy ; VRE - Variable Renewable Energy

Category: Policy and Market Structure (2/2)

Indicator category		Sub-indicators used for assessment	Rwanda	South Africa	Tanzania	Uganda	Zambia
Political Environment	Commitment of grid importance / grid target	Grid target / strategy in national policy / planning or NDC	Yes	Yes	Yes	Yes	Yes
	Climate Change	Official domestic or international net zero goal / target	Yes (2050)	Yes (2050)	Yes (2050)	Yes (2050)	Yes (2050)
	RE Electricity Target	Official RE electricity goal / target	Yes	Yes	Yes	Yes	Yes
	Equal access to grid	Legal or regulatory guarantee for equal third-party access	Yes	Yes	Yes	Yes	Yes
Power - Security of supply	Reserve margin at peak load - % of system load (2022)		38.4%	-33.3%	26.2%	33.6%	39.9%
	Power Net Import (% of net consumption, 2022)		2.6%	-1.8%	1.9%	-7.9%	-14.1%
Power generation - Clean energy status	% of fossil fuel in installed power capacity (2022)		48.5%	77.1%	62.0%	15.7%	16.3%
	% of fossil fuel in electricity generation (2022)		43.2%	87.7%	63.1%	1.0%	11.1%
	% of RE power capacity (2022)		50.2%	15.5%	32.5%	77.4%	82.5%
VRE & Non-synchronous assets	% of VRE in power installed capacity mix (solar & wind electricity, 2022		8.6%	14.4%	1.0%	6.5%	2.4%
	% of VRE in electricity generation mix (solar & wind electricity generation, 2022)		1.8%	6.9%	0.5%	2.3%	0.7%
Power flexibility	Total (WEF Flexibility Index)		N/A	3.21	99.27	N/A	94.24
	Regional interconnection	Total existing capacity of interconnectors to neighboring systems (MW, known)	257	7180	100	2400	2090
		Regional pool participation (number)	1	1	2	1	1
	Power generation sources	% of hydro power in installed capacity (w/o pumped hydro, 2022)	42.8%	1.2%	28.8%	79.3%	82.8%
		% of gas power in installed capacity (2022)	8.7%	0.0%	49.0%	0.0%	0.0%
	Energy storage	% of pumped hydro in installed capacity (2022)	0.0%	4.6%	0%	0.0%	0.0%
		% of utility-scale battery storage vs installed power generation capacity (2022)	0%		0%	0%	0%

Note: RE – Renewable Energy ; VRE - Variable Renewable Energy

Category: Grid Development Ecosystem (1/4)

Indicator category		Sub-indicators used for assessment	Egypt	Ethiopia	Ghana	Kenya	Nigeria
Grid Assets - Status & planning	Transmission	Existing transmission capacity (MW or MVA) or Circuit Length (km, 2022)	54507 km 199517 MVA	21397 km	6472 km 9642 MVA	5,455 MVA	TCN wheeling capacity 8229 MW
		5-year CARG of capacity (%, 2017-2022)	6.5%	N/A	6.4%	4.7%	6.4%
		5-year CARG of circuit length (%, 2017-2022)	3.3%	4.2%	2.2%	4.6%	N/A
		Total capacity (MW) of RE power plant projects in transmission connection queue (latest)	Not reported	Not reported	Not reported	Not reported	Not reported
	Interconnectors	Existing interconnector transmission capacity (MW, known)	840	6000	438	2145	872
		Planned capacity by 2030 (MW, known)	3000	1600	655	2000	1600
	Distribution	Existing transformer / distribution capacity (MW) or Line & Cable length (km)	100344 MVA / 578588 km (June 2023)	N/A	N/A	15149 MVA / 310312 km (FY 2023/24)	N/A
		5-year CAGR of distribution line length (most recent 5 years)	2.6%	N/A	N/A	6.4%	N/A
	Mini-grids	Total mini-grid capacity (MW, 2022)	N/A	N/A	325	N/A	12
Power System / Grid Development Planning	Established grid planning & update procedure	Integrated generation and transmission planning	Yes	Yes	Yes	Yes	Yes
		Established transmission capacity allocation approach for interconnection	N/A	Yes	Yes	Yes	Yes
	Geospatial grid development planning	Electrification plan developed based on demand assessment and/or geospatial least cost analysis	N/A	Yes	Yes	Yes	Yes
		RE-resource oriented / RE scale up minded grid development assessment & planning	Yes	Yes	Yes	Yes	Yes
		RE zoning / zones	No	No	No	No	No
		Geospatial planning or produced zoning guidance to inform commercial development of the RE resource	Yes	Yes	Yes	Yes	Yes
		Dedicated renewable energy evacuation corridors	No	No	No	No	Yes

Category: Grid Development Ecosystem (2/4)

Indicator category		Sub-indicators used for assessment	Rwanda	South Africa	Tanzania	Uganda	Zambia
Grid Assets - Status & planning	Transmission	Existing transmission capacity (MW or MVA) or Circuit Length (km, 2022)	1158 km (June 2023)	33 194 km 155 820 MVA (March 2023)	6139 km 6519 MVA 2380 MW	6445.5 MVA	10407 MVA
		5-year CARG of capacity (%, 2017-2022)	N/A	0.6%	13.4%	19.8%	9.6% in one year
		5-year CARG of circuit length (%, 2017-2022)	7.0%	0.3%	6.4%	N/A	15.5% in one year
		Total capacity (MW) of RE power plant projects in transmission connection queue (latest)	Not reported	Not reported	Not reported	Not reported	Not reported
	Interconnectors	Existing interconnector transmission capacity (MW, known)	257(?)	7180	100	2400(?)	2090
		Planned capacity by 2030 (MW, known)	300	1450	6750	3750	2800
	Distribution	Existing transformer / distribution capacity (MW) or Line & Cable length (km, 2022 or latest)	29504 km (2023)	146927 MVA / 375760 km (2024)	163804 km (2023)	70565 km (2024)	12500 km (2022)
		5-year CAGR of distribution line length (most recent 5 years)	3.9%	1.15%	9.6%	5.96%	N/A
	Mini-grids	Total mini-grid capacity (MW, 2022)	N/A	N/A	2.2 MW	N/A	N/A
Power System / Grid Development Planning	Established grid planning & update procedure	Integrated generation and transmission planning	Yes	Yes	No	Yes	Yes
		Established transmission capacity allocation approach for interconnection	Yes	Yes	Yes	Yes, but not formalized yet	Yes
	Geospatial grid development planning	Electrification plan developed based on demand assessment and/or geospatial least cost analysis	Yes	Yes	Yes	Yes	Yes
		RE-resource oriented / RE scale up minded grid development assessment & planning	Yes	Yes	Yes	Yes	Yes
		RE zoning / zones	No	Yes	No	No	No
		Geospatial planning or produced zoning guidance to inform commercial development of the RE resource	Yes	Yes	Yes	Yes	Yes
		Dedicated renewable energy evacuation corridors	No	Yes	No	No	No

Category: Grid Development Ecosystem (3/4)

Indicator category		Sub-indicators used for assessment	Egypt	Ethiopia	Ghana	Kenya	Nigeria
Power System / Grid Development Planning (continued)	Mini-grid framework	Established mini-grid policy and framework (RISE score, 2022)	N/A	72.9	50.4	72.9	89.8
		Clear regulations on what will occur when the main grid reaches a mini grid's service area	N/A	Yes	Yes, in RISE But UN report says this is uncovered as of 2022	Yes	Yes
Grid Investment / Finance	Grid development ODA (disbursement)	Weighted 5-year average per MW of on-grid power generation capacity (Million USD / GW, 2017-2022)	0.768	25.702	12.769	37.725	18.628
	Economic / Investment Policy & Regulations (enabling environment) - Renumeration & cost recovery	Transmission grid investment / cost recovery regulations / methods	Yes	Yes	Yes	No	Yes
		Clear grid tariff determination method & its cost reflectiveness	Yes	Yes	Yes	No	Yes
		Deep or shallow method of power plant connection cost allocation - supporting RE	Yes	No	Yes	Yes	No
Time / Risks	Financial cost / cost of Capital (WACC)	Power sector project interest ratio (range or average)	N/A	N/A	N/A	N/A	N/A
		OECD Country Risk Classification	6	7	7	7	6
		Country Credit rating (WEF ET Index, 2024)	0.28	0.1	0	0.3	0.25
	Total commission time (from permit application to commission)	Transmission line projects	N/A	N/A	N/A	More than 7 years	N/A
		Interconnector projects	N/A	N/A	N/A	N/A	N/A
Private participation	Private sector participation in grid development - type of allowed participation / business models		Yes Only EPC participation	Yes Quite limited - with invited EPC	**Yes** EPC and private ownership of assets	**Yes** concession agreements, EPC and IPT	Yes EPC

Note: EPC: Engineering, Procurement and Construction; IPT Independent Power Transmission

Category: Grid Development Ecosystem (4/4)

Indicator category		Sub-indicators used for assessment	Rwanda	South Africa	Tanzania	Uganda	Zambia
Power System / Grid Development Planning (continued)	Mini-grid framework	Established mini-grid policy and framework (RISE score, 2022)	81.25	21.04	78.75	62.50	68.33
		Clear regulations on what will occur when the main grid reaches a mini grid's service area	Yes	Yes	Yes	Yes	Yes
Grid Investment / Finance	Grid development ODA (disbursement)	Weighted 5-year average per MW of on-grid power generation capacity (Million USD / GW, 2017-2022)	294.992	0.304	58.272	38.871	10.265
	Economic / Investment Policy & Regulations (enabling environment) - Renumeration & cost recovery	Transmission grid investment / cost recovery regulations / methods	Yes	Yes	Yes	No	No
		Clear grid tariff determination method & its cost reflectiveness	Yes	Yes	Yes	No	Yes
		Deep or shallow method of power plant connection cost allocation - supporting RE	No	No	No	No	Yes
Time / Risks	Financial cost / cost of Capital (WACC)	Power sector project interest ratio (range or average)	N/A	N/A	N/A	N/A	N/A
		OECD Country Risk Classification	6	4	6	6	7
		Country Credit rating (WEF ET Index, 2024)	N/A	0.42	N/A	N/A	0
	Total commission time (from permit application to commission)	Transmission line projects	N/A	N/A	N/A	6-10 years	N/A
		Interconnector projects	N/A	N/A	N/A	N/A	N/A
Private participation	Private sector participation in grid development - type of allowed participation / business models		Yes. Defined PPP–BOO, BOOT, and BTO and EPC + Finance models	Yes Only EPC participation	Yes Only EPC participation	Yes IPT or EPC contractor for UETCL projects	Yes whole of grid concession, merchant, IPT, and EPC models

Note: BOO - Build-own-operate; BOOT- Build-own-operate-transfer; BTO – Build-to-own; EPC: Engineering, Procurement and Construction; IPT Independent Power Transmission; PPP-Public private partnership;

Category: Grid Operations (1/2)

Indicator category		Sub-indicators used for assessment	Egypt	Ethiopia	Ghana	Kenya	Nigeria
Grid operation economics & charge	Network cost / charge allocation (basis of cost-reflective charge)	Rules define the size and allocation of costs for use of the transmission and distribution system (e.g. wheeling charges, locational pricing)	Yes	Yes	Yes	Yes	Yes
		Wheeling charge	charged based on kWh	No discriminatory application	charged based on kWh	No	charged based on point to point
Grid operation-technical policy / regulations & operation resource procurement	Grid codes – VRE power plants - connection procedures / operational requirements		Yes	Yes	Yes	Yes	Yes
	Flexibility (ancillary service)	Regular assessment of flexibility	Yes	No	Yes	Yes	No
		Existence of competitive / public procurement	No	No	No	No	No
	Resource adequacy	Existence of competitive / public procurement	N/A	No	Yes	No	No
Grid efficiency - losses	Grid losses - total	Total loss (% of total power generation, 2022) – transmission and distribution	17.9%	18.1%	29.3%	22.7%	14.2%
	Grid loss -transmission	% of total power generation / % of total loss (2022)	3.8% (2021)	N/A	4.1%	4.0%	8.2%
	Grid loss-distribution	% of total power generation / % of total loss (2022)	22.5% (2021)		30.0%	18.0%	25.0%
Power reliability system	Existence of an incidence/outage recording system (or SCADA / EMS with such functionality)		Yes	Yes	Yes	Yes	Yes
Grid operation - Congestion management & Dispatch	Dispatch	RE priority dispatch	Yes	No	Yes	Yes	Yes
		Merit-order / economic dispatch	Yes	Yes	Yes	Yes	Yes
		Real-time dispatch	No	No	Yes	Yes	No
		High quality VRE forecasting for dispatch operation	No	No	Yes	Yes	Yes
	Power flow control	Mechanisms to compensate RE projects for lost generation due to certain curtailments	Yes	No	Yes	Yes	Yes
Digitalization	Digital Infrastructure readiness (WEF ETI Index)		44.07	27.36	38.83	46.86	35.73

Note: RE – Renewable Energy ; VRE - Variable Renewable Energy

Category: Grid Operations (2/2)

Indicator category		Sub-indicators used for assessment	Rwanda	South Africa	Tanzania	Uganda	Zambia
Grid operation economics & charge	Network cost / charge allocation (basis of cost-reflective charge)	Rules define the size and allocation of costs for use of the transmission and distribution system (e.g. wheeling charges, locational pricing)	No	Yes	Yes / No (The 2021)	No	Yes
		Wheeling charge	N/A	No discriminatory application	N/A	No	Clear rate setting methodology
Grid operation-technical policy / regulations & operation resource procurement	Grid codes – VRE power plants - connection procedures / operational requirements		Yes	Yes	Yes	No	No
	Flexibility (ancillary service)	Regular assessment of flexibility	Yes	Yes	Yes	Yes	No
		Existence of competitive / public procurement	No	Yes	No	No	N/A
	Resource adequacy	Existence of competitive / public procurement	N/A	No	Yes	No	No
Grid efficiency - losses	Grid losses - total	Total loss (% of total power generation, 2022) – transmission and distribution	13.6%	11.0%	12.9%	19.2%	10.3%
	Grid loss -transmission	% of total power generation / % of total loss (2022)	N/A	2.3% (2023)	N/A	4.8%	5.6%
	Grid loss-distribution	% of total power generation / % of total loss (2022)	N/A	9.7% (2023)	N/A	17.6%	N/A
Power reliability system	Existence of an incidence/outage recording system (or SCADA / EMS with such functionality)		Yes	Yes	Yes	Yes	Yes
Grid operation - Congestion management & Dispatch	Dispatch	RE priority dispatch	Yes	Yes	No	Yes	No
		Merit-order / economic dispatch	Yes	Yes	No	No	No
		Real-time dispatch	Yes	Yes	No	No	No
		High quality VRE forecasting for dispatch operation	Yes	Yes	No	No	No
	Power flow control	Mechanisms to compensate RE projects for lost generation due to certain curtailments	Yes	No	No	Yes	No
Digitalization	Digital Infrastructure readiness		N/A	45.86	37.84	N/A	32.11

Note: RE – Renewable Energy ; VRE - Variable Renewable Energy

Category: Grid Services to Consumers (1/2)

Indicator category		Sub-indicator used for assessment	Egypt	Ethiopia	Ghana	Kenya	Nigeria
Service quantity – electricity access	Electricity access ratio (2022)	Total access ratio (%)	100	55.4	85.1	76	60.5
		Urban access ratio (%)	N/A with 100% access ratio	94.0	95.0	98.0	89.0
		Rural access ratio (%)		43.0	71.6	68.4	27.0
	2030 electricity access deficits	% of total population unelectrified in 2030 using the most recent 5-year access growth ratio (CAGR)		28.8%	2.5%	34.3%	51.6%
	Existence of on-grid access plan and targets			Yes	N/A	No	Yes
	On-grid electricity access (# of population or share)			61931525	23952965	9659877	122767854
	Solar mini-grid access	# of served population by solar mini-grid		10000	16000	137000	217000
Service quantity – electricity consumption	Annual electricity consumption per person (kWh per person)		1592.2	85.9	571.8	178.1	144.5
	5-year CARG of annual electricity consumption per capita (%, 2017-2022)		-0.1%	1.2%	6.6%	-0.9%	0.4%
Service Quality - Power reliability	Power reliability data availability	SAIFI (WEF ET Index SAIFI (2024 score)	3	N/A	36.3	6.9	N/A
		SAIDI (WEF ET Index SAIDI (2024 score)	2.0	N/A	55.9	12.0	N/A
		Existence of SAIFI and SAIDI measurement	Yes	No	Yes	Yes	Yes
		Standards of performance on reliability (e.g. number of guaranteed hours per day, duration of the electricity, frequency of outages, etc.)	No	Yes	Yes	Yes	Yes
Power Affordability	Consumer connection fees	Affordability of the electricity connection fee for residential consumers (RISE Indicator, 2022)	N/A	93.1	67.9	85.1	99.9
		On-grid connections: Consumer financing mechanisms	Yes	No	No	Yes	No
	Consumer tariffs	Average residential consumer tariff (USD/kWh, 2023)	0.048	0.039	0.138	0.102	0.091
	Policy / financing mechanisms for vulnerable groups to support vulnerable groups		Yes	No	Yes	Yes	Yes

Category: Grid Services to Consumers (2/2)

Indicator category		Sub-indicator used for assessment	Rwanda	South Africa	Tanzania	Uganda	Zambia
Service quantity – electricity access	Electricity access ratio (2022)	Total access ratio (%)	50.6	86.5	45.8	47.1	47.8
		Urban access ratio (%)	98.0	87.1	78.5	72.0	87.0
		Rural access ratio (%)	38.2	93.4	36.0	36.0	15.0
	2030 electricity access deficits	% of total population unelectrified in 2030 using the most recent 5-year access growth ratio (CAGR)	-11.9%	84.5%	-5.1%	-9.9%	30.5%
	Existence of on-grid access plan and targets		Yes	No	Yes	Yes	Yes
	On-grid electricity access (# of population or share)		3843602	51509369	25575969	18532785	6000454
	Solar mini-grid access	# of served population by solar mini-grid	11000	100	20000	73000	39000
Service quantity – electricity consumption	Annual electricity consumption per person (kWh per person)		62.5	3348.7	121.1	84.0	747.7
	5-year CARG of annual electricity consumption per capita (%, 2017-2022)		6.9%	-3.1%	2.4%	6.7%	0.5%
Service Quality - Power reliability	Power reliability data availability	SAIFI (WEF ET Index SAIFI (2024 score)	N/A	6.0	46.8	N/A	4.9
		SAIDI (WEF ET Index SAIDI (2024 score)	N/A	30.5	20.9	N/A	51.2
		Existence of SAIFI and SAIDI measurement	Yes	Yes	Yes	Yes	Yes
		Standards of performance on reliability (e.g. number of guaranteed hours per day, duration of the electricity, frequency of outages, etc.)	Yes	Yes	Yes	Yes	Yes
Power Affordability	Consumer connection fees	Affordability of the electricity connection fee for residential consumers (RISE Indicator, 2022)	87.0	0.0	0.0	0.0	67.7
		On-grid connections: Consumer financing mechanisms	Yes	Yes	Yes	Yes	Yes
	Consumer tariffs	Average residential consumer tariff (USD/kWh, 2023)	0.215	0.154	0.081	0.217	0.054
	Policy / financing mechanisms for vulnerable groups to support vulnerable groups		Yes	Yes	Yes	Yes	No

Category: Sustainability and Just Transition (1/2)

Indicator category		Sub-indicator used for assessment	Egypt	Ethiopia	Ghana	Kenya	Nigeria
Environmental and Social Impacts	Environmental planning & regulations	Strategic Environmental & Social Impact Assessment Framework and implementation status for energy and transmission development planning, policy and programme	No	Yes	Yes	No	Yes
		Project-level Environmental impact Assessment Framework and Implementation for transmission projects	Yes	Yes	Yes	Yes	Yes
People-centered deliberation	Public engagement / participation / consultation framework	Public consultation requirement for transmission / interconnector projects to impacted general public & communities (Y/N)	Yes	Yes	Yes	Yes	Yes
	Compensation framework to landowners and affected local stakeholders by transmission / interconnector projects		Yes	Yes	Yes	Yes	Yes
Carbon intensity of the power system	Carbon intensity per unit of generated electricity (g CO2eq / kWh/ yr)		426.6	0.237	331.1	88.1	319.9

Category: Sustainability and Just Transition (2/2)

Indicator category		Sub-indicator used for assessment	Rwanda	South Africa	Tanzania	Uganda	Zambia
Environmental and Social Impacts	Environmental planning & regulations	Strategic Environmental & Social Impact Assessment Framework and implementation status for energy and transmission development planning, policy and programme	Yes	Yes	Yes	Yes	Yes
		Project-level Environmental impact Assessment Framework and Implementation for transmission projects	Yes	Yes	Yes	Yes	Yes
People-centered deliberation	Public engagement / participation / consultation framework	Public consultation requirement for transmission / interconnector projects to impacted general public & communities (Y/N)	Yes	Yes	Yes	Yes	Yes
	Compensation framework to landowners and affected local stakeholders by transmission / interconnector projects		Yes	Yes	Yes	Yes	Yes
Carbon intensity of the power system	Carbon intensity per unit of generated electricity (g CO2eq / kWh/ yr)		319.4	882.2	277.4	7.3	96.7

5 | Regional Findings

Common Opportunities & Issues Across Africa

Maximizing flexibility

- African countries have not experienced severe grid system problems from variable renewable energy integration yet.
- Rapid expansion of clean electricity supply capacity and grids are critical for many countries to achieve energy security, deliver universal electricity access and to increase economic and social development.
- Many countries have power flexibility resources (gas, hydro and increasing interconnectors).
- Progress has been made in strengthening transmission grid business environment, which can contribute to cost efficiency, innovation and grid capacity growth.

Regional leadership and cooperation

- Progress is observed in the diverse scope and depth of system planning, economic regulations (tariff and ratio setting methodologies) and technical regulations (grid codes).
- Wider scope and deeper expertise backed by clear principles will become essential for policy and regulations to support rapid power system transition and growth.
- Further leadership growth and regional cooperation through the Africa Union and regional power pools can create a common basis for robust regional power trading.
- Setting common regional guidance for system planning, economic and technical regulations can (1) greatly enhance cost and time efficiency by pooling and sharing resources, (2) support cross-border power trade and market integration and (3) enhance strategic environmental assessment for country's network policy, plan and programme.

Common Opportunities & Issues Across Africa

Electricity Policy

- Commitment to grid development varies across African countries, with very few committing to the Global Energy Storage and Grids Pledge at COP29. However, all countries have renewable electricity targets and most guarantee equal access to the grid network.
- Power sector's institutional structure also varies from vertically integrated State-Own-Enterprise (SOE) utility, to legally unbundled or partially unbundled structure, to fully unbundled with liberalized wholesale market. Egypt, Kenya, and South Africa are in process of introducing wholesale competitive markets, while Uganda plans to return to vertical integration from legally unbundled structure. The common aspect is the dominance of State-owned Enterprises (SOEs).
- Power trade between countries is currently very small, but there are growing signs of rapid increases in interconnector capacity and trading agreements among countries, supported by regional pools.

Common Opportunities & Issues Across Africa

Electricity Market Structure

- African countries selected for this project can be categorized into three groups regarding their electricity generation and power mix profile –
  1. Dominant fossil fuels (mostly gas power) with hydro as the secondary power source;
  2. Strong clean electricity profile with hydro power, followed by fossil fuels (mostly natural gas) as the secondary source;
  3. Strong coal dominance (South Africa) without natural gas.

  The difference between the first and second groups stemmed from water resource availability, as eastern African countries have better access to abundant water resources, they enjoy cleaner profiles with hydro power than western and southern African counterparts.
- All countries, except South Africa and Egypt, have electricity consumption per capita level far below the Modern Energy Minimum of 1000kWh/yr/capita. With the expected population growth and the necessity to achieve universal access, higher tier electricity provision via on-grid expansion becomes important for more rapid economic and social development.
- Most countries enjoy quite high reserve margins based on installed capacity. However, these margins can be quickly depleted with strong electricity access expansion and demand growth, especially in countries with much lower firm capacity than (name-plate) installed capacity .
- All countries show small variable renewable energy (VRE) share, no renewable power plants waiting for connection queue and no curtailment issues are reported at the moment of writing.

Common Opportunities & Issues Across Africa

Grid Development Ecosystems

- Not all countries have a plan for grid development. Countries are aware of the importance of integrated power generation and transmission system planning and some have established planning frameworks and procedures with geospatial, least-cost planning.
  - However, not all countries publish system plans based on accelerated energy transition scenarios and projections.
  - System planning in some countries show weak VRE deployment inclusion / assessment. Dedicated renewable development zones and evacuation network corridors are not seen currently in all countries, except Nigeria and South Africa.
  - Some supply and demand projections seem impractical considering recent trends and should be revisited.
- Many countries have good transmission capacity for their existing power generation capacity, except Nigeria.
- Countries are also actively engaging in expansion of interconnectors through collaboration with regional pools and international donors to increase power trading.
- The age of assets greatly impacts the performance and potential to incorporate advanced VRE-related grid operation, however, asset age data availability is a challenge.
- Economic regulations—including through tariff and network charges—are key to enabling investment recovery, promoting cost efficiency and competition, and supporting system planning goals, though their scope and depth vary widely across countries.
  - Cost-reflectiveness and efficiency are recognized in many countries, but not always reflected in rate setting methodologies.
  - In some countries, pricing principles—such as tariff and ratio setting, cost allocation (including for power plant connections), and calculation methods—need clearer definition, and while others have well-developed methodologies, ongoing updates and strong institutional capacity is needed to keep pace with evolving power system demands.
- All countries permit private-sector participation in grid asset development, but the level of participation, available business models and their actual activity levels vary and need further investigation to examine the effectiveness of those settings.

Common Opportunities & Issues Across Africa

Grid Operations

- Many countries have rules and rate setting formulas to determine the size and allocation of costs for use of the transmission system. However, the details vary considerably by country.
  - Some countries use well-advanced and clear rate setting methods, but others lack clear pricing / cost allocation principles, impacting rate cost-reflectiveness and ability to motivate private sector investment.
  - As for wheeling charges, no discriminative behaviors are found as most countries established clear and equal third-party access to the grid. However, it was difficult to see wheeling charge rules through published information, particularly in vertically integrated operations.
  - Power trade agreements via interconnectors can be improved with clear rules on operational charges in each regional pool.
- Based on available data, most grid loss stems from distribution system that needs to reduce both technical and commercial loss.
- Many countries' codes have dedicated sections for VRE and / or non-synchronous generators technical and safety requirements.
  - However, the scope and level of detail in the grid codes vary. While many codes have detailed requirements for network connection, system operation including ancillary services, safety and other operational requirements for both VRE and synchronous generators, a couple of countries' codes need to be updated to accommodate VRE-specific technical operational issues.
  - Regular assessment of flexibility is not performed in some countries.
  - In most countries ancillary services and resource adequacy are not competitively procured.
- For congestion management and dispatch, most countries engage in merit-order / economic dispatch; however, the existence of priority dispatch for renewable electricity depends on country.
  - Due to low VRE share and their current market structure, real-time dispatch and advanced VRE forecasting is not incorporated into operation in many countries.
  - Digitalization readiness level is low in general.
  - These dimensions can be incorporated into the grid codes and digitalization needs to be enhance in both physical assets and software to take advantages of advance market and network operation for VRE expansion and integration.

Common Opportunities & Issues Across Africa

Grid Services to Consumers

- In the countries assessed in this project, only Egypt has universal access. While all assessed countries have quite high electricity access in urban areas, in low energy access countries rural access is low and grid expansion is critical to achieve universal energy access.
- The countries assessed in this project have very low or low electricity consumption per capita compared to the Modern Energy Minimum (MEM) goal of 1000 kWh, except South Africa and Egypt.
    - For countries with low consumption per capita, off-grid technologies such as mini-grid and solar home systems cannot cost effectively provide higher energy consumption access without on-grid expansion, although they are critical for universal electricity access.
- In terms of electricity service quality, all assessed countries have performance standards and measurement systems in place for power reliability, such as SAIFI and SAIDI.
- Power affordability affects both electricity access and energy consumption levels.
    - Many countries show good affordability for residential consumption tariffs, however a couple of low electricity access countries have expensive tariffs that are not affordable for vulnerable low-income populations.
    - Some countries with expensive tariffs have financial mechanisms to support vulnerable population groups, however, it is important to lower costs and reduce tariff levels themselves to avoid price distortion through subsidies.
    - Creating economies of scale for cost reduction through simultaneous demand stimulation and supply expansion often has hurdles that need concerted, holistic and simultaneous efforts are necessary including power system planning, economic and technical regulations, business model development and better access to finance, along with productive use of energy, project planning and development.
    - In most countries, grid connection fees are generally affordable for consumers. However, in some countries, affordability remains a challenge. While financial support mechanisms are often in place to assist in these cases, their adequacy and effectiveness require further evaluation.

Common Opportunities & Issues Across Africa

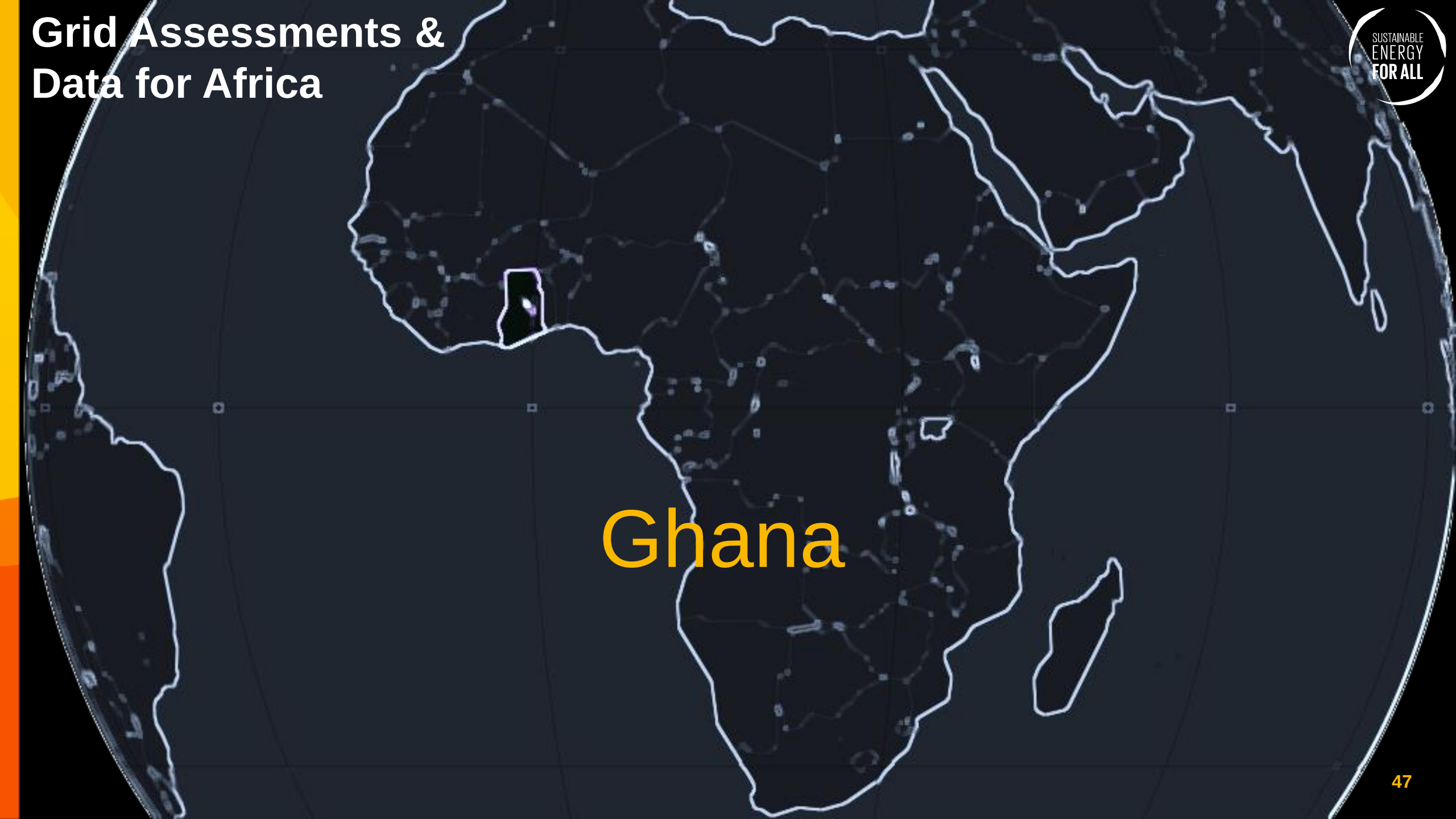
Sustainability and Just Transition

- All countries assessed have good frameworks and practices, often based on international standards, for transmission and interconnector project-level environmental social impact assessment (ESIA) and their implementation is robust.
  - Higher standard, project-level ESIA has been prompted by requirements posed by international donors / funders such as multi-lateral development banks, for both domestic transmission and cross-border interconnectors.
- In addition, all countries practice public consultation and compensation for lost property and economic losses. Many also have stakeholder engagement planning and processes in place, as well as resettlement planning for affected people.
- As for strategic environmental (and social) assessment (SEA), many countries also have frameworks and / or guidelines, but actual implementation and their practices vary.
  - Implementation of SEA on grid / network plans can be fortified in many countries, the process should be open to all stakeholders, and their results need to be disclosed to be public. This is particularly true for power system and network policy, plans and programmes.
  - As all countries target renewable expansion, robust SEA can clarify uncertainties for private sector development of renewable energy and grid development projects while reducing project-level ESIA burdens.
- Carbon intensity per unit of electricity generation varies across countries with their electricity generation mix, but generally their global positions are good as many countries have low carbon emissions with hydro power generation.

SUSTAINABLE ENERGY FOR ALL

Appendix 1 | Country Deep-dives

Grid Assessments & Data for Africa



Country Overview

Total Population (2023)	Land Area (2022, square km)	GDP per Capita (2023, PPP 2021 international dollar)	Annual GDP Growth ratio (2023)	Net ODA received (2022 Current USD)	Poverty headcount ratio at 2017 PPP USD 2.15 a day (2018, % of population)	Population Estimate (2030)	WB Income Group (2024)
33,787,914 Urban (57%)	227,533 km^2	USD 6,796.5	2.9%	USD 1,046 million (1.4% of GNI)	25.1%	38,775,850 (15$ up from 2023)	Lower-middle income

- Ghana is a western African country with high urban population ratio. The country is facing the Atlantic Ocean and share borders with Togo, Cote d'Ivoire, and Burkina Faso.
- The country experienced economic slowdown associated with macroeconomic challenges from 2012. Although the economy recovered in 2017, the Covid pandemic worsened living standards and the poverty ratio is rising. Inflation ratio was 38.1% in 2023.
- Macroeconomic stability and reforms are essential to strengthen the insolvency regime, access to finance, and the legal and regulatory environment for foreign direct investment.
- **Energy sector is cited as structural reform target sector to avoid energy shortfall.**

Sources: World bank Development Indicators; World Bank Ghana overview; WorldAtlas.com

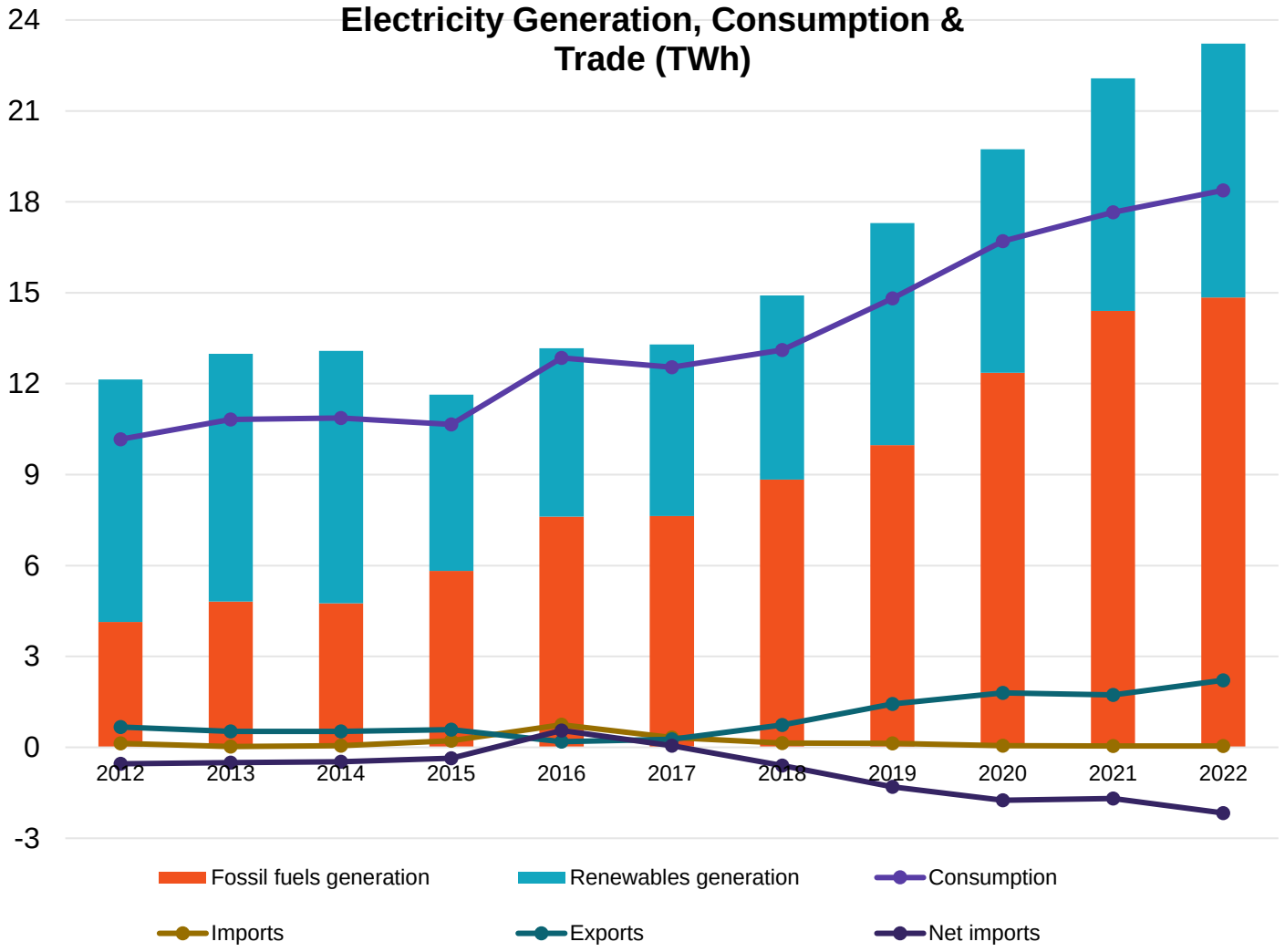
Power Sector Overview

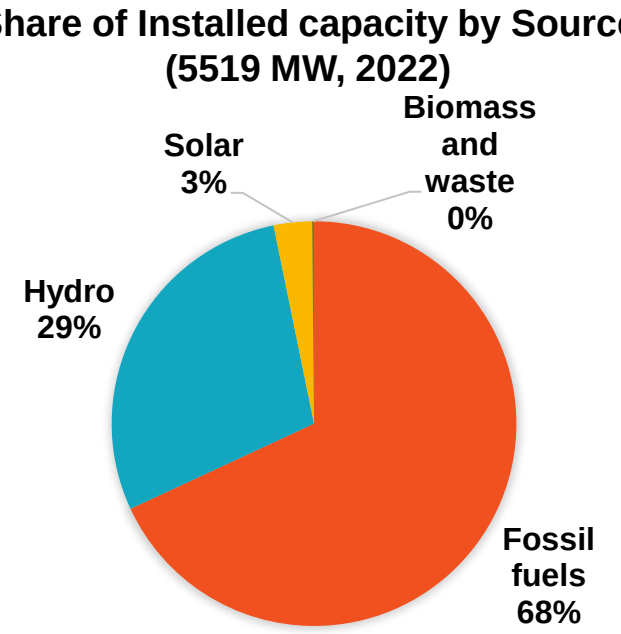
Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**5.5**
	% of fossil fuel power capacity (2022)	**68.1%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	3.5%
	Annual total grid-connected power generation (TWh) (2022)	**23.2**
	% of fossil fuel power generation (2022)	63.9%
	5-year CAGR of total grid-connected power generation (2017-2022)	**11.8%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**19.1**
	5-year CAGR of electricity net consumption (2017-2022)	**8.8%**
Power Trade	Power Import (% of net consumption) (2022)	0.3%
	Power Export (% of net consumption) (2022)	7.7%
	Power Export (% of generation) (2022)	9.3%

Ghana is one of a few countries in Africa with open competitive wholesale market, with robust market data reporting and disclosing system.

Power Sector in General	Unbundling Status	Unbundled (Legal)
	Private participation	Yes
	Power Generation	Yes (On-grid with IPP, mini-grid and SHS sectors are liberalized)
	Transmission (System Operation)	No (SOE, GRIDCO is the SO)
	Distribution / Retails	Privatized & liberalized but limited (The on-grid distribution is open only in Industrial Zone with one private firm. Off-grid sector is public-led but many private companies participate.)
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	Yes
	Market integration with neighboring systems	No
	Regional pool participation	Yes (WAPP)
Regulated status	National / Independent regulatory body	Yes (since 1998)

Power Sector – Generation

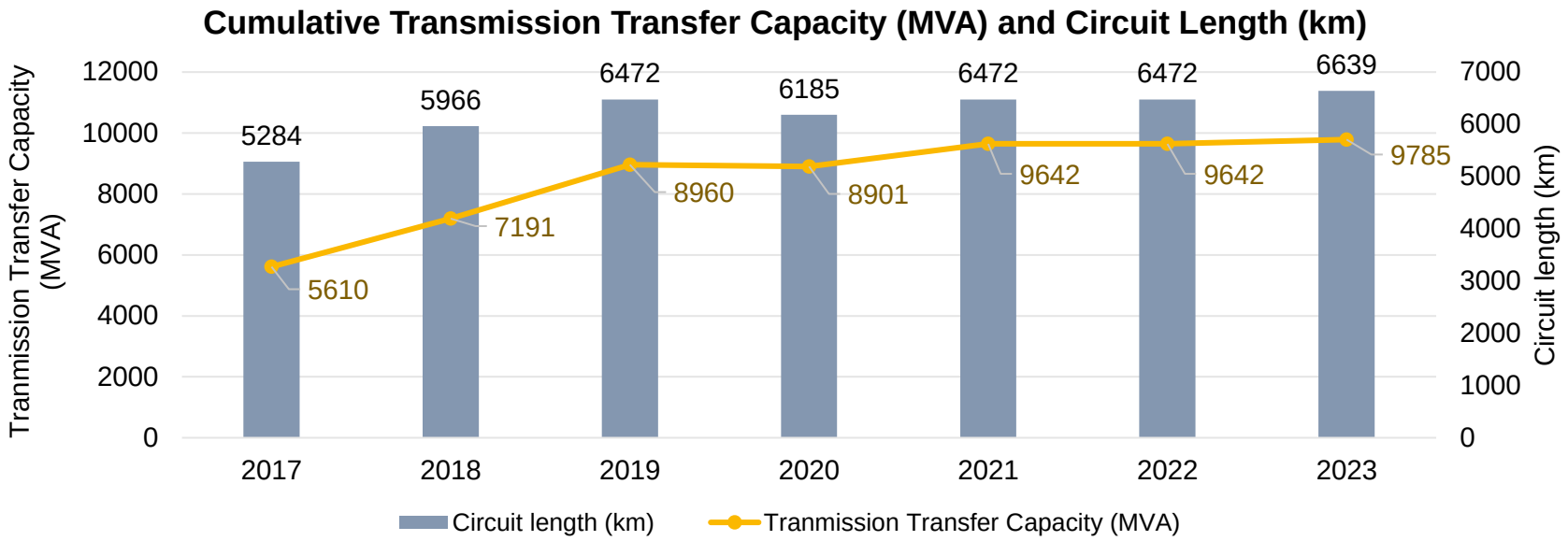




- Ghana's power and electricity generation mixes have high shares of fossil fuels.
- Ghana has a high share (68%) of fossil fuels in installed capacity, followed by hydro power (29%) and solar (3%). Fossil fuel capacity is dominated with gas power.
- The share of fossil fuels in generation capacity and electricity is increasing as well, resulting in decline in renewable energy share.
- Both supply and demand are growing but the growth ratio of consumption is much larger than that of supply. Still the country is a net exporter of power to neighboring countries.

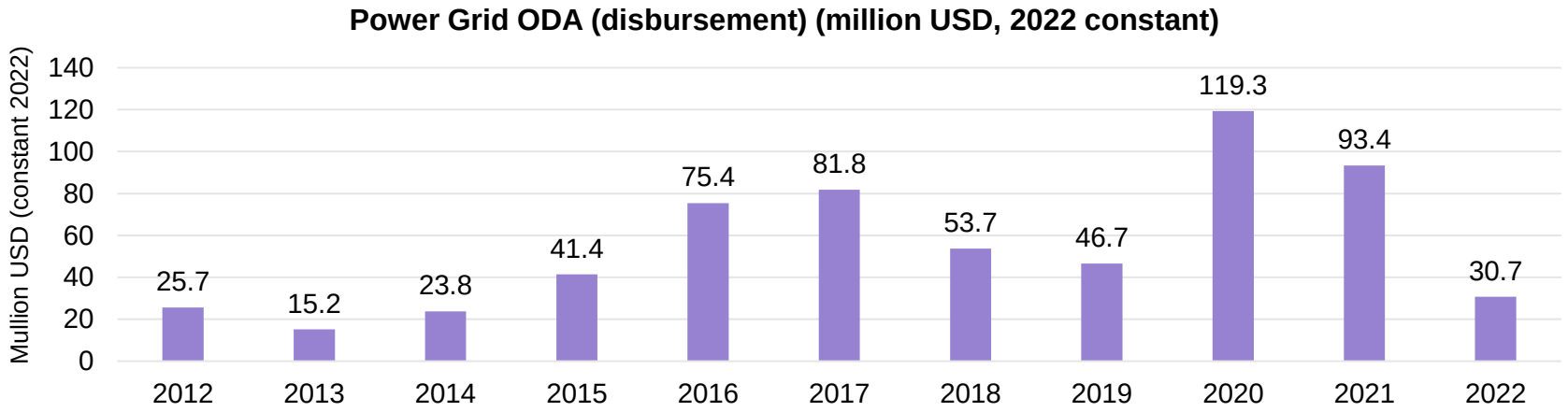
Data Source: US EIA International database – Electricity

Power Sector – Transmission



Data Source: GRIDCO Electricity Supply Plan (2018, 2019, 2020, 2021, 2022) & Annual Report (20, 2023)

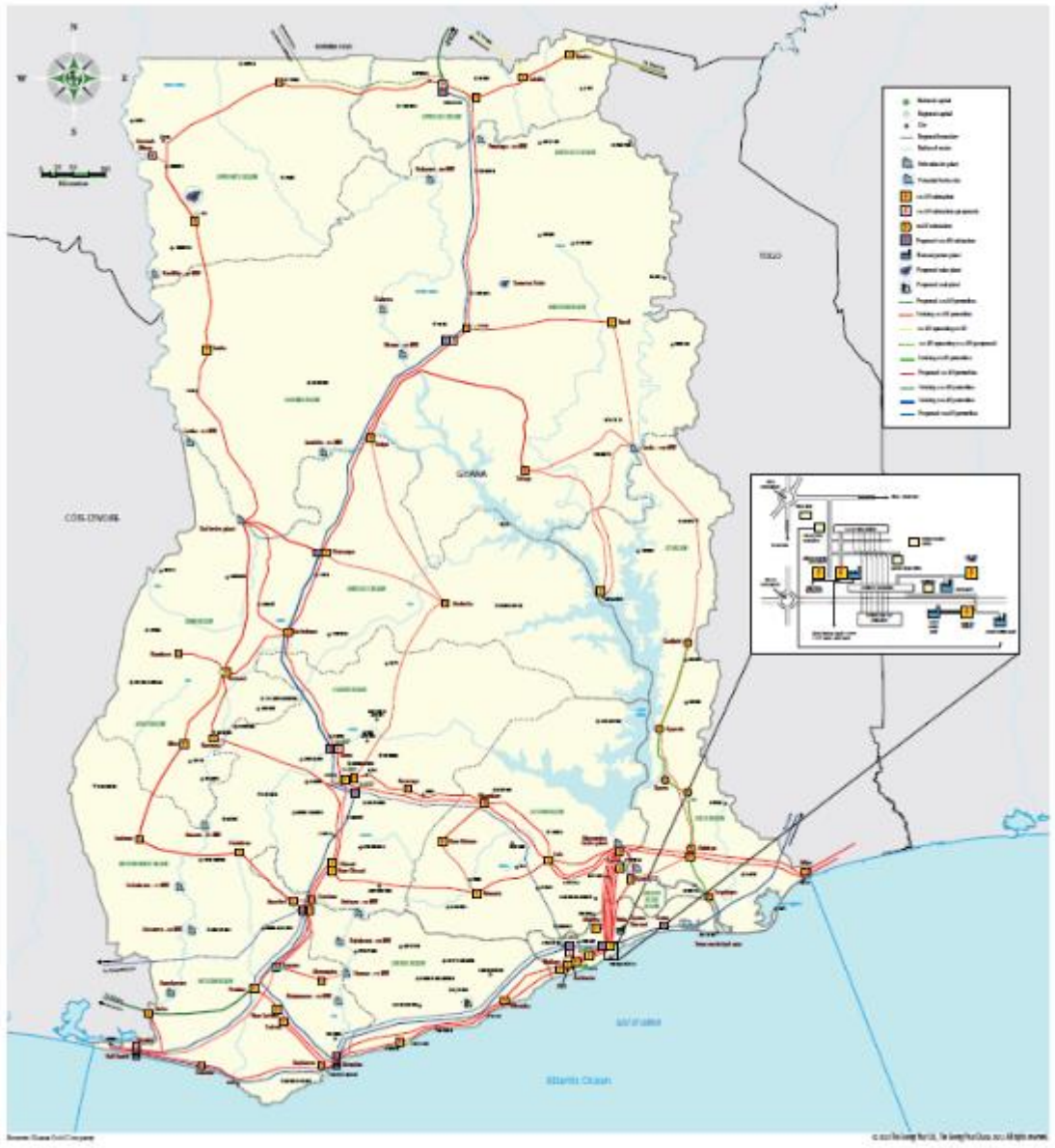
- Ghana's transmission circuit length has increased 83% in six years, while its transformer capacity has increased 26%, showing strong growth trend.
- The circuit length reached 6,639 km in 2023. The most recent 5-year average annual growth ratio is 2.2 %.
- Transmission transfer capacity stood 9,785 MVA in 2023. The most recent 5-year average annual growth rate is 6.4%.



Note: The figures include ODA for both transmission and distribution grid Data Source: OECD Creditor Reporting System,

- Total power grid ODA disbursement is fluctuating year by year. It peaked in 2020, then showing a decline in recent years.
- Weighted 5-year average power grid ODA disbursement per MW of total on-grid power installed capacity (RE and non-RE) is 12.8 Million USD / MW.

Power Sector Overview – Transmission

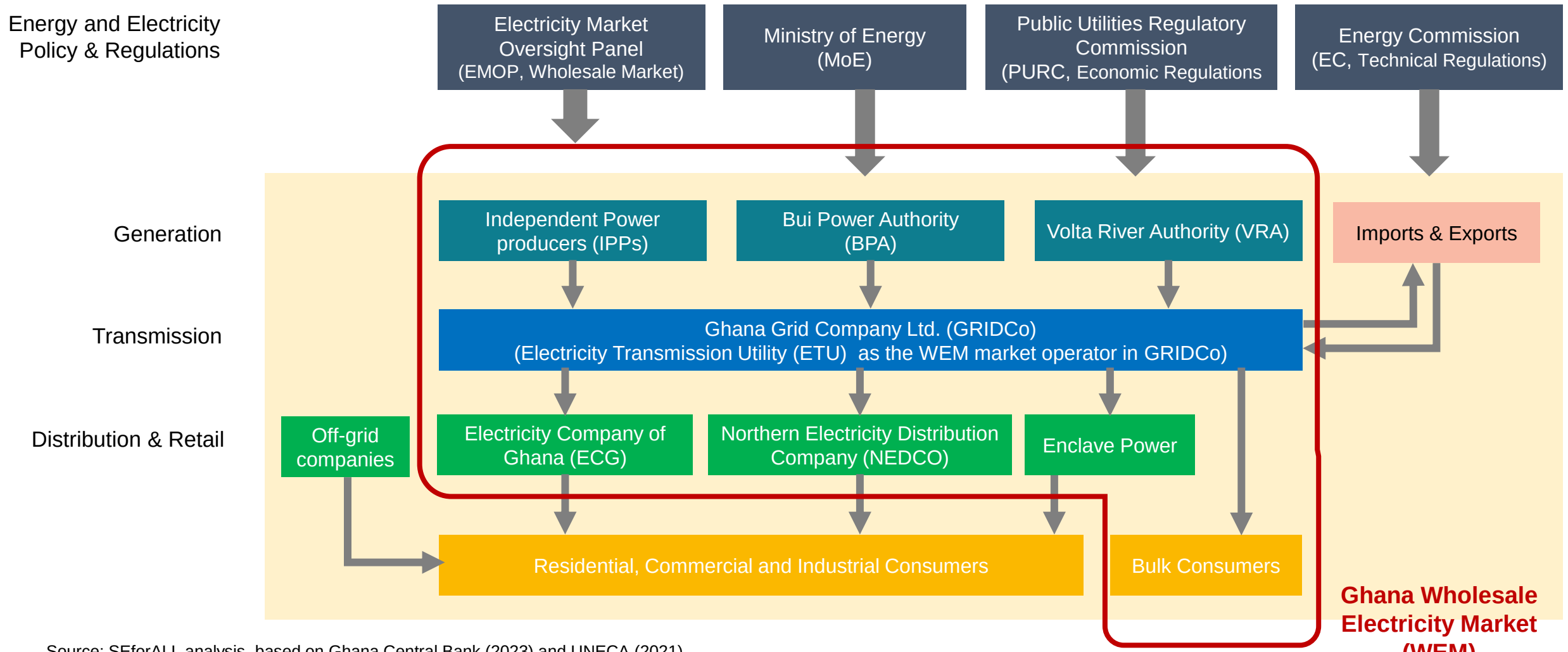


- **Ghana's transmission system is composed of four voltage levels (330 kV, 225 kV, 161 kV, and 69 kV lines).**
- The Ghana power system is interconnected with Côte d'Ivoire and Burkina Faso at 225 kV and with Togo at both 161 kV and 330 kV. Recent projects include:
  - WAPP Ghana - Côte d'Ivoire 330 kV interconnection project;
  - WAPP Ghana-Togo-Benin 330 kV electricity interconnection project (commissioned in 2022)

Ghana's Transmission System 2022

Source: Energy Year (2022) Ghana's Transmission System

Power Sector Structure



Source: SEforALL analysis based on Ghana Central Bank (2023) and UNECA (2021)

Power Sector Structure – Wholesale Market

Components	Characteristics
Wholesale Electricity Market (WEM) structure	1) **Bilateral Contracts Market (BCM)** – The majority of trades occur here as contracts between wholesale suppliers and other market participants (contracts between wholesale sellers (including IPPs) and wholesale buyers); and 2) **Spot Market -** trade electricity beyond contracted capacity between market participants to make up the shortfalls and enable balancing. The Spot Market is reserved only for incremental trading.
Market Operator	The **Electricity Transmission Utility (ETU)** is the market operator of the WEM
Market Participants	Sellers and buyers of electricity, or wholesale suppliers and customers. There are three types of authorized market participants: a) Any entity with an operating license from the Energy Commission (EC); b) Any entity is registered with the ETU; and c) Any entity has entered into a contractual arrangement with the ETU. They are wholesale electricity suppliers (including power generating utilities and the IPPs), distribution companies, electricity brokerage enterprises, and bulk customers.
Spot Market	▪ The spot market price for electricity be based on the system marginal cost of supply and a merit-order dispatch ▪ The Public Utilities Regulatory Commission (PURC) developed the Electricity Transmission Ancillary Services Pricing Policy and Guidelines for the procurement of ancillary services at the spot market of the WEMs as well as the Market Regulations Manual and the Electricity Market Rules. ▪ The administration and operation of the WEM by GRIDCO is supervised by the **Electricity Market Oversight Panel (EMOP)** which will advise the Energy Commission accordingly.

Source: UNECA (2021)

Power Sector – Policy and Plan related to Power System Planning

Act, Policy, Plan and Programme	Objectives
Power Sector Reform Program (PSRP) (1995)	Reorganized the market structure and governance, restructuring and unbundling of vertically integrated utility to increase the private investments and enable greater competition in the electricity market and increase the efficiency of the power system.
National Energy Policy (2010)	Set the country's energy sector goals, in line with the mid-term macroeconomic goals and establish a framework for energy management and an environment to increase energy sector investment and renewable energy in the national energy mix.
Renewable Energy Act (2011)	Aims to create a regulatory environment to attract private sector for renewable energy development and utilization
Renewable Energy Master Plan (REMP) (2019)	The first national roadmap for the long-term development of renewable energy, aiming to increase renewable generation capacity to about 1,360 MW by 2030. An investment plan to increase renewable energy technologies throughout Ghana between 2019 and 2030 and aim to improve business environment for private sector growth.
Energy Sector Recovery Program (2019)	Aims at achieving financial sustainability of the state-owned utilities and ensure a sustainable energy sector by providing comprehensive recovery program for the energy sector between 2019 and 2023.
Strategic National Energy Plan (SNEP) (2019)	A framework to guide decision-makers to meet national energy demand sustainably. It covers the entire energy sector for the period 2020-2030, projects energy demand estimates, assesses long-term energy supply and options based on different scenarios, identifies energy supply constraints and challenges, finds key policy issues and formulates Action Plan.
Integrated Power System Master Plan for Ghana (IPSMP) (2019 & 2023)	▪ A subset of the SNEP to provide a comprehensive development view of power generation and transmission facilities. ▪ Provides the overall guidance and assumptions for all the other planning documents such as the Annual Supply/Demand Plans, the Transmission Master Plan, and the Distribution Plan. ▪ The Plan proposes a least-cost / least regret long-term generation capacity expansion plan to adequately meet projected national electricity demand, aiming at increasing resilience, achieving cost competitiveness, and keeping the local environmental and climate commitments. The 2023 plan covers the period up to 2040.
Electricity Supply Plan for Ghana Power System (annual update)	Power sector medium-term outlook with demand projections and resource adequacy assessment, annual update of the strategy for power service delivery and priority generation and transmission projects / works.
National Energy Transition Investment Plan (2023)	Target net zero by 2060, with various sectoral changes and technologies and four main decarbonization technologies – renewables, low-carbon hydrogen, battery electric vehicles, and clean cookstoves.

Source: SEforALL analysis

Policy and Regulatory Environment for Grid Development and Operation

System Planning	Economic Regulations	Technical Regulations
▪ Ghana's power system planning has a comprehensive with well-organized hierarchical procedure, regulatory oversight and stakeholder engagement. Its framework and procedure that consider different scenarios of renewable expansion in various sectors. ▪ The Strategic National Energy Plan (SNEP) covers the entire energy sector, assessing energy demand, supply needs and options and policy issues and formulate Action Plan. The 2019 version covers 2020-2030 period. ▪ Integrated Power System Master Plan for Ghana (IPSMP) is a sub-set of the SNEP, focusing on power sector. It formulates a least regret capacity expansion plan, providing guidance / assumptions for subsequent transmission development plan and annual supply plan among others. The 2023 plan covers the period up to 2040. For transmission, it identifies required transmission transfer capacity for different zones. ▪ Publicly available Transmission Master Plan, however, is missing, not updated since 2011.	▪ Ghana's economic regulations related to transmission / distribution network asset development and system operation charges are quite advanced. ▪ The ratio setting methodology for asset investment recovery is essentially a hybrid of performance-based incentive regulations with cost-plus revenue principles. This method ensures cost recovery and clarify revenue stream. Regulated Asset Base (RAB) and each cost component are clearly defined, and calculation formulas for revenue requirements are given in the electricity ratio setting guidelines. The philosophy behind the method and regulatory approval process for network tariff / ratio setting are also clearly stipulated by the PURC. ▪ Transmission operation charges are divided into two charges; 1) TSC1 ratio for GRIDCO to recover cost of transmission network operations, and 2) TSC2 ratio for GRIDCO to recover transmission losses). They are clearly defined by the PURC, and the changes are applied to unit of electricity basis without discrimination. ▪ Currently, the introduction of capacity market is in progress, while the 2023 PURC ratio setting guidelines define capacity procurement costing and mandatory competitive procurement for new power plants.	▪ Ghana has two separate grid codes; one for all types of generators (2009) and the other is renewable specific sub-codes (2015). ▪ The 2009 National Grid Codes clarify the roles / responsibilities for all grid participants and specify technical requirements and procedures for 1) grid development planning, 2) network connection, 3) system operation including scheduling and dispatch and ancillary services, 4) information and data, 5) performance standards, 6) safety, among others including governance. The main codes clarify economic dispatch, real-time dispatch, and merit-order operation with least cost supply over the hydrologic year (November 1st to October 31st). ▪ The 2015 Renewable energy sub-codes focuses on minimum technical connection conditions for a Variable Renewable Power Plant (VRPP) and detailed system operation requirements and parameters. The codes also specify requirements of VRE forecasting for real-time operation and mention curtailment, but no detailed conditions are given. ▪ Ghana's grid codes are advanced for VRE integration. They can be further enhanced by including operational and safety requirements for battery storages and demand side management and cover cyber security.

Source: SEforALL analysis

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	5519 MW (2022)	7606 MW
	Annual Growth Ratio (%)	3.5% (2017-2022)	4.1% (2022-2030)
	VRE (MW)	98 MW (2022)	1204 MW
	Ratio of VRE (%)	1.78% (2022)	15.8%
Electricity Demand	**Peak Demand (MW)**	3469 MW (2022)	5479 MW
	Annual Growth Ratio (%)	---	5.9% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	31.7%	38.8%
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	3.0% (2017-2022)	-1.8% (2022-2030)
Transmission	**Transformer capacity** of transmission lines	6639 MVA (2023)	9890 MVA (2030)
	Annual Growth Ratio (%)	6.4% (2018-2023)	5.1% (2022-2030)
	Circuit length of transmission lines	9785 km (2023)	N/A
	Annual Growth Ratio (%)	2.2% (2018-2023)	N/A

Data Sources: USEIA; Ghana Energy Commission (2023) Integrated Power System Master Plan for Ghana; GRIDCOP Electricity Supply Plan (2018, 2019, 2020, 2021, 2022) & Annual Report (20, 2023) (see Appendix 2)

- Ghana is projecting approximately 39% increase in power capacity between 2022 and 2030, requiring 4.1% annual growth rate. VRE is expected to increase more than 12-fold. Peak demand is projected to increase 57% during the period. Reserve margin against installed capacity remain large.
- In terms of transmission grid, approximately 50% increase in transmission transformer capacity up to 2030 is planned with 5.1% annual growth ratio that is slightly lower than the past 5-year ratio up to 2023.

Key Indicators

Indicator	Data
RE share in power mix (2022)	30.5%
VRE share in power mix (2022)	1.8%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	-8.9%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	8.8%
System flexibility (WEF 2024 indicator, 0-100)	99.7
Demand projection (2030)	5479 MW (peak)
Generation supply target (2030)	7606 MW
Grid target / strategy in national policy / planning or NDC	No
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	6472 km
Transformer capacity (MVA, 2022)	9642 MVA
Annual average growth in transmission line length (over 5 years)	2.2% (2018-2023)
Current interconnections capacity (MW, known)	438
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes (limited with EPC)
Grid loss (total, %, 2022)	29.3%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	36.3
SAIDI (2023)	55.9
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	85.1%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	571.8
Average residential tariff (USD/kWh)	0.098 (2022) 0.138 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	N/A
Annual average growth in distribution line length (over 5 years)	N/A
Distribution grid loss (%)	30.0% (2022)

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries (See Appendix 2)

Key Findings

Progress

- Ghana has an open, competitive market structure, and is one of the more liberalized power sector in Africa.
- There has been progress in economic and technical regulations for grid development and system operation.
- Economic regulations for transmission investment recovery, cost allocation and clear tariff determination methodology are robust.
- Sub-grid codes for renewable power plants offer clear technical operational requirements for variable renewable energy (VRE) power plants.

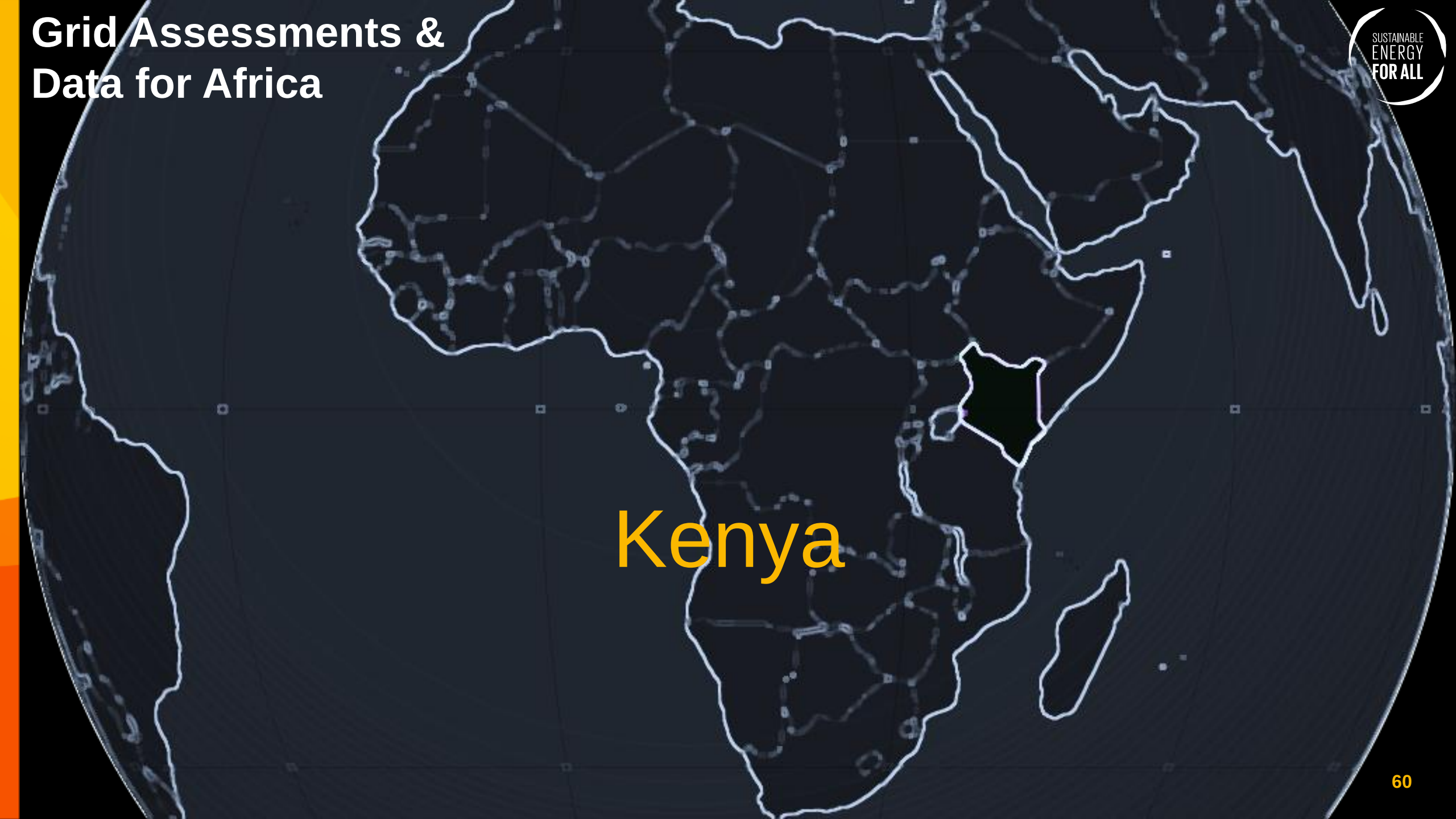
Challenges

- Although the country has a well-established, integrated electricity supply planning framework, transmission part of the plan is not updated lately and remain ambiguous both technically and financially.
- Private companies can participate in transmission asset development through EPC contract, but the existing licensing regime practically reduces further contribution and business models.
- Increase in electricity consumption per capita by on-grid expansion of electricity service and simultaneous demand stimulation becomes important for further economic and social development.
- Electricity access ratio is high compared to other Sub-Saharan Africa countries, but the service needs to reach rural areas with clear last-mile access strategy and implementation.
- Highly inefficient Grid compared to other African countries.
- The penetration of VRE has been very low and one of bottleneck is lack of robust grids to absorb more VRE.

Conclusion

- Ghana needs to prioritize investments in grid expansion and improving its grid efficiency and reliability as it has high grid losses and system interruption frequency and duration.
- Ghana is planning to increase VRE share massively by 2030 (16%) while increasing the power system size 40%, although the current share is quite small (less than 2% in 2022). This means significant focus on grid investment by 2030.
- Per Ghana Energy Transition Plan, Ghana needs to invest in 60 GW transmission and distribution network by 2060 for a net-zero power system.

Grid Assessments & Data for Africa



Country Overview

Total Population (2023)	Land Area (2022, square km)	GDP per Capita (2023, PPP 2021 international dollar)	Annual GDP Growth ratio (2023)	Net ODA received (2022 Current USD)	Poverty headcount ratio at 2017 PPP USD 2.15 a day (2018, % of population)	Population Estimate (2030)	WB Income Group (2024)
55,339,003 Urban (28%)	569,140 km^2	USD 5,683.0	5.6%	USD2,652 million (2.4% of GNI)	36.1%	63,103,942 (15% up from 2023)	Lower-middle income

- Kenya's economy is the largest and most diversified in East Africa, growing strong for the past 20 years, constantly achieving 5-6% annual GDP growth ratio, except the Covid-pandemic years. The country's growth has been supported by significant policy, structural and economic reforms.
- Kenya's key development challenges remain, including poverty, inequality, youth unemployment, transparency and accountability, climate change, continued weak private sector investment, and the vulnerability of the economy to internal and external shocks.
- The government prioritizes agriculture, healthcare, affordable housing, micro and small enterprises, and the digital and creative economy to strengthen the economy from bottom-up.

Sources: World bank Development Indicators; World Bank Kenya Overview; WorldAtlas.com

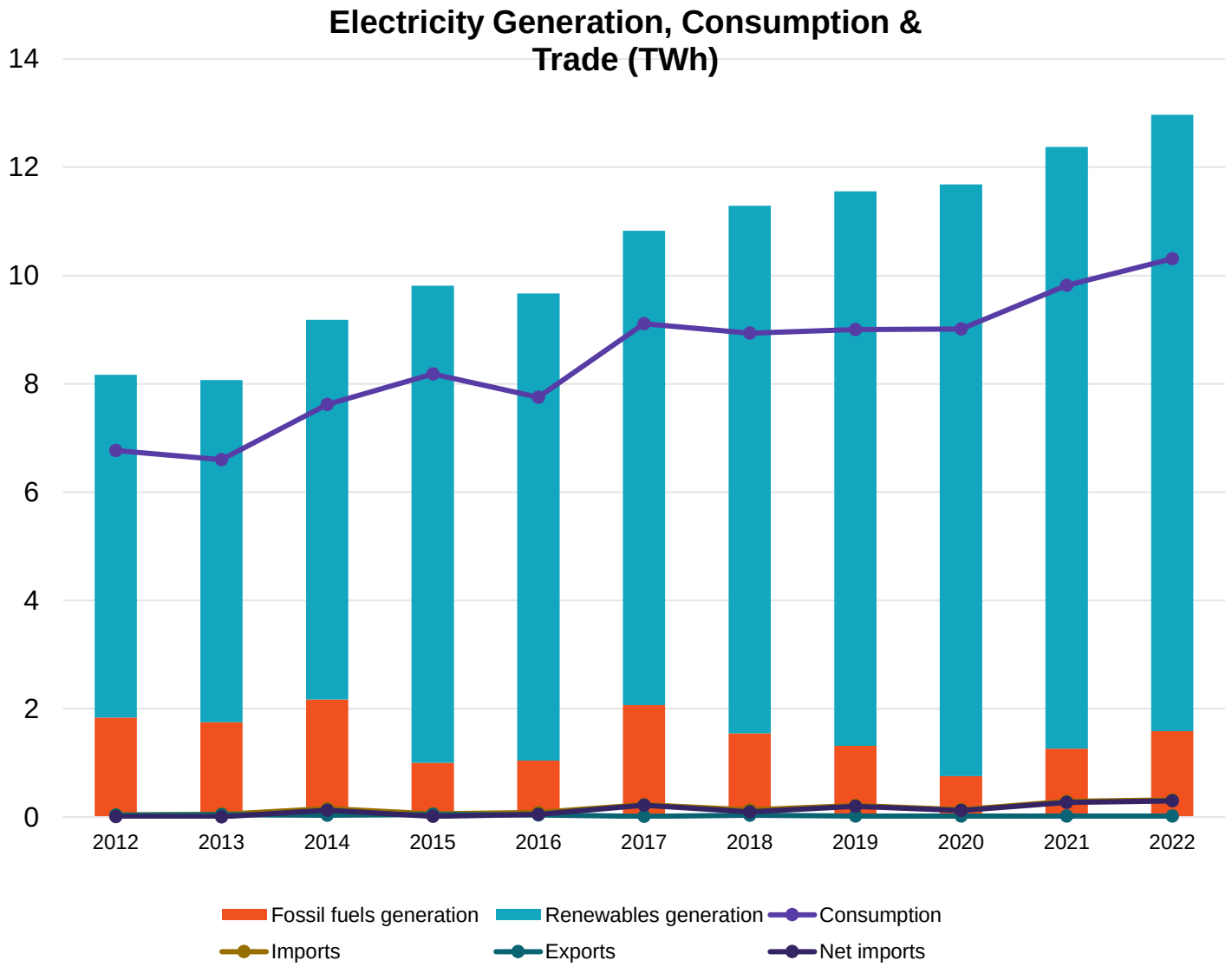
Power Sector Overview

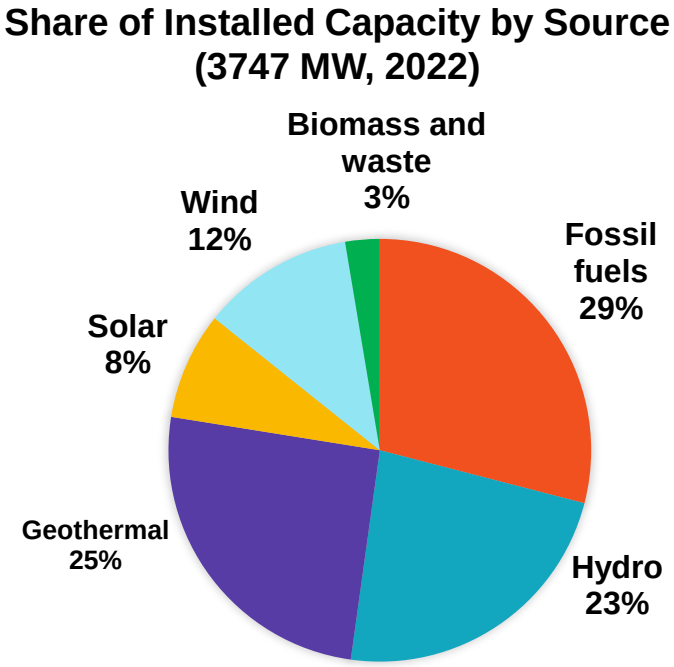
Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**3.7**
	% of fossil fuel power capacity (2022)	**29.0%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	8.5%
	Annual total grid-connected power generation (TWh) (2022)	**13.0**
	% of fossil fuel power generation (2022)	7.7%
	5-year CAGR of total grid-connected power generation (2017-2022)	**3.7%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**9.6**
	5-year CAGR of electricity net consumption (2017-2022)	**1.1%**
Power Trade	Power Import (% of net consumption) (2022)	2.3%
	Power Export (% of net consumption) (2022)	0.1%
	Power Export (% of generation) (2022)	0.2%

Power Sector in General	Unbundling Status	Unbundled (Legal)
	Private participation	Yes
	Power Generation	Yes (On-grid with IPP & mini-grid and SHS)
	Transmission (System Operation)	No (SOE) KETRACO (100% SOE) as the SO
	Distribution / Retails	Very limited - only in mini-grids and SHS. Kenya Power & Lighting Company (KPLC) is currently the sole distribution company
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - single offtaker of retail and distribution (Kenya Power) **The 2024 Electricity Act revision specifies development of wholesale market design / structure within three years**
	Market integration with neighboring systems	No
	Regional pool participation	Yes (EAPP)
Regulated status	National / Independent regulatory body	Yes (since 1998)

The country has an unusual transmission sector structure – 100% SOE Electricity Transmission Company Limited (KETRACO) and Kenya Power (50% SOE) both own and operate transmission lines (the latter only for those built before the establishment of KETRACO in 2008). The rest is open for private sector for both development and operation, but currently no other companies are in the sector. KETRACO is designated as the national system operator by the Energy Act of 2019.

Power Sector – Generation

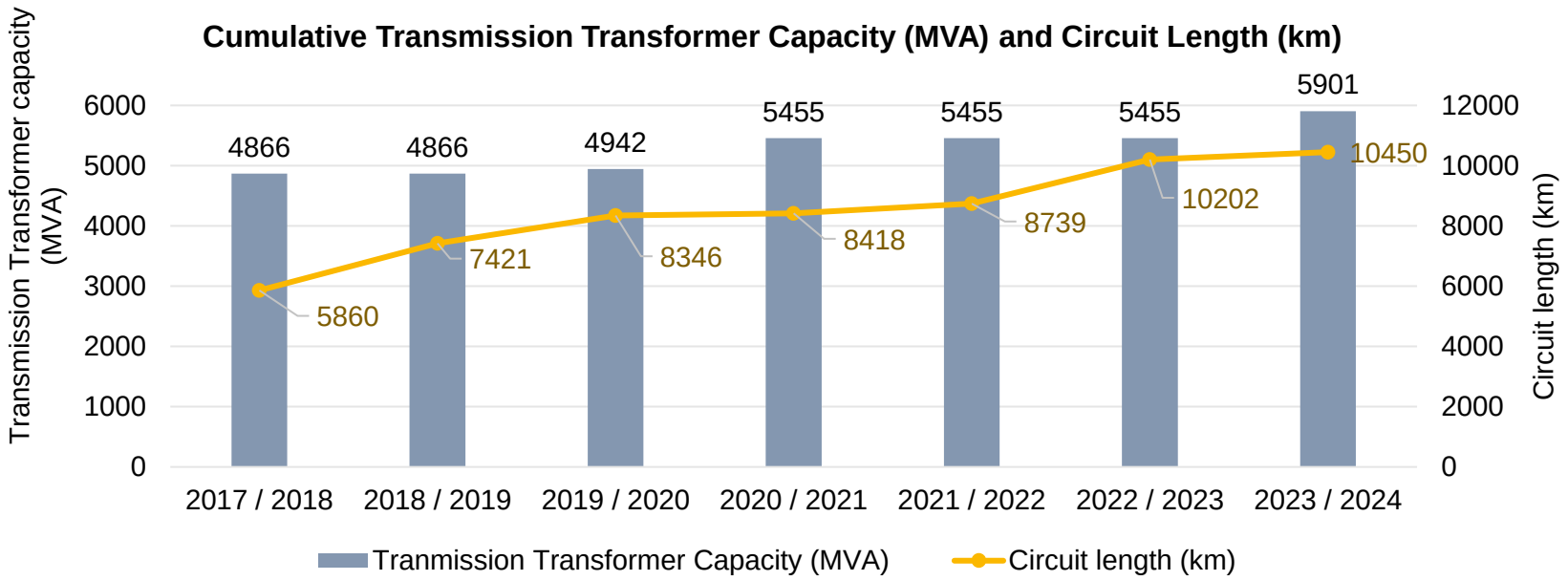




- Kenya generates more than 90% of electricity by renewable sources, enjoying a well-diversified power mix with geothermal, hydro, wind and solar.
- On-grid power installed capacity and power generation are growing steadily, annually at 8.5% and 3.7% respectively, while consumption growth is very weak.
- Although fossil fuel power still occupies 30% of the power mix, this diversity provides the strength to Kenya for increasing electricity access and consumption level.
- Power trade has a very small profile.

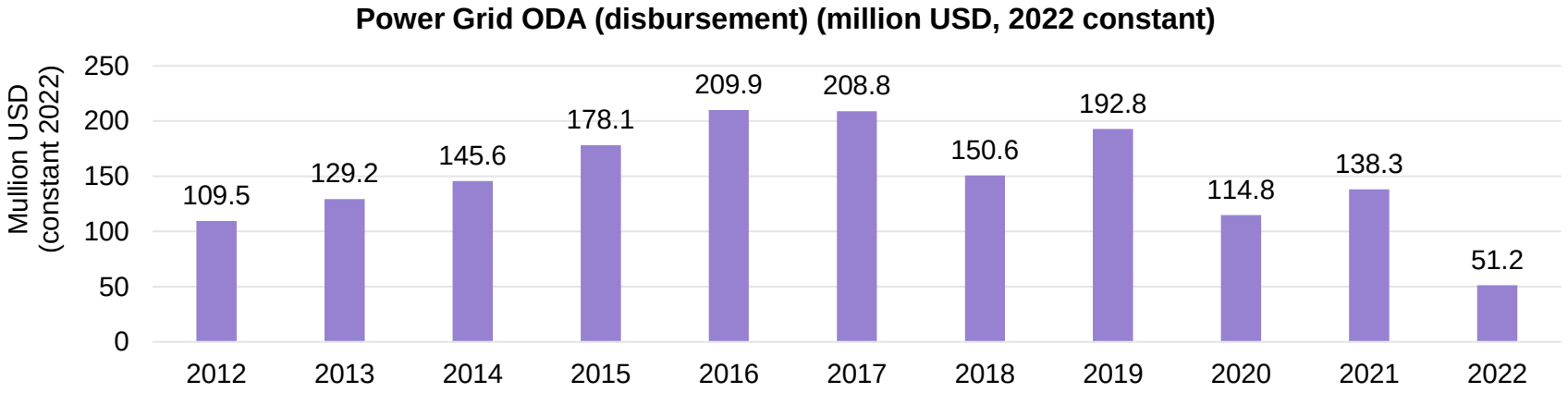
Data Source: US EIA International database – Electricity

Power Sector – Transmission



Data Source: Kenya Power Annual Reports 2017-18, 2018-19, 2023-24

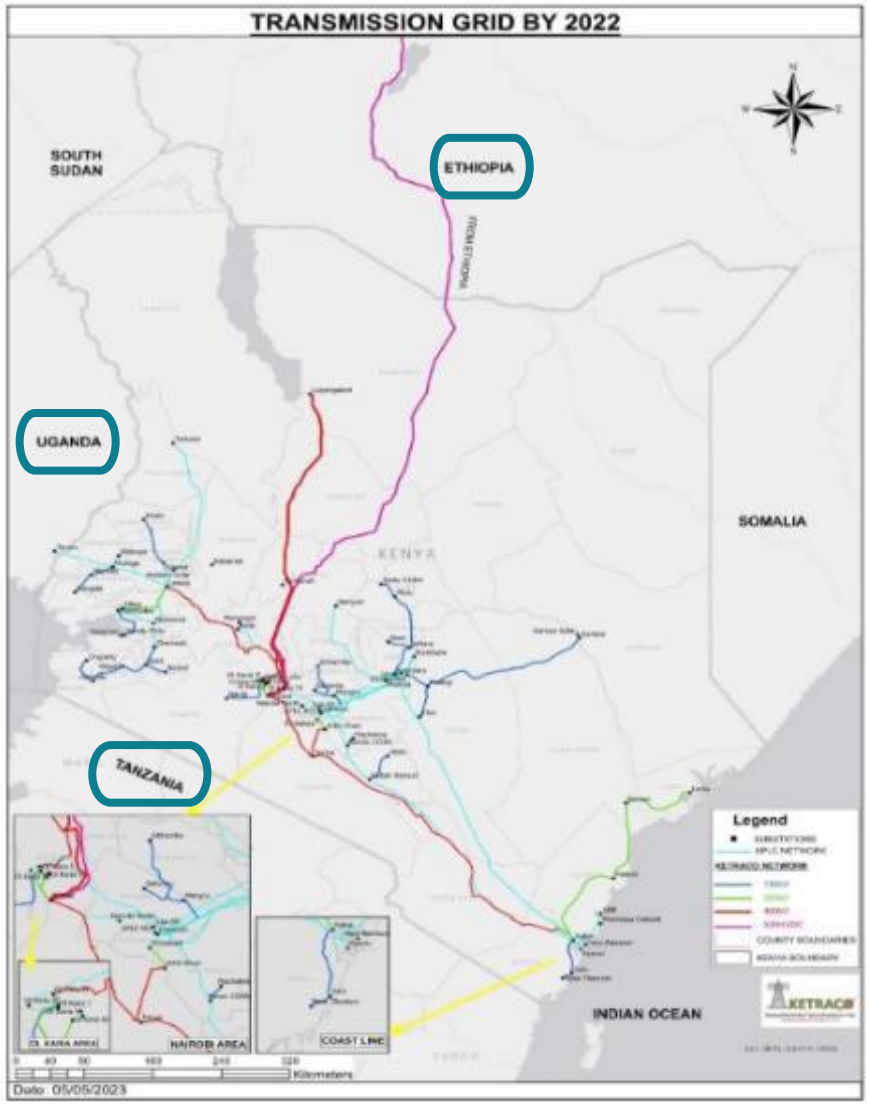
- Kenya's transmission circuit length has increased 78% in six years, while its transformer capacity has increased 21% in five years, showing good growth trend.
- The circuit length reached 10,450 km in FY2023/24. The most recent 5-year average annual growth ratio is 4.6%
- Transmission transformer capacity stood 5,901 MVA in FY 2022/23. The most recent 5-year average annual growth ratio is 3.9%

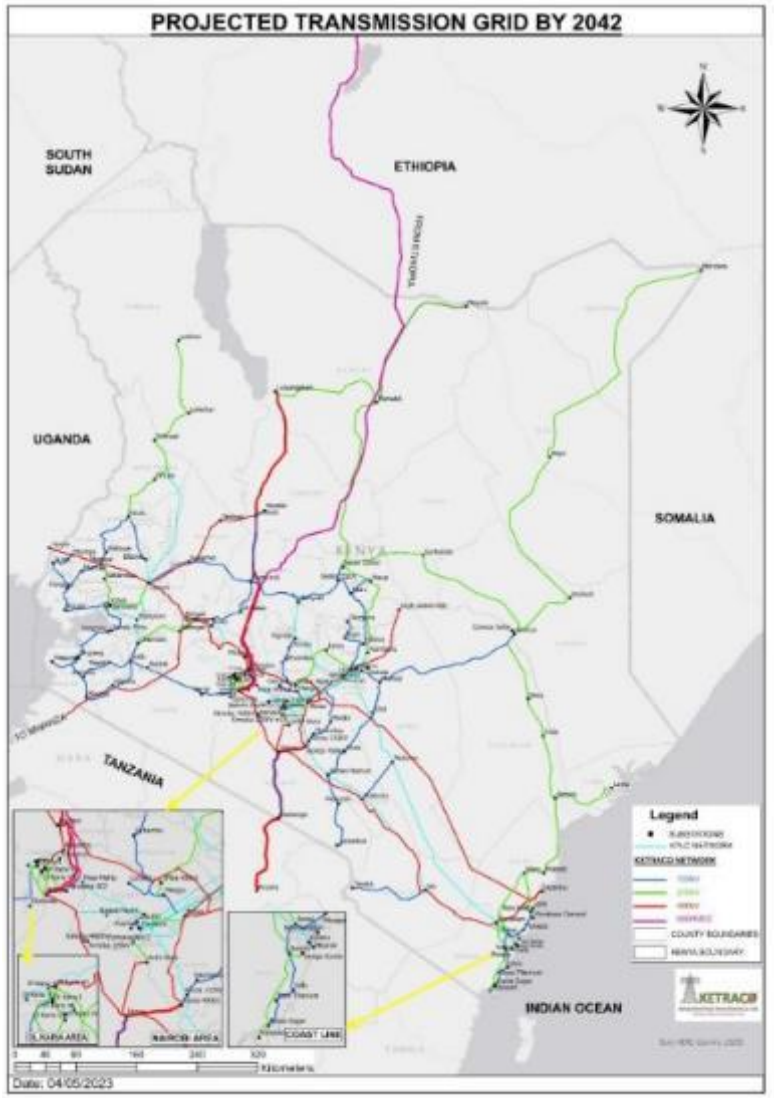


Note: The figures include ODA for both transmission and distribution grid Data Source: OECD Creditor Reporting System,

- Total power grid ODA disbursement peaked in 2016 in the past decade with stead increase. Then the disbursement shows a fluctuating trend.
- Weighted 5-year average power grid ODA disbursement er MW of t total on-grid power installed capacity (RE and non-RE) is 37.7 Million USD / MW.

Power Sector Overview – Transmission

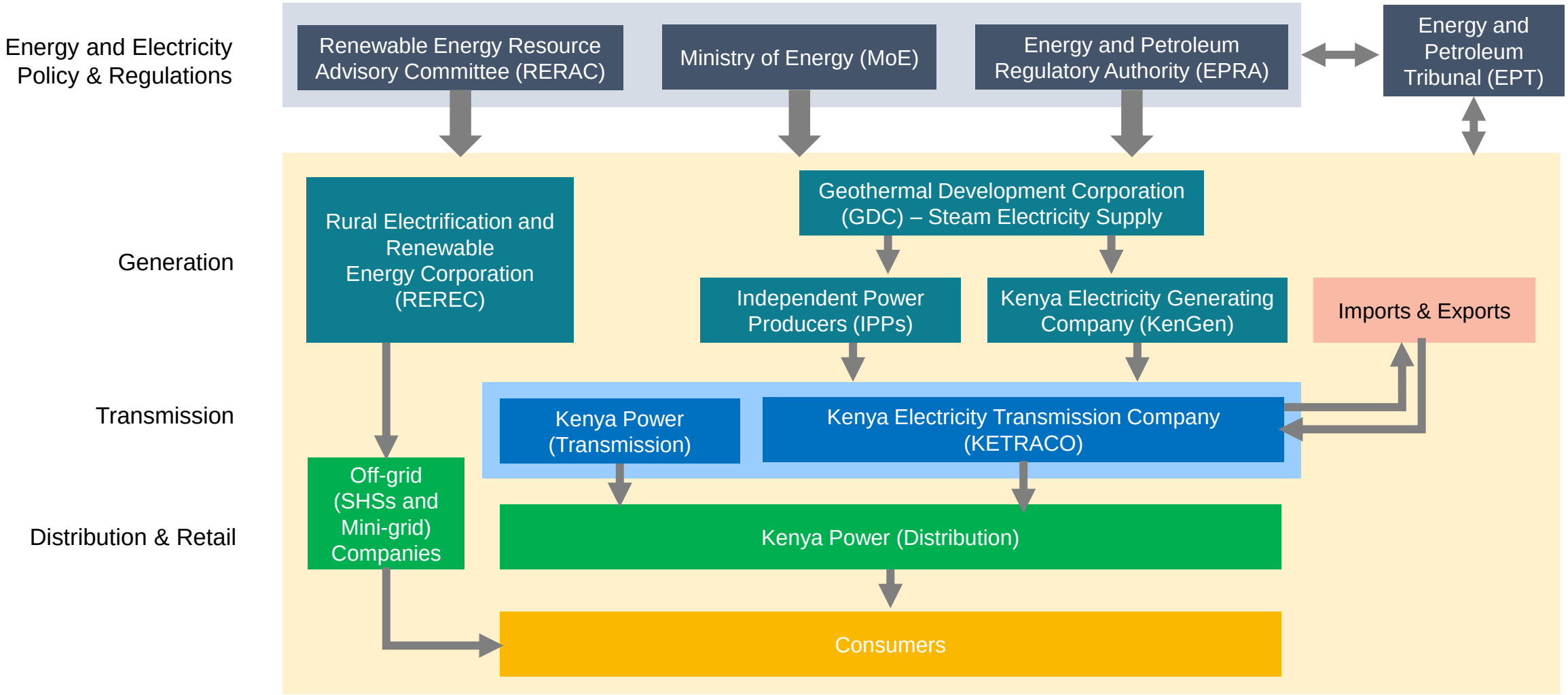




Source: KETRACO (2023) Transmission Master Plan 2023-2042

- **Kenya's transmission system is composed of four voltage levels (1282 km of 500 kV -HVDC, 2431 km of 400 kV, 2003 km of 220 kV, 3462km of 132 kV).**
- KETRACO Transmission Master Plan 2023-2042 mentions that KETRACO **is constructing 3281 km of transmission line (circuit length) and 6418 MVA of transformer capacity (as of May 2023)**
- KETRACO owns transmission lines built after the company's inception in 2008, but Kenya Power still owned the assets built before the year**. Transfer of all Kenya Power's transmission assets to KETRACO will be completed within 2025.**
- Kenya is directly interconnected with Uganda, Ethiopia, and Tanzania.
  - Kenya- Uganda Interconnector (132km 400kV Lessos-Tororo line, 1200 MW) is currently in process of upgrading to 400 kV
  - Ethiopia – Kenya Interconnector (612km 500kV HVDC Eastern Electricity Highway Project, 2000MW)
  - Kenya – Tanzania Interconnector (96km 400kV, a part of 2000 km, 1000 MW link to SAPP (Zambia))
- **KETRACO reports voltage and frequency instabilities (both high and low) in the grid, creating system operation challenges.**

Power Sector Structure



Source: SEforALL analysis based on Ministry of Energy (2021), Oxfam (2024) and UNECA (2022)

Power Sector – Policy and Plan related to Power System Planning

Act, Policy and Plan	Objectives
Power Generation and Transmission Master Plan (PGTMP) Kenya Long Term Plan 2015 - 2035	▪ Plan country's power system expansion with 1) future demand scenarios / projections, 2) analysis of suitable fuels and technologies, their optimal sizing, siting, and scheduling; 3) power generation system modeling; and 4) modeling of the transmission grid and analysis of its performance; and 5) investment analysis with financial implications ▪ Currently an update is in progress.
National Climate Change Framework Policy (NCCFP) & National Climate Change Action Plan (NCCAP)	▪ While the National Climate Change Framework Policy (NCCFP) provided a framework to guides the development of specific, detailed, and costed climate change interventions, the regular and periodic National Climate Change Action Plan (NCCAP) implement them.
National Energy Policy (NEP) (2018)	▪ Provides policy recommendations related to coal, renewable energy (particularly geothermal and hydro), electricity, energy efficiency, land, environment, health and safety, energy services, energy financing, pricing, and socioeconomic issues.
Kenya National Electrification Strategy (2018)	▪ Provide a roadmap to achieve universal electricity access in both residential and business sectors over the shortest period and at an acceptable quality of service. Currently in process of updating the Strategy.
Energy Act of 2019	▪ Liberalized new segments of generation, transmission, distribution and retail sub-sectors chains to private sector
Least-Cost Power Development Plan (LCPDP) The latest: Longer term (2020-2040) Long-term 2021 -2030 Medium-term Plan (2023-2027)	▪ The Energy Act 2019 mandates an Integrated National Energy Plan (INEP) and bi-annual preparation of the 20-year Least Cost Power Development Plan (LCPDP) and 5-year Medium Term Power Development Plan alternately. ▪ LCPDP aims to guide stakeholders on the status of the power supply system, generation and transmission capacity expansion opportunities, and the resource requirements for the expansion program. ▪ The plan includes load forecast, generation expansion planning, ancillary service requirements, identification of target transmission network, estimation of costs and an analysis of their impact on electricity tariffs and eventually determination of the impact of the entire plan on climate change. ▪ The plan is prepared by staffs from MOE, EPRA and sector agencies, with close collaboration with private sector players, which is coordinated by Kenya Power.
KETRACO Transmission Master Plan 2023-2042 (2023)	▪ Kenya Transmission Company (KETRACO) has been mandated to plan, design, construct, own operate and maintain high voltage electricity transmission grid and regional power interconnectors infrastructure.

Source: SEforALL analysis

Policy and Regulatory Environment for Grid Development and Operation

System Planning	Economic Regulations	Technical Regulations
▪ Kenya's 2016 Power Generation & Transmission Master Plan (PGTMP) explored scenarios with diverse RE expansion paths / cases for 20-year timeframe. Although an update of the plain is currently under way, the update span could be shortened. ▪ The Least Cost Power Development Plan has been formulated since 2020 through collaboration between public and private sectors, establishing power generation planning framework further with load forecast, resource endorsement, generation expansion planning, ancillary service requirements, identification of target transmission network, estimation of costs and an analysis of their impact on electricity tariffs and the impact of the entire plan on climate change. ▪ KETRACO then develops and publishes long-term (20 years), medium term (10 years) and short- term (5 years) Transmission Master Plan (TMP). The 20-year plan is updated every two years. The plan is fed to and considered as the national master plan. ▪ The planned transfer of Kenya Power Transmission assets to KETRACO (to be completed in 2025) will further consolidates the process of system planning in near future.	▪ The EPRA is responsible for economic regulations and setting tariffs with defined formula and calculating and approving tariff levels for not only retail tariffs but also transmission sub-sector charges. ▪ However, tariff formulas used by the EPRA for transmission part of tariffs are not made public. ▪ Cost-reflectiveness is reportedly low, while laws do not define periodic review for tariffs. ▪ However, economic regulations and various tariff / charge settings can be changed greatly with the intended wholesale market development. The 2024 Electricity Act Amendment (ENERGY (ELECTRICITY MARKET, BULK SUPPLY AND OPEN ACCESS) REGULATIONS, 2024) 1) specifies the development of wholesale market structure / design within three years, including capacity market; 2) clarifies cost-reflectiveness to recover costs of capital costs, O&M costs, return of equity, other financial costs and taxes, and 3) designates the EPRA to set network charges, wheeling charges and ancillary service charges. ▪ The introduction of wholesale market and power trading can clarify various costs for network services by the system and market operators and advance transparent economic regulations for better private sector participation.	▪ Kenya's transmission codes are well-developed, following international standards. ▪ The Kenya's grid codes are extensive and an excellent example of conforming both international standards / practices and domestic requirements by specifying both EAPP interconnector requirements and domestic national transmission requirements for 1) system planning, 2) network connections of synchronous generators, 3) network connection of VRE power plants, 4) operational planning, 5) system operation under various circumstances; and 6) balancing, frequency control and ancillary services. This strong international aspects of the Kenya's grid codes are important for greater regional power trading as well as regional technical VRE integration / flexibility utilization and market integration through interconnectors. ▪ The codes also separately cover domestic requirements for governance, cyber security, and data exchange. ▪ The country also provide priority access to grid to RE (hydro), use real-time dispatch and VRE forecasting, and provide compensation to RE curtailment. Priority access to RE other than hydro can be specified further.

Source: SEforALL analysis

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	3747 MW (2022) (2304 MW Firm capacity 2022)	4689 MW (3650 MW Firm capacity)
	Annual Growth Ratio (%)	8.5% (2017-2022)	2.8% (5.1% - firm capacity) (2022-2030)
	VRE (MW)	743 MW (2022)	1207 MW
	Ratio of VRE (%)	19.8% (2022)	21.6%
Electricity Demand	**Peak Demand (MW)**	2171 MW (2022)	3320 MW
	Annual Growth Ratio (%)	---	5.5% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	28.9% (6% against firm capacity)	89% (10% - against firm capacity)
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	2.6% (2017-2022)	-2.3% / -0.4% (against firm capacity) (2022-2030)
Transmission	**Transformer capacity** of transmission lines	5901 MVA (FY 2023/24)	15,174 MVA (2030)
	Annual Growth Ratio (%)	3.9% (FY2017/18-FY2023/24)	17.0% (FY 2023/24-2030)
	Circuit length of transmission lines	9137 km (FY2023/24)	N/A
	Annual Growth Ratio (%)	4.3% (FY2017/18-FY2023/24)	N/A

Data Sources: USEIA; Kenya Power Annual Reports 2017-18, 2018-19, 2023-24; KETRACO (2023) KETRACO Transmission Master Plan 2023/2042; Least Cost Power development Plan 2021

- Kenya is projecting approximately 25% increase of power capacity between 2022 and 2030, requiring annual growth ratio of 2.8%. VRE is expected to increase 62% but its share will only increase 1.8%. Peak demand is projected to increase 53% during the period. Reserve margin against installed capacity remain large but its against firm capacity will be just around 10%.
- The transmission grid is planned for a massive expansion (157%) by 2030.

Key Indicators

Indicator	Data
RE share in power mix (2022)	42.2%
VRE share in power mix (2022)	19.8%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	59.2%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	1.1%
System flexibility (WEF 2024 indicator, 0-100)	84.0
Demand projection (2030)	192 TWh (IRENA)
Generation supply target (2030)	56 GW (total) 43 GW (on-grid) (IRENA)
Grid target / strategy in national policy / planning or NDC	No
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	8739 km
Transformer capacity (MVA, 2022)	5,455 MVA
Annual average growth in transmission line length (over 5 years)	4.6% (2019-2024)
Current interconnections capacity (MW, known)	2145
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	No / No
Private participation / investment in transmission asset development (Y/N)	Yes (with multiple biz models)
Grid loss (total, %, 2022)	22.7%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	6.9
SAIDI (2023)	12.0
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	76.0%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	178.1
Average residential tariff (USD/kWh)	0.087 (2022) 0.102 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	15149 MVA (FY 2023/24)
Distribution overhead and cable length (km)	310312 km 310312 km (FY2023/24)
Annual average growth in distribution line length (over 5 years)	6.4% (FY2019/22-FY2023/24)
Distribution grid loss (%)	18.0% (2023)

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries (See Appendix 2)

Key Findings

Progress

- Kenya has a strong system planning framework and grid operational technical regulations are robust. KETRACO is actively engaging and planning massive transmission grid development.
- Kenya has strong interconnector transfer capacity within the Eastern Africa Power Pool (EAPP) and the domestic transmission line capacity is growing 4% annually.
- The 2019 Electricity Act opened multiple models for private sector participation.
- Kenya enjoys well-diversified renewable energy presence in power sector with geothermal, hydro, wind and solar. This gives the country an excellent position in energy transition.
- Security of supply looks good now with a large power installed capacity against the current peak demand, but it becomes low (6%) with firm capacity. The introduction of wholesale open market trading is planned in near future.

Challenges

- Economic regulations that translate the system planning into business and practices show relative weakness. Transmission asset investment recovery method / formula are not made in public, and cost reflectiveness are not clear. However, the planned wholesale market introduction, its structure and market rules can make positive impacts by clarifying cost-reflective tariff setting formulas for further private competition to the sector.
- Electricity consumption per capita remains very low and the growth of the country's whole electricity consumption is very weak. Grid expansion and investment will be important to account for high population growth, growth of electricity access, and increasing higher tier electricity access to current electrified and unelectrified population.

Conclusion

- Grids in Kenya can support increased investment because of strong institutions, policies, and the need to deliver more energy for energy access and economic development.
- Kenya's grid losses are significantly higher than the average in Africa, and priority regulatory and market intervention is needed.
- Per Kenya Energy Transition Plan, Kenya needs to invest in 70 GW transmission and distribution network by 2050 for a net-zero power system.

Grid Assessments & Data for Africa

Country Overview

Total Population (2023)	Land Area (2022, square km)	GDP per Capita (2023, PPP 2021 international dollar)	Annual GDP Growth ratio (2023)	Net ODA received (2022 Current USD)	Poverty headcount ratio at 2017 PPP USD 2.15 a day (2018, % of population)	Population Estimate (2030)	WB Income Group (2024)
13,954,471 Urban (18%)	24,670 km^2	USD 3,060.0	8.2%	USD 1,077 million (8.3% of GNI)	52.0%	16,375,704 (17% up from 2023)	Low income

- Rwanda is a small, landlocked and low-income country, located in central Africa. The country's population density is among the highest in the continent.
- The country’s economy is also among the fastest growing in the continent with above 7% of annual average GDP growth ratio for the past 20 years. The government targets to become a middle-income country by 2035 and a high-income country by 2050.
- Weak job creation, low productivity, infrastructure gaps, limited progress in innovation, sub-optimal allocative efficiency, and inclusive growth are cited as developmental challenges.
- It is necessary to stimulate private sector investment to enhance productivity growth, raise incomes, and provide the financing to address infrastructure shortfalls.

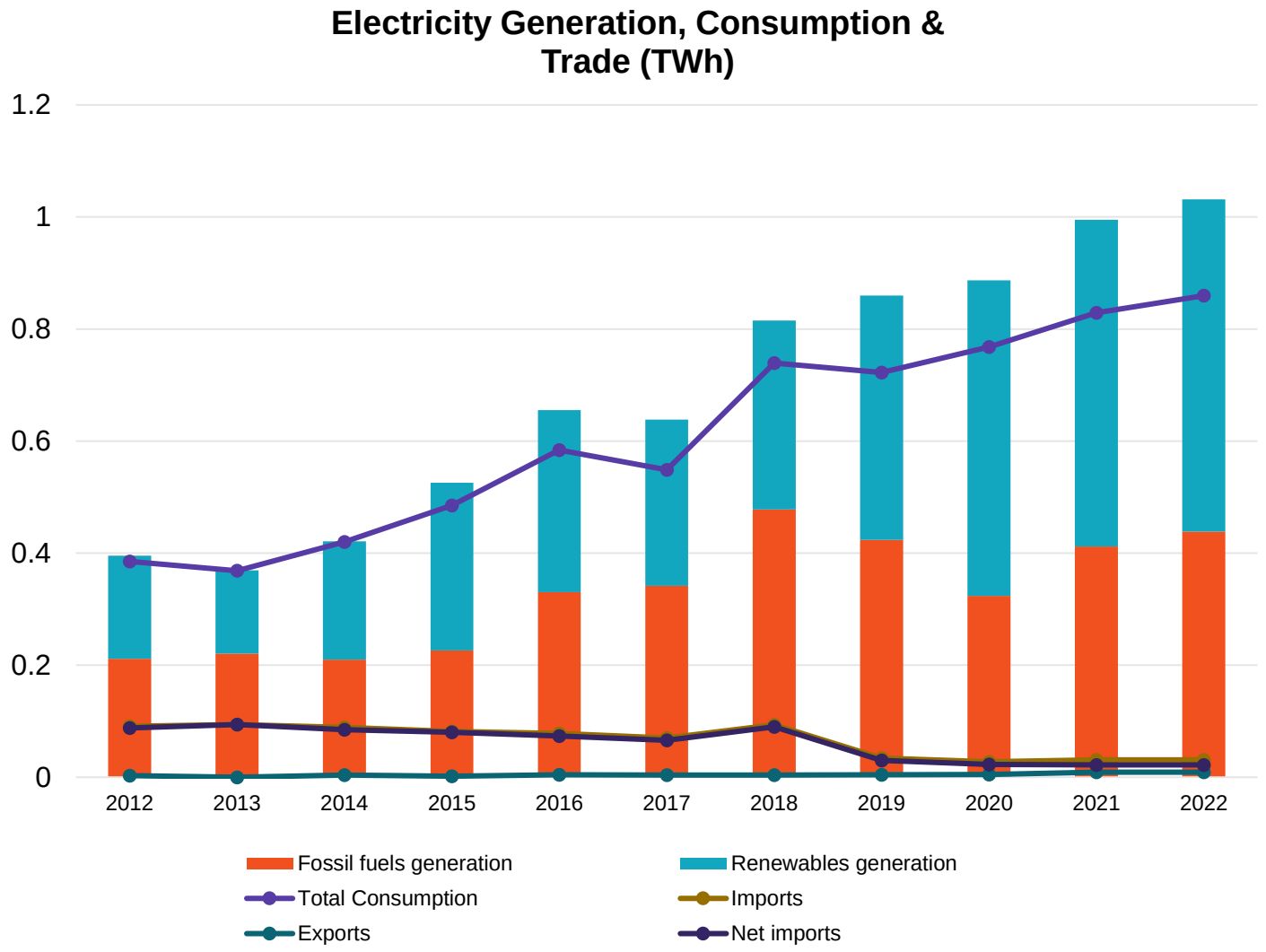
Source: World bank Development Indicators; The World Bank Rwanda overview; WorldAtlas.com

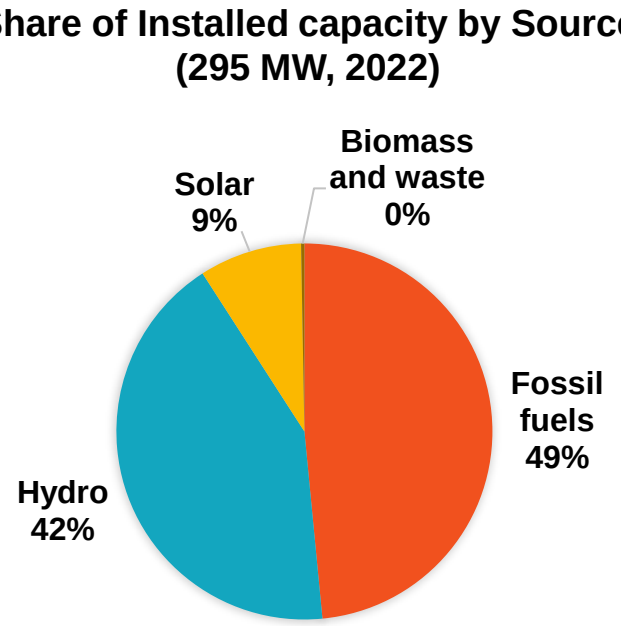
Power Sector Overview

Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**0.295**
	% of fossil fuel power capacity (2022)	**48.5%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	5.3%
	Annual total grid-connected power generation (TWh) (2022)	**1.0**
	% of fossil fuel power generation (2022)	43.2%
	5-year CAGR of total grid-connected power generation (2017-2022)	**10.1%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**0.861**
	5-year CAGR of electricity net consumption (2017-2022)	**9.4%**
Power Trade	Power Import (% of net consumption) (2022)	3.6%
	Power Export (% of net consumption) (2022)	0.9%
	Power Export (% of generation) (2022)	1.0%

Power Sector in General	Unbundling Status	Vertically Integrated (SOE - Rwanda Energy group (REG))
	Private participation	Yes
	Power Generation	Yes
	Transmission (System Operation)	No (SOE) REG subsidiary - The Energy Utility Corporation Limited (EUCL) performs system operation
	Distribution / Retails	Yes. But not on on-grid sector that has a single retailer – Rwanda Energy group (REB) subsidiary (EUCL) Off-grid / Mini-grid sector is open to private developers and operations in business
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No
	Market integration with neighboring systems	No
	Regional pool participation	Yes (a member of Eastern Africa Power Pool - EAPP)
Regulated status	National / Independent regulatory body	Yes (since 2003)

Power Sector – Generation

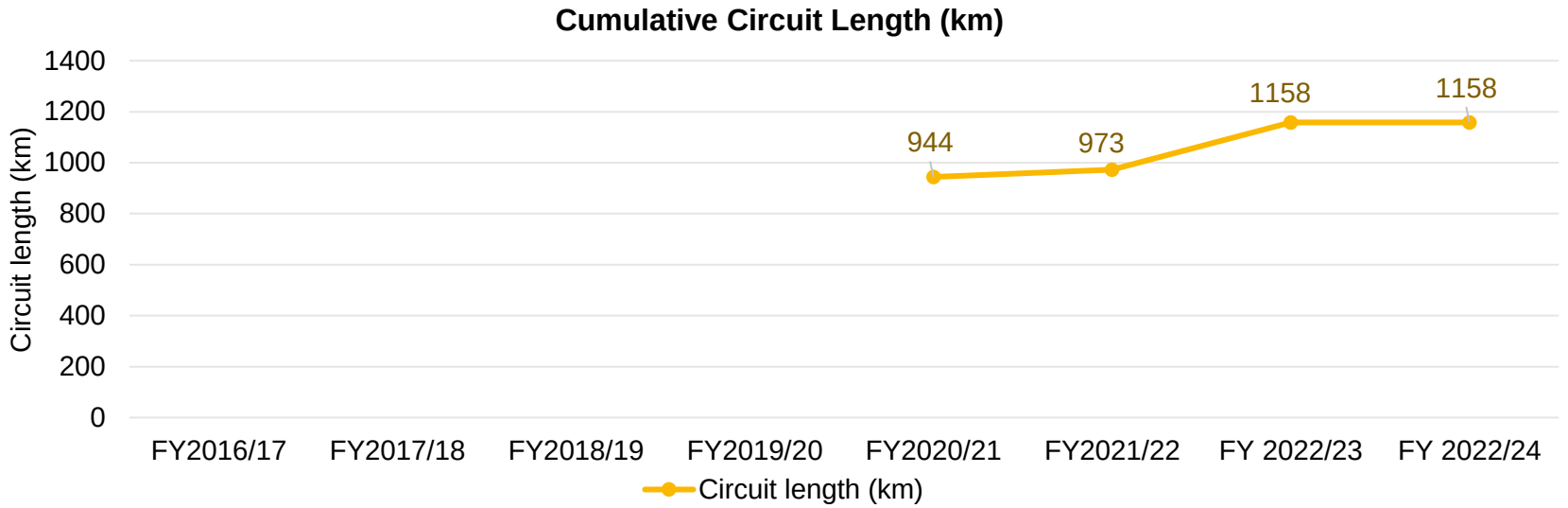




- Rwanda's power system is very small. But strong growth in both electricity generation and consumption has been observed.
- While hydro power is the single largest source in installed capacity, however, nearly half of electricity is generated by heavily polluting peat-fired power plant, methane gas and other fossil fuel thermal power plants.
- Renewable energy has increased the share in power generation mix in recent years.
- Regional power trade is not a large part of the profile.

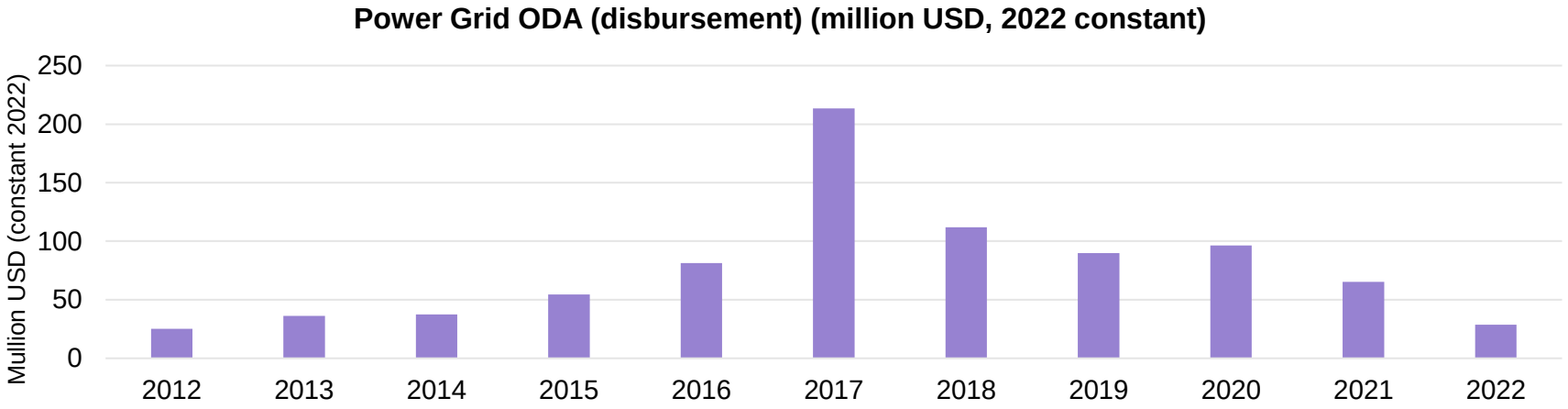
Data Source: US EIA International database – Electricity

Power Sector – Transmission



- Rwanda's transmission circuit length has increased by 22% in three years.
- The circuit length reached 1,158 km in 2023. The most recent 3-year average annual growth ratio is 7 %.
- Transmission transformer capacity data was not available

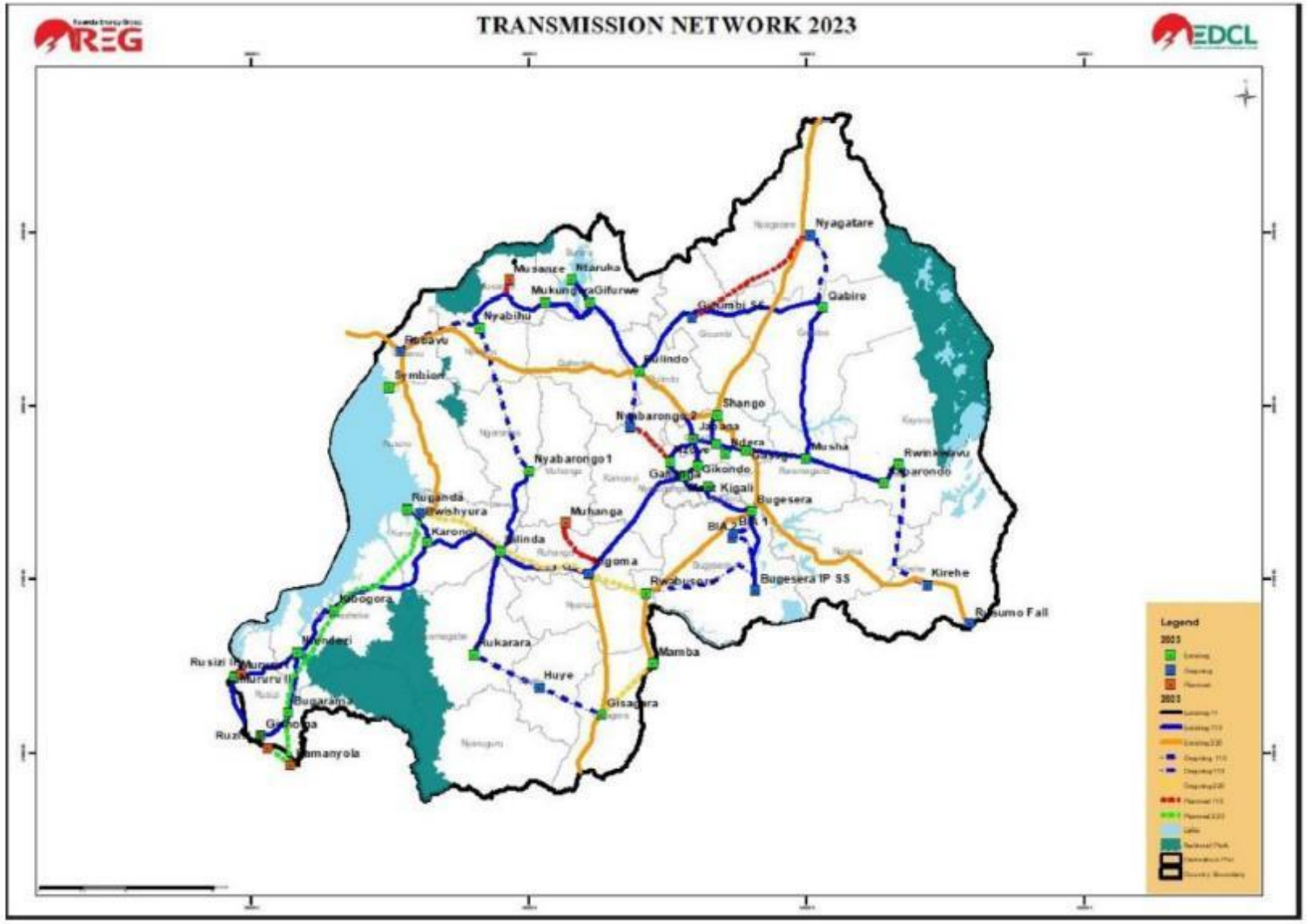
Data Source: REG Annual Reports FY2023-24, FY2022-2023, FY 2021-2022



- Total power grid ODA disbursement peaked in 2017 with downward trend to 2022.
- Weighted 5-year average power grid ODA disbursement per MW of total on-grid power installed capacity (RE and non-RE) is 295.0 Million USD / MW, which was the highest among African countries (2017-2022) .

Note: The figures include ODA for both transmission and distribution grid Data Source: OECD Creditor Reporting System,

Power Sector Overview – Transmission

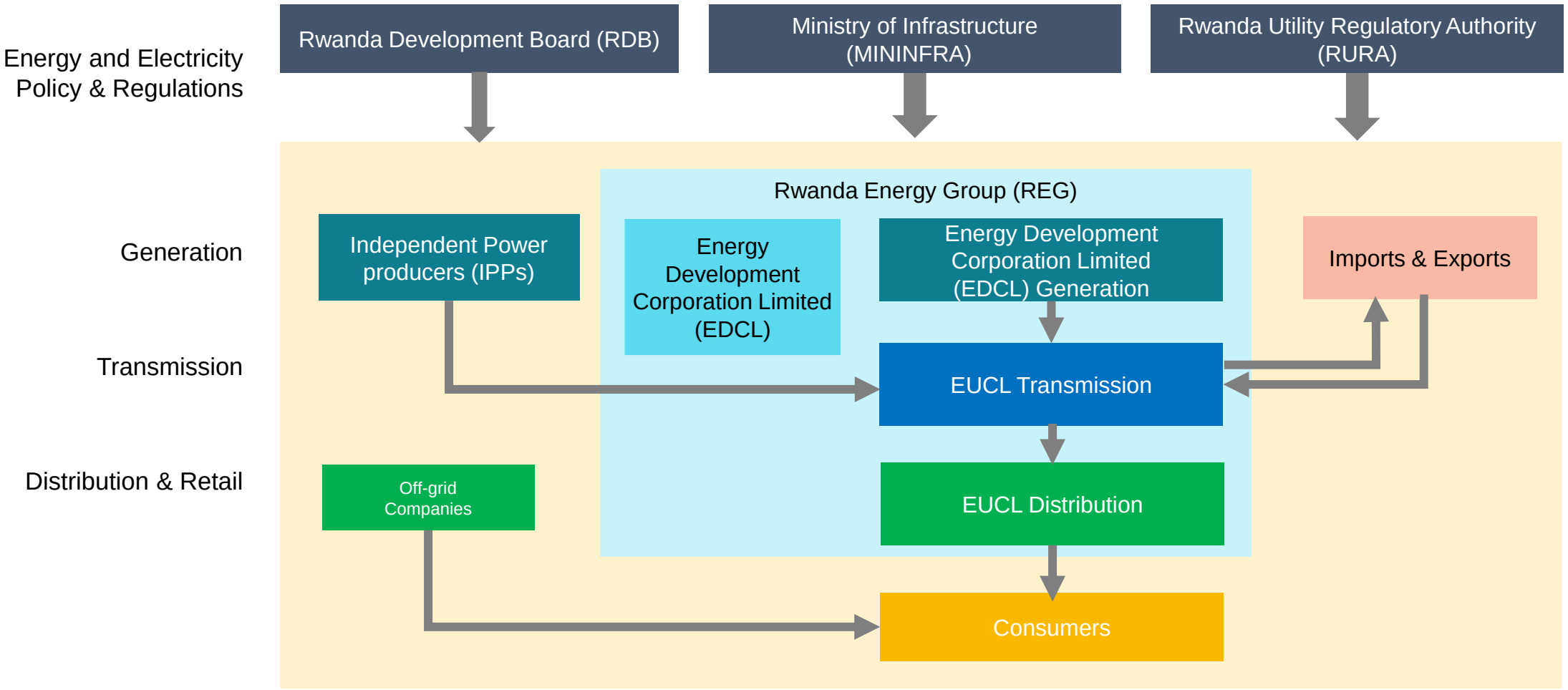


- **Rwanda's transmission system is composed of two voltage levels (510 km of 220 kV lines, 648 km of 110 kV lines).** The existing 70kV lines (28 km) are in a process of being upgraded to 100 kV currently.
- Rwanda has **direct but small capacity of interconnector links** to the neighboring countries.
  - Burundi, Rwanda and Tanzania - 372 km of 220 kV line from 80MW Regional Rusumo Falls Hydroelectric Project, commissioned in March 2024
  - Rwanda - Democratic Republic of Congo - Uganda 220 kV interconnection through 220kV/100kV Shango substation (2019)
- **The REG points out that the system operation often encounters difficulties with voltage instability and blackouts due to its small size of network, lack of multiple evacuation lines, and substations without n-1 connections, in addition to the weak interconnector link.**

Rwanda's HV Transmission System 2023

Source: REG (2023) RWANDA: TRANSMISSION MASTER PLAN (2023 2030)

Power Sector Structure



Source: SEforALL analysis based on UNECA (2021)

Power Sector – Policy and Plan related to Power System Planning

Policy, Plan and Programme	Objectives
Rwanda Energy Policy (REP) (2015)	▪ Aims to outline a long-term vision for the energy sector, provide high-level goals, and recommends clear and coordinated approaches for achieving that vision, identifying key policy issues, and set policy framework to guide decisions on the extraction, development and use of Rwanda's energy resources. REP 2015 was the revision of 2011 version. ▪ Focused on electricity access and services to ensure sufficient, reliable, sustainable and more affordable power supply.
National Strategy for Transformation (NST1 2017-2024) & (NTS2 2024-2029)	▪ The implementation instrument for Rwanda's Vision 2020 and Vision 2050, integrating long-term global and regional commitments to development goals / agenda including the Paris Agreement and Sustainable Development Goals (SDGs) ▪ NST1 and 2 identify electricity and its universal access as essential means for economic and social transformation for promoting industrialization and export growth and enhancing basic social infrastructure. The NST1 called private sector participation to help reach off-grid areas and invest in grid expansion, while the NST2 further strengthens the focus on renewable energy, climate resilience and clean energy transition in addition to universal access.
Energy Sector Strategic Plan (ESSP) 2018-2024 (2018)	▪ **A part of the power sector master plan** that set implementation strategy for NTS1 and REP by translating policy directives and principles into concrete measures necessary to reach medium-term targets, reflecting current resource constraints and risk and uncertainties. The 2018 version set tangible outcome indicators achievable by 2024.
Rural Electrification Strategy (2016)	▪ Provide key principles of providing the most appropriate form of electricity access to households based on REP and ESSP
National Electrification Plan (NEP) (2018) & (2023 revision)	▪ **A part of the power sector master plan (electrification)** based on principles and targets set by the NST, providing national / regional maps based on the technologies (grid expansion, mini-grid and SHS) to be applied.
Least Cost Power Development Plan (LCPDP) 2024-2050 (2023)	▪ **A power sector master plan (generation)** provides a least-cost, systematic power generation development / expansion plan to optimize tariff affordability. The most recent version, in 2023, is segmented into two phases: entry of committed projects (2024 – 2030) and the long-term (2030 - 2050). It also targets to achieve the Paris Agreement and SDGs and engages risk assessments of climate change impacts on hydropower power generation. The plan also offers renewable energy sources (RES) assessment and potentials mapping. The LCPDP is periodically updated by the EDCL
Rwanda Transmission Master Plan 2020-2028 (2020) & 2023-2030 (2023)	▪ **A part of power sector mater plan (transmission) -** The REG creates periodic update of transmission development master plan with established framework and procedure for medium term of 7 to 8 years. Load forecasts and power flow analysis are done to identify reinforcement and expansion needs that are prioritized and mapped for yearly projects and estimate their costs.

Source: SEforALL analysis

Policy and Regulatory Environment for Grid Development and Operation

System Planning	Economic Regulations	Technical Regulations

▪ Rwanda has clear hierarchical power system planning framework and procedure.
▪ Based on goals and objectives set by Rwanda Energy policy (REP) and National Strategy for Transformation (NST), a series of power sector master plans are developed.
  ○ National Electrification Plan (NEP) provides detailed geospatial maps with universal access technology strategy
  ○ Least Cost Power Development Plan (LCPDP) establishes least-cost, systematic power generation development plan, periodically updated by EDLC. **The plan also provide RE potential map.**
  ○ Electricity Transmission Master Plan (medium-term 7-to 8 years) is developed by REG, engaging in power flow analysis to network expansion and identifying reinforcement needs and cost estimates. The transmission planning framework and requirements are specified by the grid codes. Investment plan is specified in the REG Strategic Plan.
▪ Rwanda's system planning framework and procedures show high institutional capacity in this dimension.
	▪ According to both the Africa Energy Portal's Electricity Regulatory Index country assessment and the UNECA's regulatory assessments, Rwanda's economic regulations set by the RURA are quite robust. Well-documented tariff setting methodology exists based on the utility's cost of service study, and the ratio setting methodologies are divided into generation, transmission and distribution.
	▪ Transmission sub-sector tariff setting methodology uses Regulated Assess Base AB cost-based formula (UNECA 2021)
	▪ Ancillary service provision by generators and the cost of stranded assets are compensated.
	▪ However, the detailed tariff and ratio setting methodologies by the RUWA are not publicly available. Only exception is the 2020 Draft Tariff Methodology for Isolated Grid in Rwanda that specify revenue requirement calculation formula with clear cost components.
		▪ The Rwanda Transmission Grid Codes cover technical requirements for 1) system operation including scheduling and dispatch, ancillary services definition and rules and 2) network connection including network planning framework and procedures, in addition to governance, metering and information exchange.
		▪ The current system operation codes clarify merit-order and economic dispatch rules, ancillary services, operating procedure, and the network codes specify the requirements based on the size of power plants / embeddedness. These requirements can be reclassified and refined for operational and connections requirements based on synchronous and non-synchronous characteristics of generators. In addition, there are no clarification of curtailment conditions / rules for VRE or VRE priority access.
		▪ Although the current grid codes cover basic aspects well, they can be enhanced further for VRE-minded technical rules, including grid codes for battery storge and demand side management in the future.

Source: SEforALL analysis

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	294 MW (2022)	547-562 MW
	Annual Growth Ratio (%)	5.3% (2017-2022)	8.1% - 8.4% (2022-2030)
	VRE (MW)	25 MW (2022)	55 MW – 56MW
	Ratio of VRE (%)	8.6% (2022)	10% (2030)
Electricity Demand	**Peak Demand (MW)**	182 MW (2022)	397 MW
	Annual Growth Ratio (%)	---	9.9% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	38.4%	37.8% - 41.6%
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	0.6% (2017-2022)	1.5% - 1.8% (2022-2030)
Transmission	**Transformer capacity** of transmission lines	N/A	N/A
	Annual Growth Ratio (%)	N/A	N/A
	Circuit length of transmission lines	1158 km (2024)	1657.84 km (2030)
	Annual Growth Ratio (%)	7.0% (FY2020/21-FY2023/24)	6.2% (2024-2030)

Data Sources: USEIA; REG (2024b) Least Cost Power Development Plan 2024-2050; REG Annual Reports FY2023-24, FY2022-2023, FY 2021-2022 (See Appendix 2)

- Rwanda is projecting approximately 90% increase of power capacity between 2022 and 2030, requiring 3% increase in annual growth ratio from the recent five-year ratio. VRE is projected to increase more than twice with its share to become 10% in 2030. Peak demand is expected to increase more than twice during the period. Reserve margin will remain large.
- In terms of transmission grid, the REG plan projects 43% increase in circuit length during the same period.

Key Indicators

Indicator	Data
RE share in power mix (2022)	50.2%
VRE share in power mix (2022)	8.6%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	8.5%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	9.4%
System flexibility (WEF 2024 indicator, 0-100)	N/A
Demand projection (2030)	397 MW (peak)
Generation supply target (2030)	547-562 MW
Grid target / strategy in national policy / planning or NDC	Yes
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	1158 km (June 2023)
Transformer capacity (MVA, 2022)	N/A
Annual average growth in transmission line length (over 5 years)	7.0% (3 years, 2021-2024)
Current interconnections capacity (MW, known)	257 (?)
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes (with multiple biz models)
Grid loss (total, %, 2022)	13.6%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	21.7 (2022-23)
SAIDI (2023)	N/A
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	50.6%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	62.5
Average residential tariff (USD/kWh)	0.241 (2022) 0.215 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	29504 km (2023)
Annual average growth in distribution line length (over 5 years)	3.9% (2018-2023)
Distribution grid loss (%)	N/A

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries (See Appendix 2)

Key Findings

Progress

- Grid development planning, economic regulations, and environmental and social impacts all show strength, indicating good foundation and high institutional capacity.
- Robust ODA supports and private business models available in transmission sector also show promise.
- Existing hydro power generation offers good starting point for energy transition as clean energy and flexibility for VRE integration.

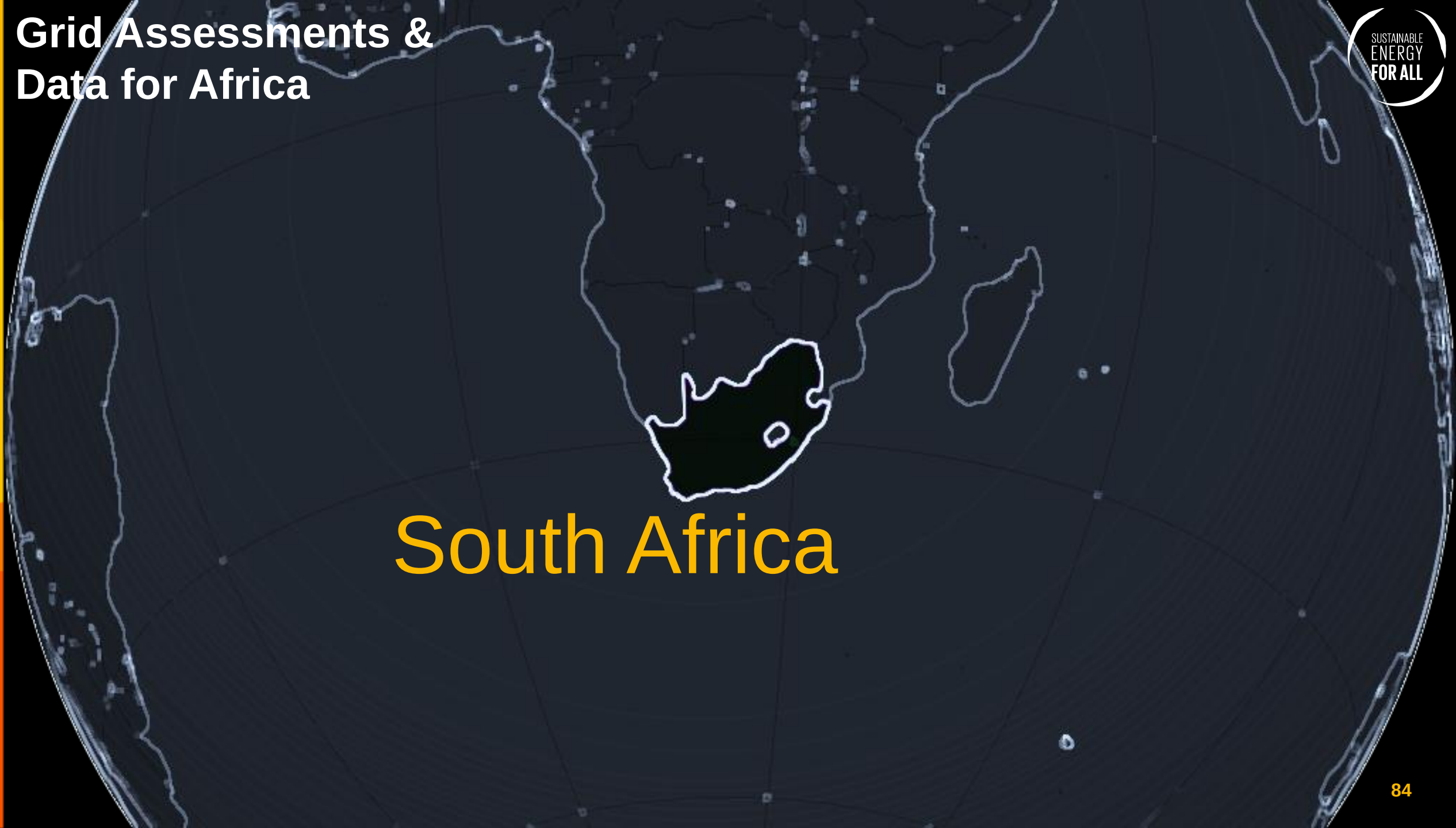
Challenges

- While grid system performance such as reliability and efficiency relatively compared to the region indicate fair services, affordability is very low and electricity access and per capita consumption is also low.
- System operation is a challenge due to its relatively closed and very small system size. Stronger growth of non-hydro renewable power generation, along with diversification of flexibility with interconnectors, utilization of demand side management and strategic placement of network energy storage can be warranted in the mid-term and long-term.
- Technical regulations and grid codes currently do not consider VRE and non-synchronous generator conditions and requirements, which becomes important considering the country's small power system and the existing operational difficulty.
- Diversification of power generation and flexible energy sources become critical while reducing fossil fuel power generation. Risks from changing weather patterns can be high with strong hydro dependance.

Conclusion

- Rwanda has significant electricity access gaps and mini-grid deployment along with T&D expansion needs to be prioritized.
- Grids management and grid strengthening needs prioritization as the country has high system interruptions.
- The country plans and projects strong increase of its power system size by 2030 (90% increase from 2022) with VRE share of 10% and this would need improvements in current grid operations and strengthening.

Grid Assessments & Data for Africa



South Africa

Country Overview

Total Population (2023)	Land Area (2022, square km)	GDP per Capita (2023, PPP 2021 international dollar)	Annual GDP Growth ratio (2023)	Net ODA received (2022 Current USD)	Poverty headcount ratio at 2017 PPP USD 2.15 a day (2014, % of population)	Population Estimate (2030)	WB Income Group (2024)
63,212,384 (Urban 69%)	12,13,090 km^2	13,690.4 USD	0.7%	USD 1,028.6 million (0.26% of GNI)	20.5%	64,659,278 (2% up from 2023)	Upper middle income

- South Africa is the southern most country and one of the most developed economies of the continent.
- The country moved to democracy in the late 1990s, but the progress stagnated in the past decade, suffering from multiple structural constraints, including infrastructure bottlenecks and low productivity, weak GDP growth, and rising unemployment and poverty.
- Electricity supply crisis since 2007 severely constrained economic activities and growth and increased operating costs for businesses with diesel backup gensets. The improvement was made in 2024 with intensive two-year government intervention to the state-owned enterprise (SOE) utility ESKOM.
- Other infrastructure also suffer from structural challenges, including transport and logistics with weak management of SOEs.

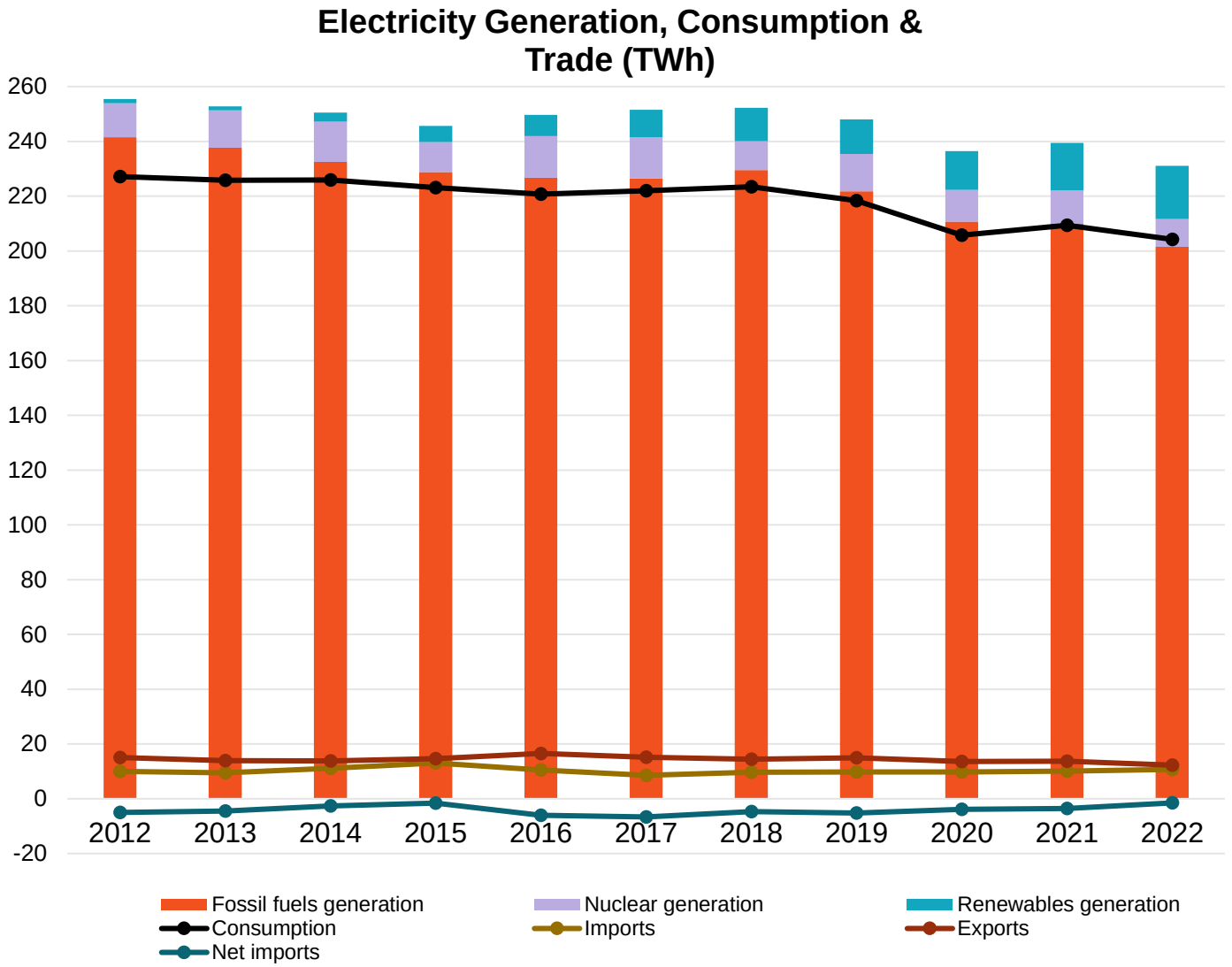
Source: World bank Development Indicators; World Bank South Africa Overview; WorldAtlas.com

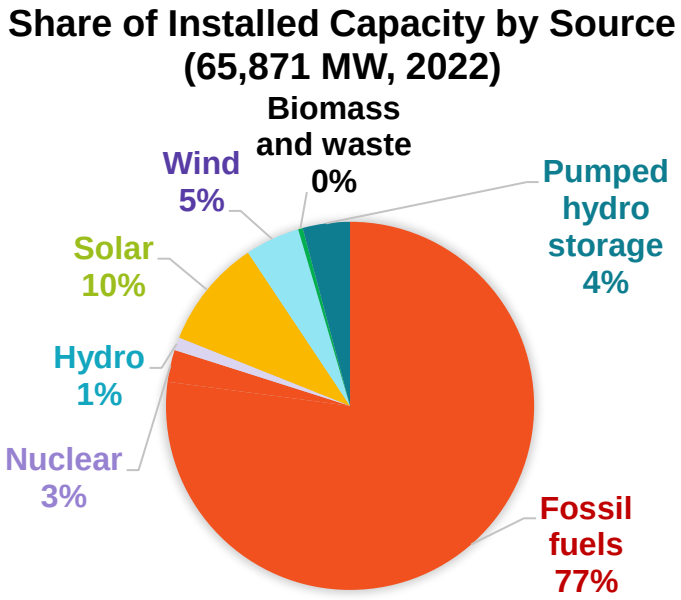
Power Sector Overview

Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**65.9**
	% of fossil fuel power capacity (2022)	**77.1%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	4.2%
	Annual total grid-connected power generation (TWh) (2022)	**229.6**
	% of fossil fuel power generation (2022)	87.7%
	5-year CAGR of total grid-connected power generation (2017-2022)	**-1.7%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**200.6**
	5-year CAGR of electricity net consumption (2017-2022)	**-2.0%**
Power Trade	Power Import (% of net consumption) (2022)	5.2%
	Power Export (% of net consumption) (2022)	6.1%
	Power Export (% of generation) (2022)	7.0%

Power Sector in General	Unbundling Status	Partially Unbundled (legal) – Transmission only
	Private participation	Yes
	Power Generation	Yes (IPPs and self-consumption generators for on-grid. private developers in SHS sector, while mini-grids are done by ESKOM)
	Transmission (System Operation)	No (National Transmission Company South Africa (NTCSA)) – a 100% subsidiary of ESKOM
	Distribution / Retails	No (SOE-ESCOM & licensed Municipalities that cover 60% of end-users)
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - single off taker (ESKOM) (Currently in reform process of establishing the Wholesale Market)
	Market integration with neighboring systems	No
	Regional pool participation	Yes (SAPP)
Regulated status	National / Independent regulatory body	Yes (since 2005)

Power Sector – Generation





- South Africa's power system is much larger than other sub-Saharan African countries, with total installed capacity of 66 GW (USEIA data). Fossil fuels dominate both power and electricity generation mixes (77% and 87% respectively, mostly from coal. The system also has pumped hydro capacity, co-developed with nuclear in the 1980s. Solar and wind together contribute 15% of installed capacity.
- Total electricity generation and consumption has been declining in the past decade. While renewable power generation increases, poor management of the system at ESKOM has been causing numerous load shedding (planned backouts) and failed delivery of power.

Data Source: US EIA International database – Electricity

Power Sector – South Africa Electricity Crisis

Electricity Crisis (2007-2023, particularly severe crisis in 2022 and 2023)

South Africa's power system has been experiencing significant problems since 2007 until March 2024 as Eskom was not able to deliver power to meet consumer demand. **Numerous load shedding / planned blackouts** were implemented to maintain the supply / demand balance, and to ensure sufficient reserve capacity to respond to significant unplanned breakdowns or disruptions to supply, to protect the power system.

Root Causes

- **Poor management at Eskom**, causing deep structural and maintenance issues, including **long-tern underinvestment for expansion and maintenance of generation assets**
- **Political corruption,** involving Eskom leadership
- **Revenue collection issues through municipalities** that distribute power to end-users but fail to pay bills to Eskom
- **Sabotage** such as stealing coals from Eskom power plants for other usages.

Situation in 2022 & 23 (Eskom Integrated reports 2023 & 2024)

- **High levels of unplanned generation unavailability, combined with low diesel fuel levels at Open Cycle Gas Turbine (OCGT) stations and / or low water levels at pumped storage stations,** leading to a need to conserve and / or replenish emergency resources, as the direct causes of the frequent loadshedding.
- The number of days with loadshedding implementation reached **280 days** in FY 2022/23 and **329 days** in FY 2023/24 (FY runs between April and March).
  - **In FY 2022/23, on average, around 15,700MW was not available for generation at total unplanned unavailability of 33.58%, with close to 4,900MW unavailable due to planned maintenance, leaving around 26,000MW capacity available for generation.**
  - The **increasing VRE leads to huge shifts in available capacity** from day to day due to their non-dispatchability.
- Immediate additional dispatchable capacity needs (FY2022/23) were 4,000MW – 6,000MW & additional renewable capacity of 13,000MW–20,000MW (with average load factor of 30%)

Government Programme 2022 & 2023

- **High-level political support** (The President's Energy Action Plan (2022) & declaration of a national state of disaster)
- Treasury's **254-billion-rand debt-relief package for Eskom**
- Eskom's two-year Generation Operational Recovery Plan
- Eskom **leadership change**
- **Decreased demand for Eskom with increasing distributed RE and storage capacity** as consumers avoided Eskom service due to increased energy bills and unreliability

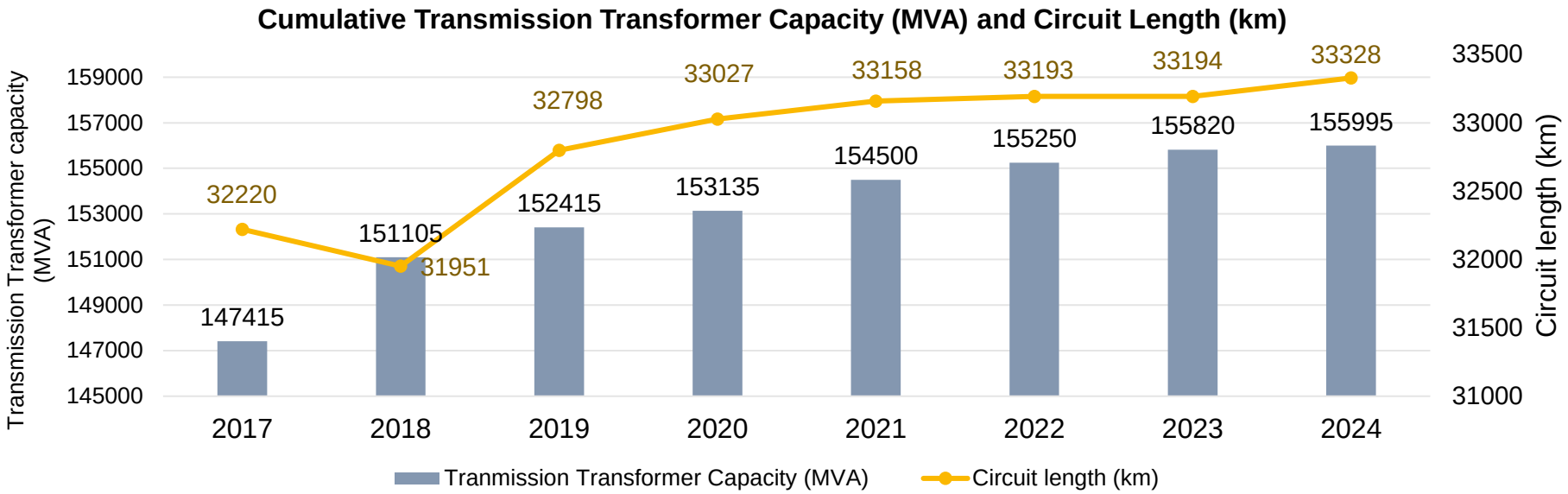
2024

No planned loadshedding / blackouts between April 2024 and January 2025

- Increase of available capacity to 35,000 MW
- Better maintenance implemented for both Eskom and IPP-owned power plants

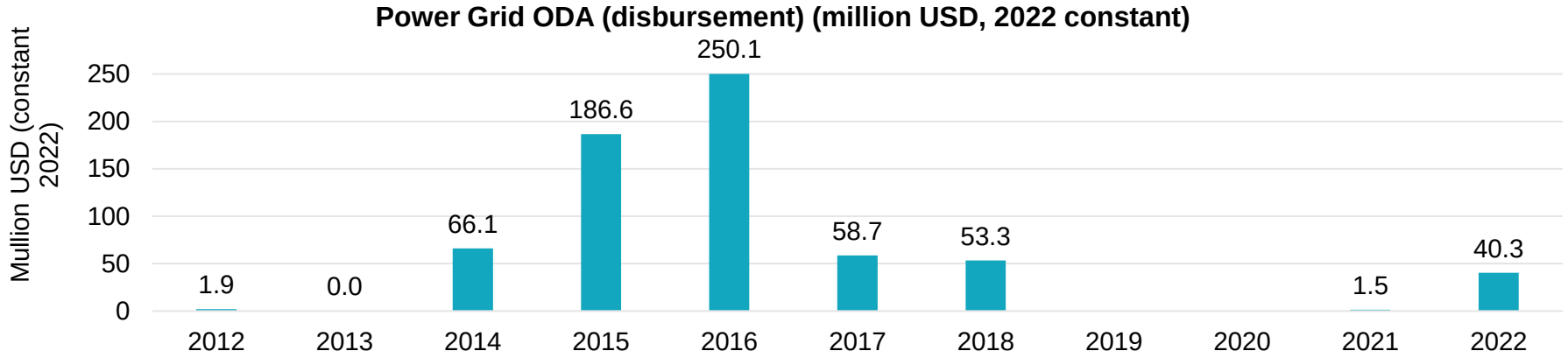
Sources: Eskom (2023, 2024) Integrated Reports 2023 and 2024; Financial Times (2024) South Africa's Eskom faces 'existential problem' as local councils fail to pay their bills, KAA (2024) South Africa's Eskom problem; and BBC (2024) Joy and relief as South Africa manages to keep its lights on

Power Sector – Transmission



- South Africa's transmission circuit length has increased 3% in six years, while its transformer capacity has increased 6%, showing a moderate growth trend.
- The circuit length reached 33,328 km in March 2024. The most recent 5-year average annual growth ratio is 0.3%.
- Transformer capacity stood 155,995 MVA. The most recent 5-year average annual growth ratio is 0.5%

Note; Data are as of the end of March each year
Data Source: Eskom Integrated Report (2021, 2023, 2024)



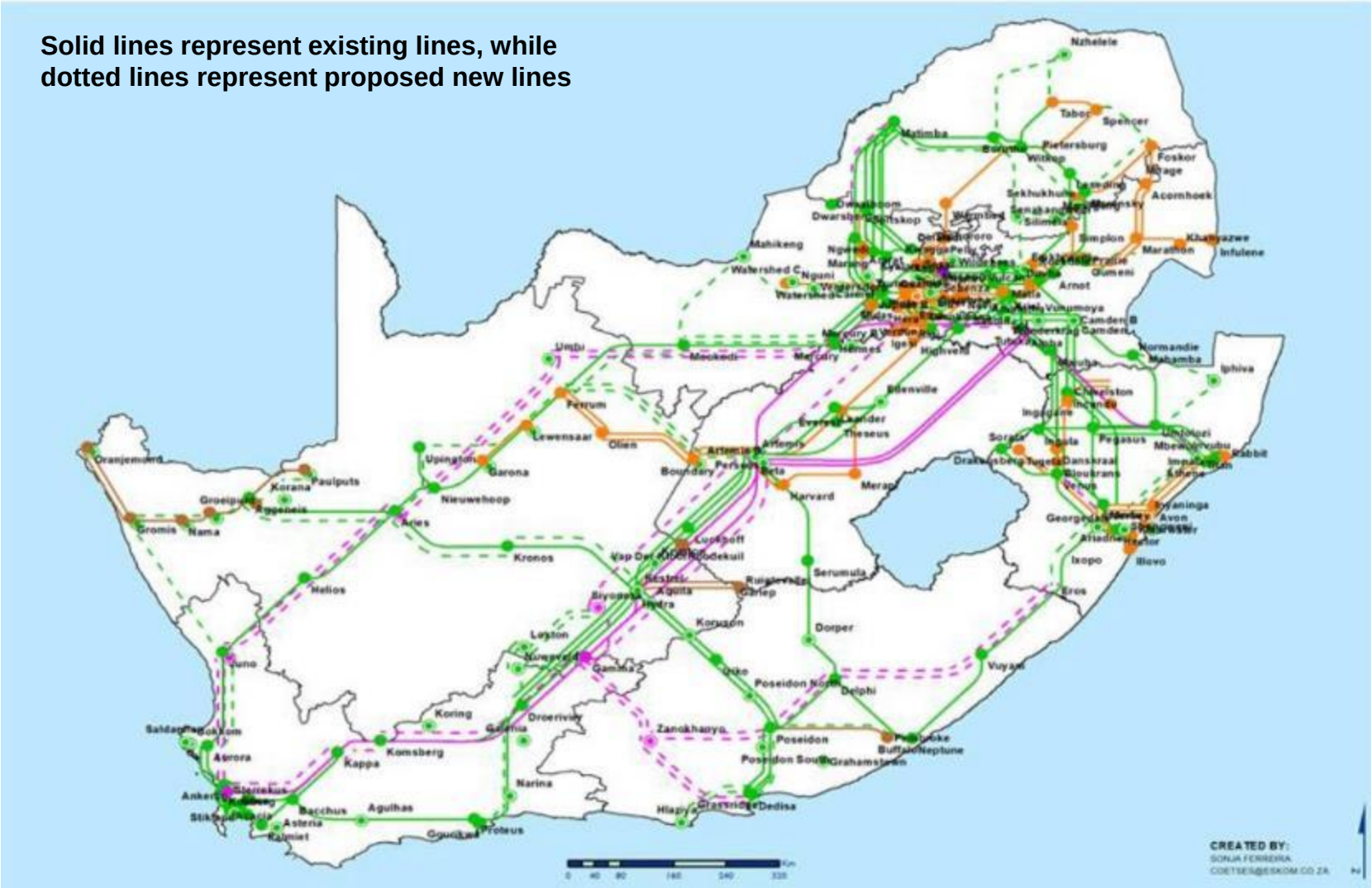
- Total power grid ODA disbursement peaked in 2016 and then showed down considerably.
- Weighted 5-year average power grid ODA disbursement per MW of total on-grid power installed capacity (RE and non-RE) is 68.3 Million USD / MW, which is much smaller compared to other sub-Saharan African countries.

Note: The figures include ODA for both transmission and distribution grid

Data Source: OECD Creditor Reporting System,

Power Sector – Transmission

South Africa's existing and planned transmission lines



- **South Africa's transmission system is composed of eight voltage levels (765 kv, 533 kV, 400 kV, 275 kV, 220 kV, 132 kV, 110 kV and 88 kV).**
- South Africa is well-interconnected, directly, with neighboring countries in SAPP. Based on a SAPP map, the current total interconnector capacity amounts to 7180 MW.
  - Botswana (132 kV & 400kV, 800 MW total)
  - Lesotho (132 kV, 230 MW total)
  - Mozambique (533 kV DC, 400 kV, 275 kV, & 110 kV, 3850 MW total)
  - Nambia (400 kV & 220 kV, 850 MW total) and
  - Swaziland (400 kV & 132 kV, 1450 MW total)

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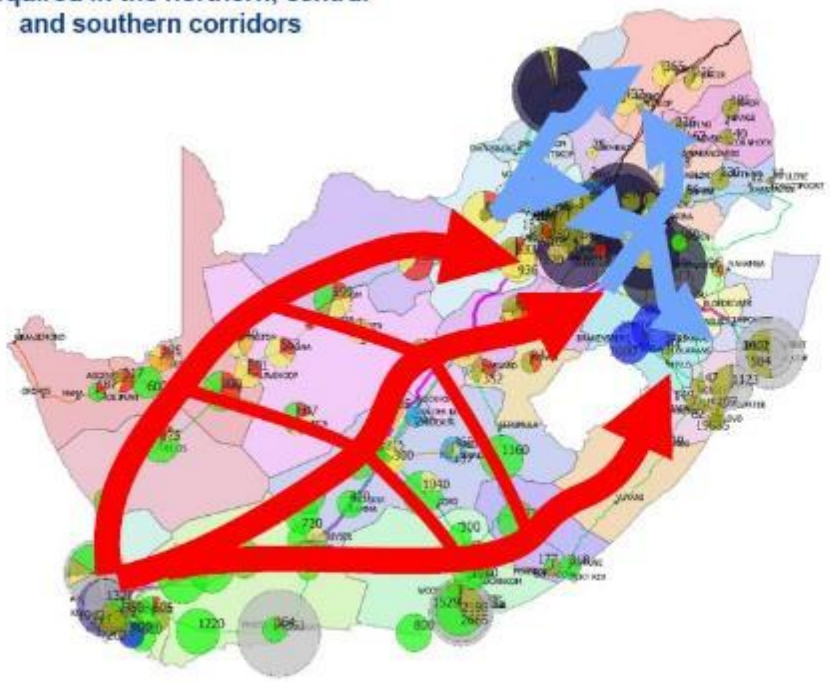
Source: NTCSA (2024) Transmission Development Plan 2025-2034

Power Sector Structure

Lower load in the South remains

Generation increase in the South

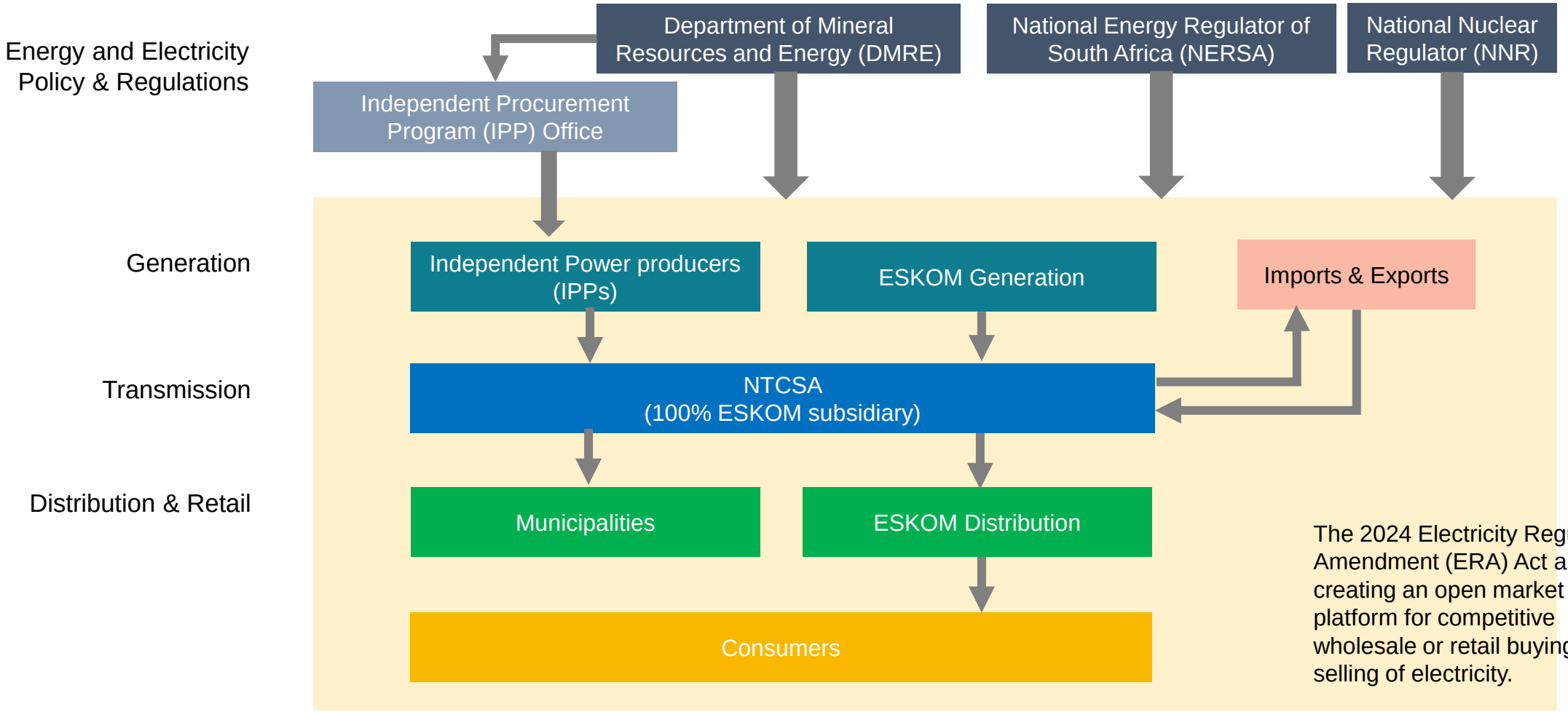
Significant transmission development is required in the northern, central and southern corridors



- Renewable energy resources are widely distributed throughout the country, especially in the Northern, Western and Eastern Cape provinces.
- However, the current generation and demand are concentrated in Eastern part of the country. The grid was primarily designed to move electricity from a very concentrated area in Mpumalanga to the rest of the country due to the geographic concentration of coal resources.
- **Large-scale and rapid investment in renewable energy, particularly in the Northern and Eastern Cape, will require unprecedented annual levels of investment in the transmission grid.**
- If this transmission investment is not expedited, there is a very real danger of service disruption.
- **Regional capacity of the transmission grid will be the main bottleneck both to the expansion of the electricity system and its decarbonization, if the investment on transmission grid were not increased rapidly.**

Sources: Government of South Africa (2022) SOUTH AFRICA'S JUST ENERGY TRANSITION INVESTMENT PLAN (JET IP) for the initial period 2023–2027; NTCSA (2024) Transmission Development Plan 2025-2034

Power Sector Structure



Note: The IPP Office was established by the DMRE, National Treasury (NT) and the Development Bank of Southern Africa (DBSA) for the specific purpose of delivering objectives of on the IPP Procurement Programme.

Source: SEforALL analysis based on ESKOM (2024) Integrated Report; Government of South Africa (2024)

Power Sector – Power System Policy and Planning

Act, Policy and Plan	Objectives
White Paper on Energy Policy (1998)	The White Paper sets policy objectives for the country's energy system and directs restructuring and liberalization of the electricity supply industry as a part of energy system.
Renewable Energy White Paper (2003)	Aims to establish a renewable energy industry to provide a sustainable alternative to fossil fuels and expand access to electricity.
National Climate Response Policy White Paper (2011)	Addresses climate change mitigation and adaptation in the short, medium, and long-term (up to 2050)
National Development Plan 2030 (2012)	The county's long-term plan, aiming to eliminate poverty and reduce inequality by 2030. The plan identifies investment needs for economic infrastructure including energy infrastructure.
Integrated Resource Plan (IRP) (2019) & IRP 2023 Draft (under public review as of November 2024)	▪ Development plan for power generation to provide a clear strategy for electricity generation expansion over a 20-year period with the least-cost electricity supply and demand balance ▪ Considers the security of supply and minimize the environment impacts through the minimization of negative emissions and water use ▪ Define the procurement schedule by technology up to 2030 with projected additional VRE installed capacity of 22,876 MW ▪ IRP's assumptions and scenarios direct the two transmission plans; long-term Strategic Grid Plan and medium-term Transmission Development Plan done by ESKOM.
ESKOM / NTCSA Strategic Grid Plan	▪ ESCOM's long-term strategic transmission corridor requirements with a 20-year planning horizon, based on IRP power generation assumptions and scenarios. ▪ Updated every 2-3 years
ESKOM / NTCSA Transmission Development Plan (TDP)	▪ ESCOM's investment plan, to clarify investment requirements for transmission network infrastructure over 10 years, showing the financial commitments required in the short to medium term. ▪ Updated annually
South Africa's Just Energy Transition Investment Plan (JET-IP) (2022)	The investment plan for 2023-2027, providing investment needs to achieve the decarbonization commitments in the Nationally Determined Contribution (NDC)

Source: SEforALL analysis

Policy and Regulatory Environment for Grid Development and Operation

System Planning	Economic Regulations	Technical Regulations
▪ The Integrated Resource Plan (IRP) is the country's long-term electricity system master plan, establishing clear framework and procedures, including stakeholder engagement. ▪ The IRP tests various scenarios, in addition to Business-as-usual (BAU), with different economic growth ratios, carbon budgets, renewable deployment ratios and gas prices, considering their impacts on the power system. With the results of these scenario, one plan is set as the IRP for long-term. The IRP is currently being updated (the 2023 draft is under public review as of November 2024). ▪ Based on the IRP results and assumptions, Eskom / NTCSA creates Transmission Development Plan (TDP) and update every two years. The Grid codes has clarified the transmission development plan procedure and specifications. ▪ The TDP uses updated data and revised IRP assumptions, providing detailed provincial grid development plans with geospatial analysis and investment / capital needs, considering advanced VRE integration techniques and flexibility resource requirements. ▪ The country also has specified dedicated renewable development zones and special transmission corridors for priority development. ▪ South Africa's clear system planning framework and procedures show high institutional capacity.	▪ South Africa has good economic regulations, as the Electricity Pricing Policy of 2008 set pricing principles for transmission tariffs, while the South Africa's grid codes (SAGC) set tariff setting methodology and procedure (components of transmission tariffs, how to determine them, input costs for setting revenue requirements, asset definitions / boundaries and cost allocation concepts, the principles behind the regulation of incomes). ▪ The tariff codes require tariffs to be connected to five-year Transmission system development plan. ▪ Cost allocation and reimbursement concepts and methods are well-developed to avoid free rider issues by late comers to use transmission assets without paying for the assets. ▪ Eskom publishes clear wheeling charge formulas. methods and modeling tool for diverse cases. ▪ As transmission unbundling to proceed further, to stimulate more private sector participation and competition, the revenue requirements and regulatory formula can be further elaborated to provide clear investment recovery guidance / incentives for the NTCSA and future private sector participation, along with developing and permitting diverse business models.	▪ The South Africa's Grid Codes (SAGC), which is well-advanced, consist of sub-codes dedicated to governance, scheduling and dispatch, network connection, system operations, information exchange, and tariff setting. Special detailed codes for renewable power plants (RPP) include specifications for dispatchable and non-dispatchable plants. The most recent addition to the grid code family is the 2023 battery storage grid codes. Both are important for VRE expansion and operation for the future. ▪ The SAGC covers detailed technical requirements for interconnection, required planning, ancillary services, and day-ahead and real-time dispatch procedures with clear dispatch algorism for dispatchable generators, demand-side resources and interconnectors as well as non-dispatchable generators (VRE). Basic grid planning and operational procedures and rules are well set in these aspects. ▪ The SAGC clarifies priority dispatch of non-dispatchable generators (renewable). The RPP code specifies requirements for operational parameters and forecasting, and curtailment conditions are also clarified by types of RPPs and rated capacity. ▪ Compensation mechanism for RPP curtailment can be clarified as a part of market rules in near future.

Source: SEforALL analysis

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	65871 MW (2022) (Firm capacity was reportedly approx. 26000 MW only)	90916 MW (2032) (97466 MW with battery storage)
	Annual Growth Ratio (%)	4.2% (2017-2022)	3.3% (2022-2032 w/o battery)
	VRE (MW)	9489 MW (2022)	44673 MW (2032)
	Ratio of VRE (%)	14.4% (2022)	49.1% (2032, w/o battery) (46% w/ battery)
Electricity Demand	**Peak Demand (MW)**	34666 MW (2022)	34000 - 46000 MW (2032)
	Annual Growth Ratio (%)	---	- 0.2% - 2.9% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	-33.3% (against firm capacity)	98.6 % -167.4% (2032)
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	0.3% (2017-2022)	0.4% - 3.6% (2022-2032)
Transmission	**Transformer capacity** of transmission lines	155995 MVA (2024)	246104 MVA (2032)
	Annual Growth Ratio (%)	0.5% (2019-2024)	5.9% (2024-2032)
	Circuit length of transmission lines	33328 km (2024)	43626 km (2032)
	Annual Growth Ratio (%)	0.3% (2019-2024)	3.4% (2024-2032)

- South Africa is projecting approximately 38% increase in power capacity between 2022 and 2030, requiring 3% annual growth ratio. VRE share is expected to increase more than three times. Peak demand is projected to increase 24% and 32% in medium-growth and high-growth scenario during the period, respectively.
- In terms of transmission grid, the NTCSA plan projects 58% increase in transformer capacity and 31% increase in circuit length during the same period, requiring significant increase in annual growth ratios to catch up with the decades of underinvestment and cope with demand for the energy transition.

Data Sources: US EIA; Eskom Integrated Report (2021, 2023, 2024); NTCSA (2022) Transmission Development Plan 2023-2032 (See Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	15.5%
VRE share in power mix (2022)	14.1%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	11.3%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	-2.0%
System flexibility (WEF 2024 indicator, 0-100)	3.2
Demand projection (2030)	34-5 GW
Generation supply target (2030)	90.9 GW
Grid target / strategy in national policy / planning or NDC	Yes
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	33 194 km
Transformer capacity (MVA, 2022)	155 820 MVA (March 2023)
Annual average growth in transmission line length (over 5 years)	0.32% (2019-2024)
Current interconnections capacity (MW, known)	7180
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes /yes
Private participation / investment in transmission asset development (Y/N)	Yes (limited with EPC but changes in progress)
Grid loss (total, %, 2022)	11.0%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	6.0
SAIDI (2023)	30.5
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	86.5%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	3348.7
Average residential tariff (USD/kWh)	0.170 (2022) 0.154 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	146927 MVA (2024)
Distribution overhead and cable length (km)	375760 km (2024)
Annual average growth in distribution line length (over 5 years)	1.2% (2019-2024)
Distribution grid loss (%)	9.7% (2023)

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries (See Appendix 2)

Key Findings

Progress

- South Africa has strong institutional readiness and grid sector capacity.
- Political awareness and commitment for the importance of grids in the clean energy transition is strong.
- A well-advanced power system planning and economic / technical regulations show high human resource and institutional capacity and readiness for more VRE integration into the power system, providing a strong foundation for more private sector participation under the unbundled sector structure and planned wholesale market introduction in the near future.

Challenges

- Grid service quantity and quality to the existing consumers are decreasing and affordability has also deteriorated.
- Electricity consumption per capital is higher than Modern Energy Minimum but has been decreasing in recent years due to Eskom's financial and service delivery issues.
- While South Africa has committed to a clean energy transition and has strong awareness of grid development, there is a weak foundation for the transition due to the coal-dominant electricity profile and inability historically to deliver power to consumers.
  - Renewable energy resources are widely distributed throughout the country; however, transmission networks need to be expanded beyond a coal reliant network concentrated in eastern part of the country (from coal mines to demand centers).
  - While South Africa has strong interconnector capacity, the growth ratio of domestic transmission assets are low with underinvestment by Eskom.
  - Security of supply was quite low with more than 30% of deficit in reserve margin against peak demand in 2023. In addition to low clean energy profile, coal dominance creates low power plant flexibility for VRE integration.
  - The long-term energy crisis jeopardized the business foundation of Eskom / NTCSA, making grid service to consumers quite poor and deteriorating for many in the recent decade.

Conclusion

- The country must build an estimated 1,400 km of new transmission lines annually for the next 10 years to meet its energy needs.
- There is an urgent need to prioritize grid stability, grid management and to accelerate efforts towards unbundling of transmission sector and building wholesale market and power trading structure.

Grid Assessments & Data for Africa

Country Overview

Total Population (2023)	Land Area (2022, square km)	GDP per Capita (2023, PPP 2021 international dollar)	Annual GDP Growth ratio (2023)	Net ODA received (2022 Current USD)	Poverty headcount ratio at 2017 PPP USD 2.15 a day (2018, % of population)	Population Estimate (2030)	WB Income Group (2024)
66,617,606 Urban (37%)	885,800 km^2	USD 3,620.8	5.1%	USD 1,077 million (3.5% of GNI)	44.9%	81,885,304	Lower-middle income

- Tanzania has experienced strong economic growth, supported by ongoing structural reforms and an improved business environment. Manufacturing, electricity, construction, tourism, trade, and financial services have driven the economy.
- Inflation remains low and stable. Strong annual 6% economic growth is expected for near future with further improvements in the business environment and full implementation of reforms that will likely attract more investment.
- Still, poverty reduction has been persistent developmental challenge. Using strong economic growth momentum, it is important to prioritize human capital development, increase agricultural productivity, and strengthen social protection and climate resilience.

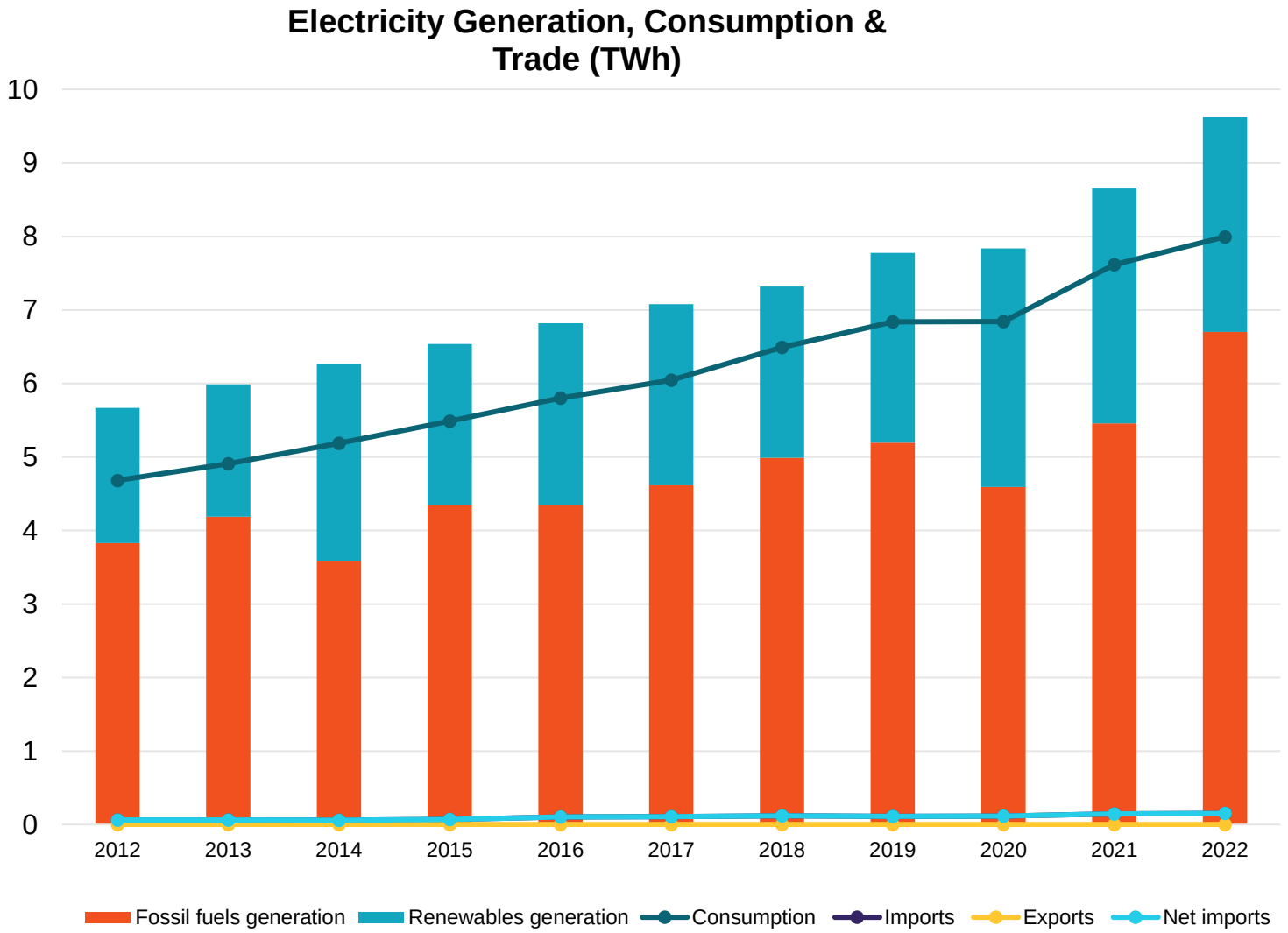
Source: World Bank Development Indicators; World Bank Tanzania Overview; WorldAtlas.com

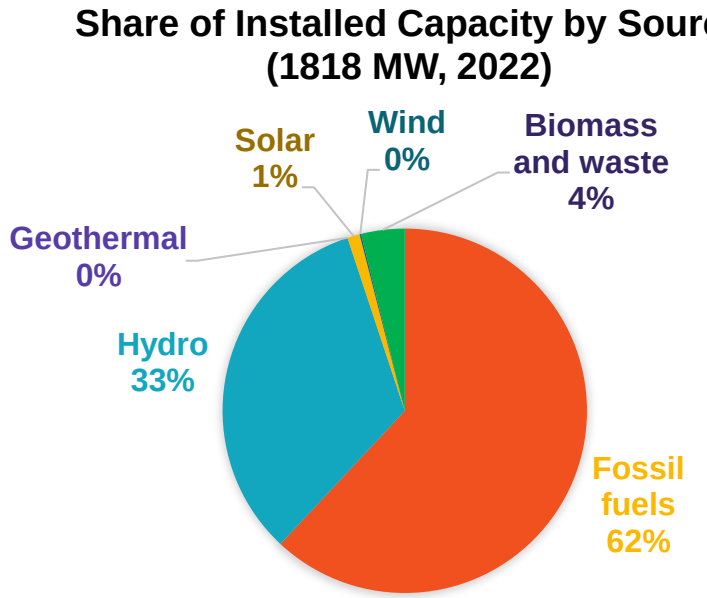
Power Sector Overview

Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**1.8**
	% of fossil fuel power capacity (2022)	**62.0%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	4.0%
	Annual total grid-connected power generation (TWh) (2022)	**9.6**
	% of fossil fuel power generation (2022)	63.1%
	5-year CAGR of total grid-connected power generation (2017-2022)	**6.4%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**7.9**
	5-year CAGR of electricity net consumption (2017-2022)	**5.6%**
Power Trade	Power Import (% of net consumption) (2022)	1.9%
	Power Export (% of net consumption) (2022)	0.0%
	Power Export (% of generation) (2022)	0.0%

Power Sector in General	Unbundling Status	Vertically Integrated (SOE – Tanzania Electric Supply Company Limited (TANESCO)
	Private participation	Yes
	Power Generation	Yes (IPPs and small power producers for on-grid and a limited number of developers in mini-grid and SHSs)
	Transmission (System Operation)	No (SOE -TANESCO)
	Distribution / Retails	Yes (but extremely limited - TANESCO with 99% market share)
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - single off taker
	Market integration with neighboring systems	No
	Regional pool participation	Yes (EAPP & SAPP)
Regulated status	National / Independent regulatory body	Yes (since 2006)

Power Sector – Generation

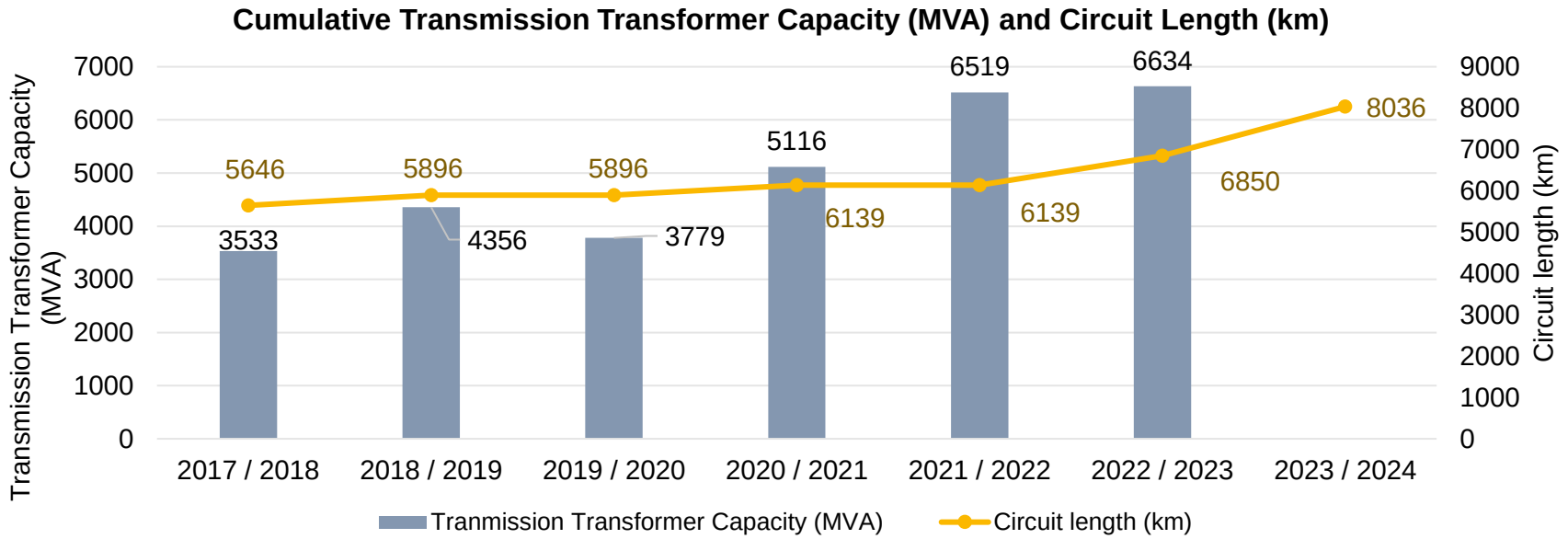




- Tanzania generates 63% of electricity from natural gas and the rest is mostly from hydro power. Electricity generation and consumption both grows at rapid pace, while power trade has a very small profile.
- Power installed capacity shows a very similar share distribution with that of electricity generation. Fossil fuels (natural gas) is the largest installed capacity (63%), followed by hydro power (33%). Geothermal, solar PV and wind have negligible capacity.

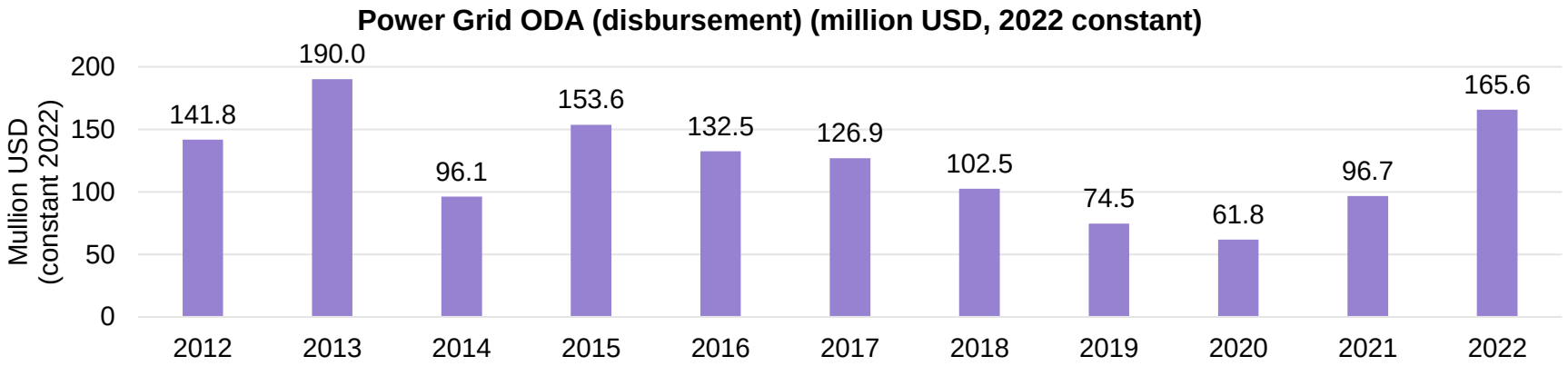
Data Source: US EIA International database – Electricity

Power Sector – Transmission



Data Source: EWURA Electricity Sub-sector Performance Reports Fiscal years 2017-18, 2018-19, 2019-20, 2020-21, 2021-22, 2022-23, 2023-24

- Tanzania's transmission circuit length has increased 42% in six years, while its transfer capacity has increased 87% in five years, showing a strong growth trend.
- The circuit length reached 8,036km in FY2023/24. The most recent 5-year average annual growth ratio is 6.4%.
- Transformer capacity stood 6,634 MVA in FY 2022/23. The most recent 5-year average annual growth ratio is 13.4% which is very high.

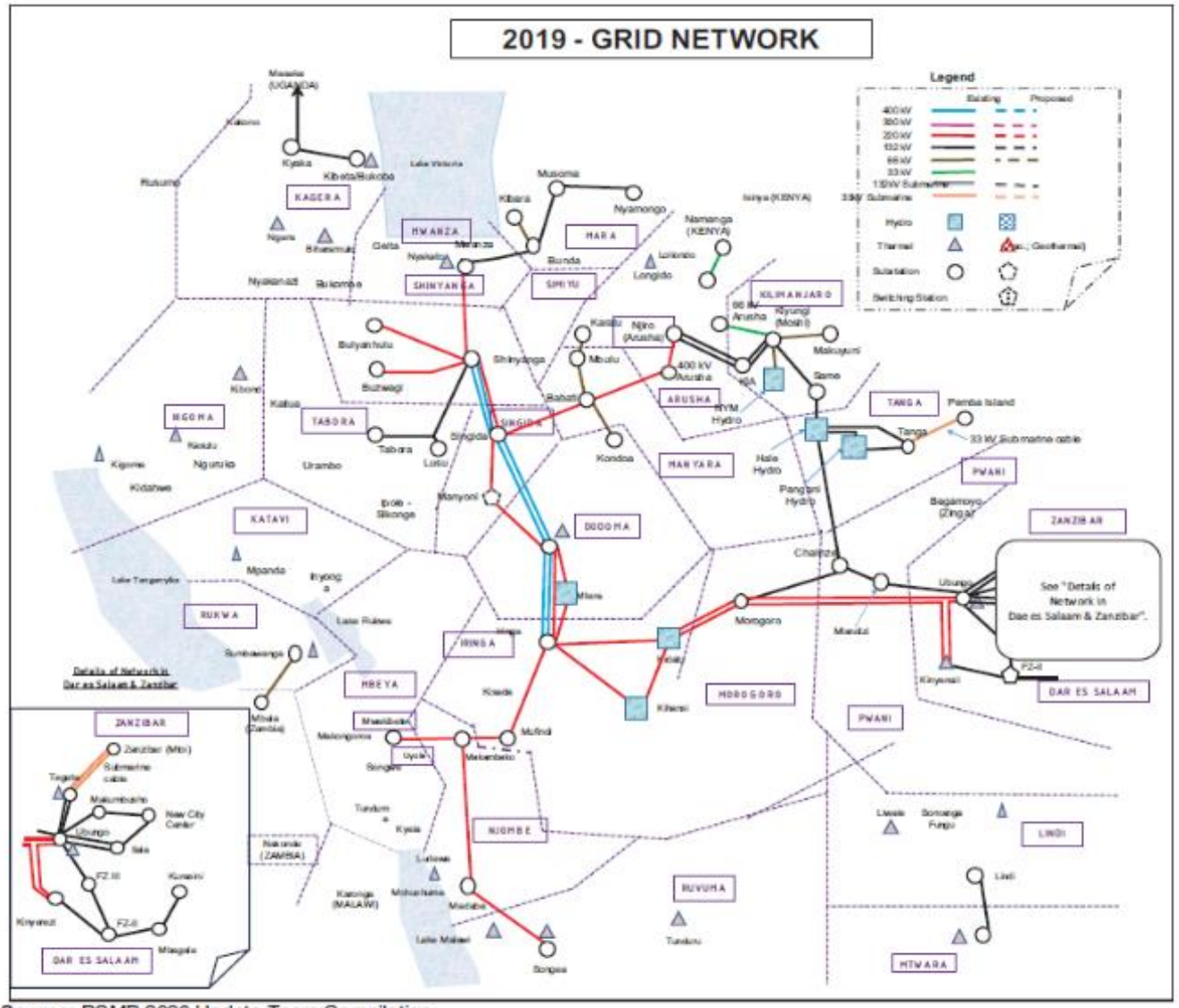


- Total power grid ODA disbursement peaked in 2013 and then showed a decreasing trend between 2015 and 2020. However, the trend has reversed since 2020. Although it has not reached the 2013 peak, it reached 165.5 million USD in 2022.
- Weighted 5-year average power grid ODA disbursement per MW of total on-grid power installed capacity (RE and non-RE) is 68.3 Million USD / MW.

Note: The figures include ODA for both transmission and distribution grid

Data Source: OECD Creditor Reporting System

Power Sector Overview – Transmission



Source: PSMP 2020 Update Team Compilation

- **Tanzania's transmission system is composed of four voltage levels (1085 km of 400 kV lines, 4137 km of 220 kV lines, 1827 km of 132 kV lines, and 580 km of 66 kV lines).**
- The 2020 Power System Master Plan assessment revealed there were some constraints at peak demand hours in the Dar es Salaam and Pwani Grid Network and could not meet the entire demand.
- Power system infrastructure in general is reportedly **aged and overloaded with weak preventive maintenance and monitoring.**

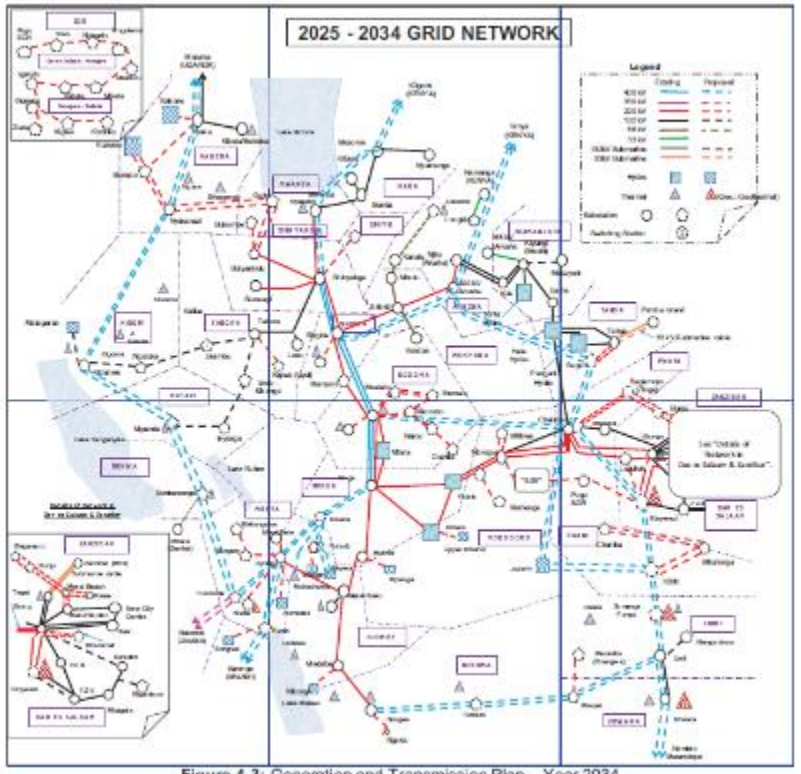


Figure 4-3: Generation and Transmission Plan – Year 2034

Source: Ministry of Energy Power System Master Plan 2020

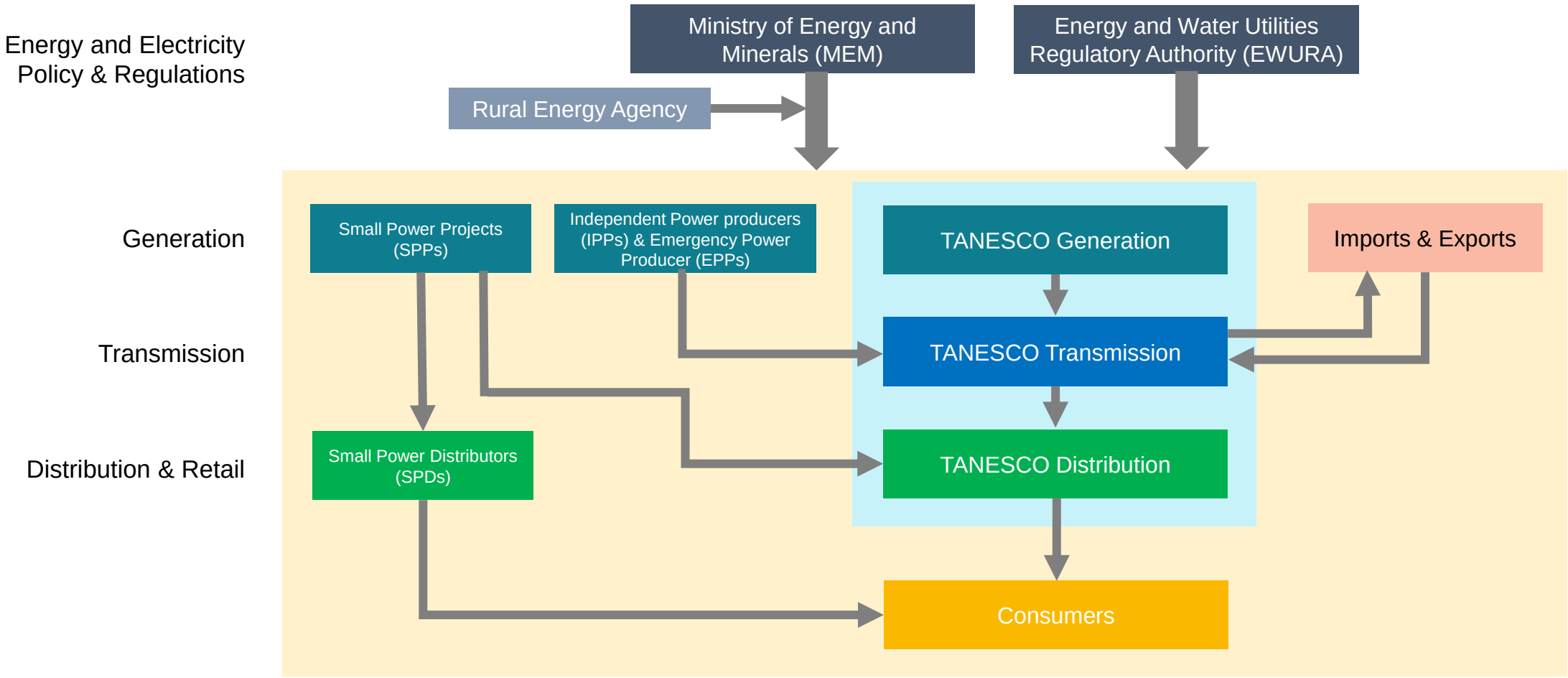
Power Sector Overview – Transmission

Source: TANESCO 2023

- TANESCO imports power from Uganda through 132 kV, Zambia through 66 kV lines and Kenya through 33 kV line.
- The existing interconnector capacity is still small, but numerous projects are planned, in progress or completed in recent years, including:
  - Tanzania (Singida – Arusha – Namanga) – Kenya (Isinya) 400 kV interconnection project (commissioned in 2023)
  - Tanzania – Zambia 400 kV interconnection project (planned for 2026)
  - Tanzania (Nyakanazi – Kyaka) – Uganda (Masaka) 400 kV interconnection project (planned for 2028)
  - Tanzania – Mozambique 400 kV interconnection project
  - Tanzania, Rwanda, and Burundi Interconnection Project 220 kV interconnector project (commissioned in 2024)
  - Tanzania – Malawi 400 kV interconnection project
  - Tanzania (Shinyanga – Mwanza – Musoma) – Kenya (Kilgories) 400 kV interconnection project

Source: World Bakk (2024) Tanzania - Improving Sustainability of the Power Sector and Accelerating Electricity Access: A Proposed WBG Roadmap; Ministry of Energy Power System Master Plan 2020

Power Sector Structure



Notes:
- Small Power Projects (SPPs) are the projects with less than 10MW of plants with RE, cogeneration, waste heat sources.
- Small Power Distributors (SPDs) are entities that purchases electricity at wholesale prices from a distribution network operator or some other bulk supplier and resells it at retail prices to Customers

Source: SEforALL analysis based on EWURA (2017) The Tanzania Electricity Grid Code

Power Sector – Policy and Plan related to Power System Planning

Act, Policy and Plan	Objectives
Rural Energy Act, 2005	Established the Rural Energy Board and Rural Energy Fund (REF) for promoting improved access to modern energy services in rural areas of mainland Tanzania
Electricity Act, 2008	Clarified a general framework for the Ministry of Energy and Minerals (MEM) and Energy and Water Utilities Regulatory Authority (EWURA). The Act have many amendments in subsequent years.
National Energy Policy (NEP) 2015	First created in 1992, the current NEP was made in 2015, targeting to create enabling environment for affordable, reliable, efficient, and clean energy services while ensuring effective community participation in the sector.
Third National Five-Years Development Plan (2021/22. - 2025/26)	The nation-wide medium term development plan with multi-sector focus. The current plan is the third edition, aiming at achieving the goals set in the National Development Vision 2025, and aiming at 2025/2026 horizon. The plan has a theme of realizing competitiveness and industrialization for human development. The energy sector aligns its aim / priority with this goal of advancing industrialization, enhancing infrastructure, and fostering private sector growth.
Tanzania Power System Master Plan (2020)	Ministry of Energy (MoE) in collaboration with TANESCO, EWURA, REA among others prepares the Power System Master Plan (PSMP), which is a 20-year time horizon planning for power generation and transmission. It provides projections for electricity demand and generation capacity needs through 2044. The next edition is planned to be released in 2025.
Nationally Determined Contributions (NDC)	The first Intended NDC was submitted in 2015 and an updated NDC was done so in 2021. The updated NDC commits to reducing emissions by between 30-35% by 2030 compared to the business-as-usual scenario.

Source: SEforALL analysis

Policy and Regulatory Environment for Grid Development and Operation

System Planning	Economic Regulations	Technical Regulations
▪ The current Power System Master Plan (PSMP) of 2020 has updated targets for the next 25 years (up to 2044). ▪ The PMSP provides investment roadmap and plans towards development of generation and transmission power projects based on the available and forecasted demand. ▪ The execution timeframes of the PMSP are set to short term plans (up to five years), medium term plans (up to ten years) and long-term plans (above ten years). ▪ While the power technical assessment process is clear and sound, the PMSP is a plan based on Business-as-Usual (BAU) projections only with least-cost analysis, resulting further increasing of fossil fuels in power and electricity generation mix by 2044 (the power mix by 2044 consist of 5,690 MW (28.15%) of hydro; 6,700 MW (33.18%) of natural gas; 5,300 MW (26.24%) of coal). ▪ The planning approach does not consider clean energy pathways, climate change goals and electricity access targets. The plan also does consider existing and planned regional interconnectors. ▪ The periodic update cycle of the PSMP is four year, can be modified to annual or every two years.	▪ Economic regulations show good progress through the 2021 tariff and ratio setting methodology rules and the grid codes that provide clear investment recovery guidance / incentives for incumbent companies as well as future private sector participation. ▪ The rules set are performance-based incentive regulation with revenue requirement of regulated companies. It creates a multi-year tariff regime with 3-year price control periods. The contents are detailed well and robust. ▪ In transmission sector, further refinement in cost allocation and pricing principles and methods can be possible, for example, geographical location-based ratio setting. ▪ The rules can stimulate more private sector participation in transmission sector by creating a clear investment environment, although developing and permitting diverse business models and removing other bottlenecks are necessary. ▪ However, the regulatory process for its initial application has not been seen and the rules are yet to be applied although several years have passed since the publication of the rules.	▪ The Tanzania grid codes cover detailed technical requirements for interconnection, required planning, ancillary services, and dispatch procedures for both synchronous (Type 1) and non-synchronous (Type 2) generators. Basic planning and operational procedures and rules are well set in these aspects. ▪ The codes do not cover the priority dispatch rules for RE and more advanced system operation requirements for Type 2 generators, targeting solar and wind, such as advanced forecasting of VRE generators into dispatch scheduling and planning. ▪ The grid codes are not clear about VRE curtailment rules. Compensation mechanism for such curtailment can be clarified simultaneously as a part of market rules. ▪ Operational and safety requirements for battery storages and demand side management can be added in medium and long-term future.

Source: SEforALL analysis

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	1818 MW (2022)	6390 MW (2030) 20200 MW (2044)
	Annual Growth Ratio (%)	4.0% (2017-2022)	17.0% (2022-2030)
	VRE (MW)	18 MW (2022)	1515 MW (2044)
	Ratio of VRE (%)	1.0% (2022)	7.5% (2044)
Electricity Demand	**Peak Demand (MW)**	1341 MW (2022)	4878 MW (2030) 17611 MW (2044)
	Annual Growth Ratio (%)	---	17.5% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	26.2% (2022)	31.1% (2030)
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	0.8% (2017-2022)	-0.5% (2022-2030)
Transmission	**Transformer capacity** of transmission lines	6634 MVA (FY 2022/23)	N/A
	Annual Growth Ratio (%)	13.4% (FY2017/18-FY2022/23)	N/A
	Circuit length of transmission lines	8036 km (FY2023/24)	15088 km (2034)
	Annual Growth Ratio (%)	6.4% (FY2018/19-FY2023/24)	6.5% (2024-2034)

- Tanzania is projecting approximately 3.5-fold increase of power capacity between 2022 and 2030, requiring 17% annual growth ratio, based on the 2020 PSMP update. VRE share is expected to increase more than seven times. Peak demand is projected to increase 160% during the period with annual growth ratio of 17.5%.
- In terms of transmission grid, the Power System Master Plan 2020 projects 87% increase in circuit length between 2022 and 2034.
- As these projection figures are created in 2019, an urgent updated master plan is warranted to provide much clearer picture for practical investment.

Data Sources: USEIA; EWURA Electricity Sub-sector Performance Reports Fiscal years 2017-18, 2018-19, 2019-20, 2020-21, 2021-22, 2022-23, 2023-24 ; Ministry of Energy (2020) POWER SYSTEM MASTER PLAN 2020 UPDATE (see Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	32.5%
VRE share in power mix (2022)	1.0%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	5.9%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	5.6%
System flexibility (WEF 2024 indicator, 0-100)	99.3
Demand projection (2030)	4878 MW (peak)/
Generation supply target (2030)	6390 MW
Grid target / strategy in national policy / planning or NDC	Yes
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	6139 km
Transformer capacity (MVA, 2022)	6519 MVA
Annual average growth in transmission line length (over 5 years)	6.4% (2019-2024)
Current interconnections capacity (MW, known)	100
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes (limited with EPC but changes in progress)
Grid loss (total, %, 2022)	12.9%
RE Priority dispatch (Y/N)	No
SAIFI (2023)	46.8
SAIDI (2023)	20.9
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	45.8%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	121.1
Average residential tariff (USD/kWh)	0.084 (2022) 0.081 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	163804 km (2023)
Annual average growth in distribution line length (over 5 years)	9.6% (2018-2023)
Distribution grid loss (%)	N/A

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries (See Appendix 2)

Key Findings

Progress

- The institutional enabling environment is in progress as good advancement has been observed recently in both economic and technical regulations, offering a decent foundation for future grid expansion.
- In particular, economic regulations have clear rate setting formula, providing good foundation for grid asset investment recovery, although its full implementation needs to be assured.
- Strong existing gas and hydro power capacity, along with rapidly increasing interconnector capacity, can provide excellent flexibility for VRE integration into the grid.

Challenges

- The Power System Master Plan needs to be updated more regularly, as the most recent published plan is six years old.
- The grid codes can be improved further with priority dispatch rules for RE, use of real-time dispatch, utilization of advanced forecasting, and curtailment conditions for VRE.
- The current system planning only considers BAU projection that will increase fossil fuels in the future, lacking clear energy transition and RE expansion targets.
- Economic regulations can be enhanced with more detailed and clear methods for network charge determination method including wheeling.
- Tanzania has extended grid networks to be available for all villages, but due to economic considerations, electricity consumption per capita is still extremely low and overall electricity access remains low at <46% nationally and 36% in rural areas.

Conclusion

- Tanzania needs to expand its mini-grid footprint but also invest significantly in grid extension and strengthening to reduce losses and interruption.
- Tanzania has a good foundation for a clean energy future, but it needs more frequent system plan updates with clear RE expansion strategy and the enhancement of economic and technical grid regulations to reduce business risks related to private sector participation in grid development and VRE-related operation.

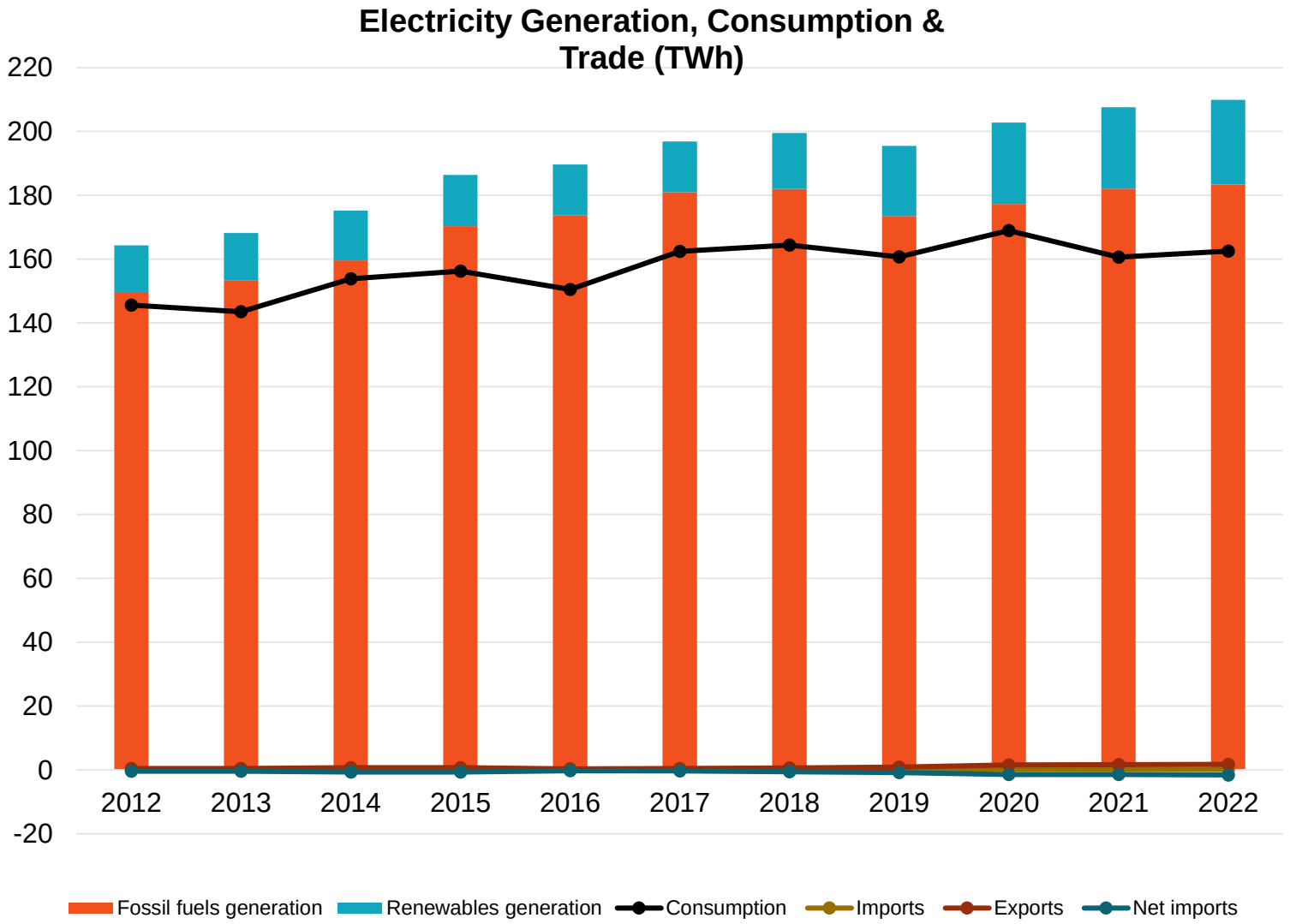
Grid Assessments & Data for Africa

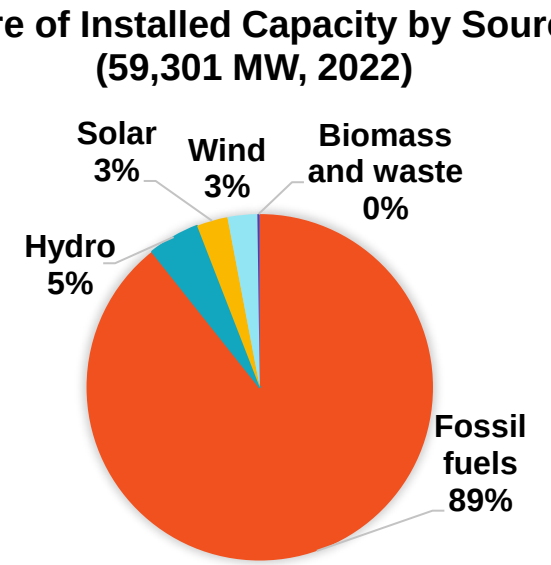
Power Sector Overview

Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**59.3**
	% of fossil fuel power capacity (2022)	**89.3%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	4.7%
	Annual total grid-connected power generation (TWh) (2022)	**209.9**
	% of fossil fuel power generation (2022)	91.0%
	5-year CAGR of total grid-connected power generation (2017-2022)	**1.3%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**176.7**
	5-year CAGR of electricity net consumption (2017-2022)	**1.7%**
Power Trade	Power Import (% of net consumption) (2022)	0.1%
	Power Export (% of net consumption) (2022)	0.8%
	Power Export (% of generation) (2022)	0.9%

Power Sector in General	Unbundling Status	Partially Unbundled (Legal) (Generation and distribution in a Egyptian Electricity Holding Company (EEHC, SOE) & transmission in Egyptian Electricity Transmission Company (EETC, SOE))
	Private participation	Yes
	Power Generation	Yes (On-grid with IPPs)
	Transmission (System Operation)	No (SOE) (EETC as the SO)
	Distribution / Retails	Yes (But quite limited with private distribution companies in licensed geographic areas)
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No **(But currently in reform process toward to competitive market structure)**
	Market integration with neighboring systems	No
	Regional pool participation	No
Regulated status	National / Independent regulatory body	Yes (since 2000)

Power Sector – Generation





- Power generation in Egypt depends heavily on fossil fuels, with approximately 90% share in, both, power capacity and electricity generation mix. Electricity generation is growing with annual growth ratio of 1.3% while consumption grows around 1.7%.
- The country has power trade surplus, but the trade profile itself is very small.
- Fossil fuel dominance shows energy security risk and strong necessity to change it for clean energy transition.

Data Source: US EIA International database – Electricity

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	59301 MW (2022)	N/A
	Annual Growth Ratio (%)	4.7% (2017-2022)	N/A
	VRE (MW)	3367 MW (2022)	35% VRE (2035)
	Ratio of VRE (%)	5.7% (2022)	N/A
Electricity Demand	**Peak Demand (MW)**	34200 MW (2022)	N/A
	Annual Growth Ratio (%)	---	N/A
Supply vs Demand	**Reserve Margin (%)**	42.3% (2022)	N/A
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	-0.4% (2017-2022)	N/A
Transmission	**Transformer capacity** of transmission lines	199517 MVA (FY2023/24)	N/A
	Annual Growth Ratio (%)	6.5% (FY2018/19-FY2023/24)	N/A
	Circuit length of transmission lines	57504 km (FY2023/24)	N/A
	Annual Growth Ratio (%)	3.3% (FY2018/19-FY2023/24)	N/A

- Due to unavailability of the Power System Plan, only the 2035 VRE share target (35%) is known.

Data Sources: USEIA; EEHC Egyptian Electricity Holding Company Annual Report (2022. 2023); MOEE (2022b) (see Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	10.5%
VRE share in power mix (2022)	5.7%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	29.2%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	1.7%
System flexibility (WEF 2024 indicator, 0-100)	95.5
Demand projection (2030)	N/A
Generation supply target (2030)	N/A
Grid target / strategy in national policy / planning or NDC	No
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	54507 km
Transformer capacity (MVA, 2022)	199517 MVA
Annual average growth in transmission line length (over 5 years)	3.3% (2019-2024)
Current interconnections capacity (MW, known)	840
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes (limited with EPC)
Grid loss (total, %, 2022)	17.9%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	3 / 1.99
SAIDI (2023)	2.0
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	100%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	1592.2
Average residential tariff (USD/kWh)	0.054 (2022) 0.048 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	100344 MVA (June 2023)
Distribution overhead and cable length (km)	578588 km 9June 2023)
Annual average growth in distribution line length (over 5 years)	2.6% (2018-2023)
Distribution grid loss (%)	22.5% (2021)

Note: RE Renewable Energy; VRE Variable Renewable Energy

Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries. (See Appendix 2)

Key Finding

Progress

- Egypt has strong economic and technical regulations for grid development and operation.
  - The Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA) clearly defines tariff rules and economic principles for tariff calculations, including network charges, electricity exchange prices between non-qualified members, and network system charges, providing a transparent pathway for investment cost recovery.
  - The grid codes have both solar PV and wind specific codes at different levels of voltage connection with clear requirements and procedures for network connection, operation and the allocation of connection costs.
- Natural gas power has close to 90% share and rapid interconnector capacity increase is also planned by 2030. Both can provide flexibility for VRE integration into the grid.
- Egypt has 100% electricity access.

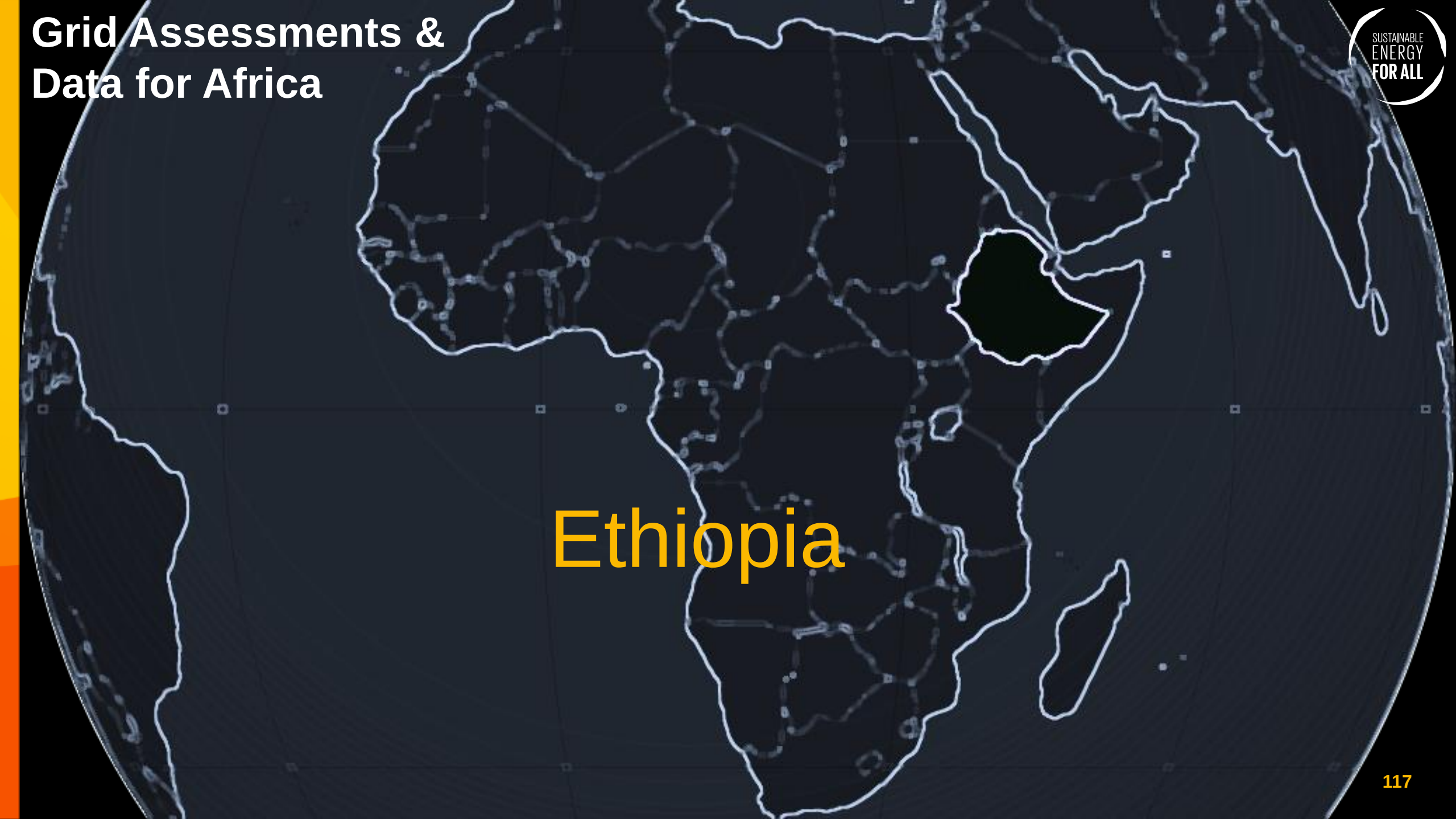
Challenges

- Approximately 90% of electricity is generates from fossil fuels (mostly from gas). The country's power mix shows a similar share of fossil fuels while RE share is 10% with 5% of VRE share. Unlike other African countries examined, hydro power share is around 5% in both electricity generation and power mixes, indicating reducing fossil fuel shares is a formidable task.
- System planning tasks are obligated by the 2015 Electricity Law (Law No. 87/2015) to the EETC, jointly with the Ministry of Electricity and Renewable Energy to produce and submit the Expansion Plan on Production for a period of 5 years and an Expansion Plan on Transmission for a period of 10 years. However, as no mandatory disclosure is required by the Law, both the plans have not been made publicly available for interested market participants, making low incentives for private sector participation to the transmission sector that is dominated by the SOT EETC.

Conclusion

- Grids in Egypt need to reduce losses as it is higher than the average losses in the African continent.
- Publicly available and clear grid investment plan is needed to incentivize more private sector participation and for more VRE integration.

Grid Assessments & Data for Africa

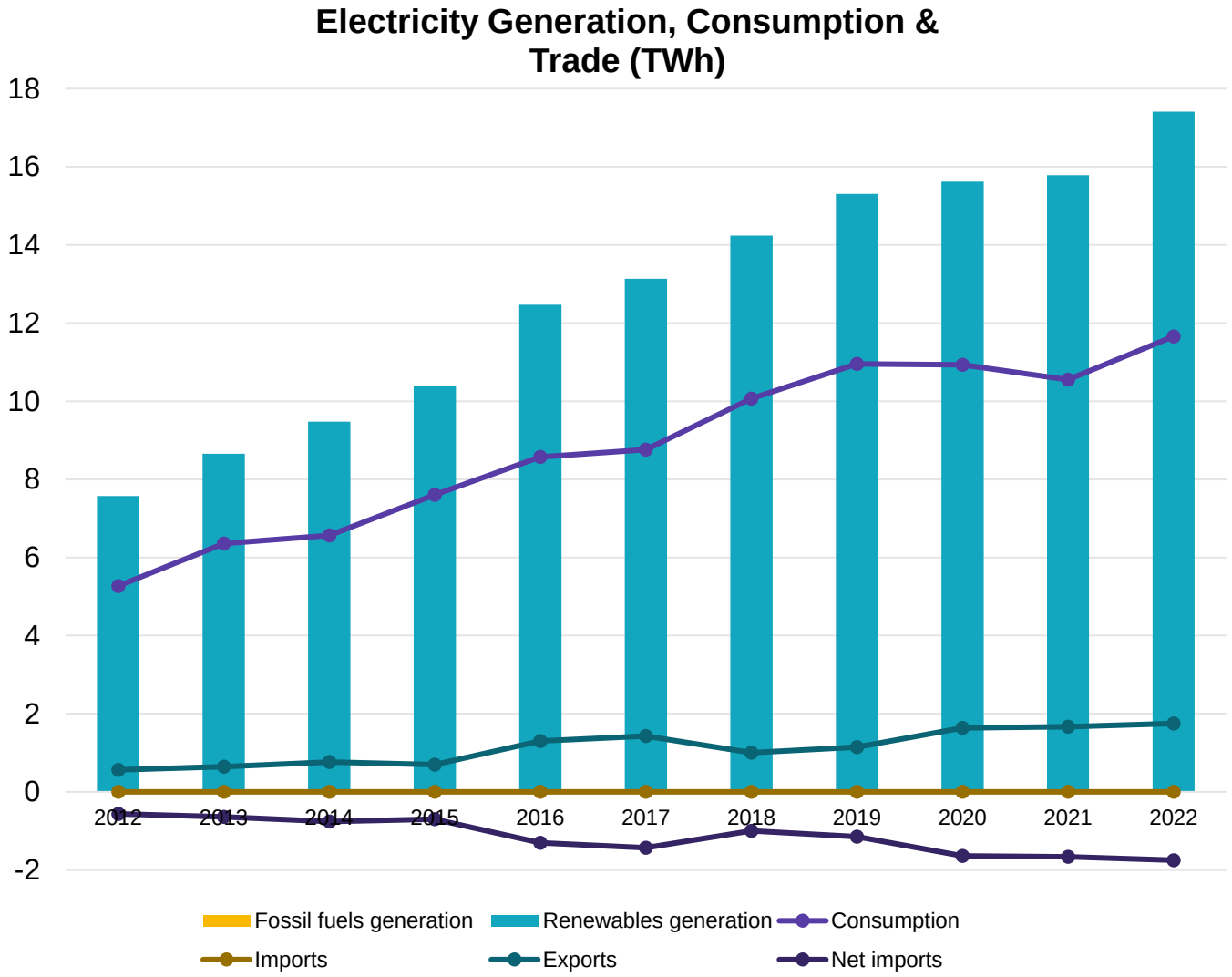


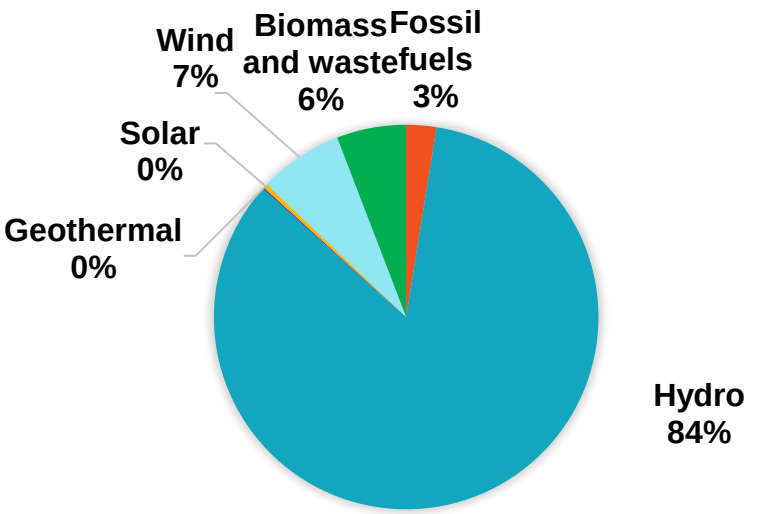
Power Sector Overview

Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**5.7**
	% of fossil fuel power capacity (2022)	**2.5%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	5.0%
	Annual total grid-connected power generation (TWh) (2022)	**17.4**
	% of fossil fuel power generation (2022)	0.0%
	5-year CAGR of total grid-connected power generation (2017-2022)	**5.8%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**10.6**
	5-year CAGR of electricity net consumption (2017-2022)	**3.9%**
Power Trade	Power Import (% of net consumption) (2022)	0.0%
	Power Export (% of net consumption) (2022)	9.6%
	Power Export (% of generation) (2022)	15.7%

Power Sector in General	Unbundling Status	Partially Unbundled (Generation and transmission is in Ethiopian Electric Power (EEP) & distribution & retail in Ethiopian Electric Utility (EEU))
	Private participation	Yes
	Power Generation	Yes (On-grid with IPP and off-grid with a limited number of developers in mini-grid)
	Transmission (System Operation)	No (SOE) Ethiopian Electric Power (EEP) as the SO
	Distribution / Retails	No Ethiopian Electric Utility (EEU, SOE) as the sole buyer and distributor of power
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - single off taker
	Market integration with neighboring systems	No
	Regional pool participation	Yes (EAPP)
Regulated status	National / Independent regulatory body	Yes (since 2001)

Power Sector – Generation





- Ethiopia has a very clean electricity generation mix with no fossil fuel generation in 2022. Installed power capacity shows the dominance of hydropower with 84% share, followed by 7% of wind energy and 6% of biomass and waste. Fossil fuels account only 3%.
- Electricity generation is growing with annual growth ratio of 6% while consumption only grows around 4%.
- The country also has power trade surplus. 16% of electricity generated was exported in 2022 with no import.

Data Source: US EIA International database – Electricity

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	5734 MW (2022)	17500 (2030)
	Annual Growth Ratio (%)	5.0% (2017-2022)	15.0% (2022-2030)
	VRE (MW)	425 MW (2022)	2275 MW (2030)
	Ratio of VRE (%)	7.4% (2022)	13% (2030)
Electricity Demand	**Peak Demand (MW)**	N/A	N/A
	Annual Growth Ratio (%)	---	N/A
Supply vs Demand	**Reserve Margin (%)**	N/A	N/A
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	1.9% (2017-2022)	N/A
Transmission	**Transformer capacity** of transmission lines	N/A	N/A
	Annual Growth Ratio (%)	N/A	N/A
	Circuit length of transmission lines	21309 km (2022)	N/A
	Annual Growth Ratio (%)	4.1% (2017-2022)	N/A

- Ethiopia is projecting approximately three-fold increase of power capacity between 2022 and 2030, requiring 15% annual growth ratio. VRE capacity is expected to increase more than five times. Those annual growth ratios are much higher than the past trends.

Data Sources: USEIA; Ethiopian Electricity Power (2025a) (see Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	91.5%
VRE share in power mix (2022)	7.4%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	4.8%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	3.9%
System flexibility (WEF 2024 indicator, 0-100)	95.6
Demand projection (2030)	N/A
Generation supply target (2030)	17500 MW
Grid target / strategy in national policy / planning or NDC	No
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	21397 km
Transformer capacity (MVA, 2022)	N/A
Current interconnections capacity (MW, known)	6000
Grid loss (total, %, 2022)	18.1%
Annual average growth in transmission line length (over 5 years)	4.2% (2017-2022)
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / No
Private participation / investment in transmission asset development (Y/N)	Yes (limited with EPC & consultancy)
RE Priority dispatch (Y/N)	No
SAIFI (2023)	N/A
SAIDI (2023)	
Consumer tariff subsidy / pricing support (Y/N)	No

Indicator	Data
Electricity access (2022)	55.4%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	85.9
Average residential tariff (USD/kWh)	0.041 (2022) 0.039 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	N/A
Annual average growth in distribution line length (over 5 years)	N/A
Distribution grid loss (%)	N/A

Note: RE Renewable Energy; VRE Variable Renewable Energy

Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries. (See Appendix 2)

Key Findings

Progress

- Ethiopia had two important updates to regulations in 2022, both of which provide a good foundation for the sector transformation.
  - The 2022 grid code revision also delivers a strong technical regulatory foundation, especially for VRE deployment and integration.
  - The 2022 electricity tariff setting methodology guidelines gave Ethiopia a very strong economic regulation profile in all generation, transmission and distribution, providing tariff formulas with detailed components along with clear conceptual basis behind the formula.
- Ethiopia currently has a strong clean electricity profile; however, this has heavy hydro dependance at 84% of installed capacity.
- The country also has a very strong interconnector profile with around 6GW of capacity, which can provide high flexibility to diversify power sources with non-hydro renewables while keeping a clean electricity profile intact during the energy transition.

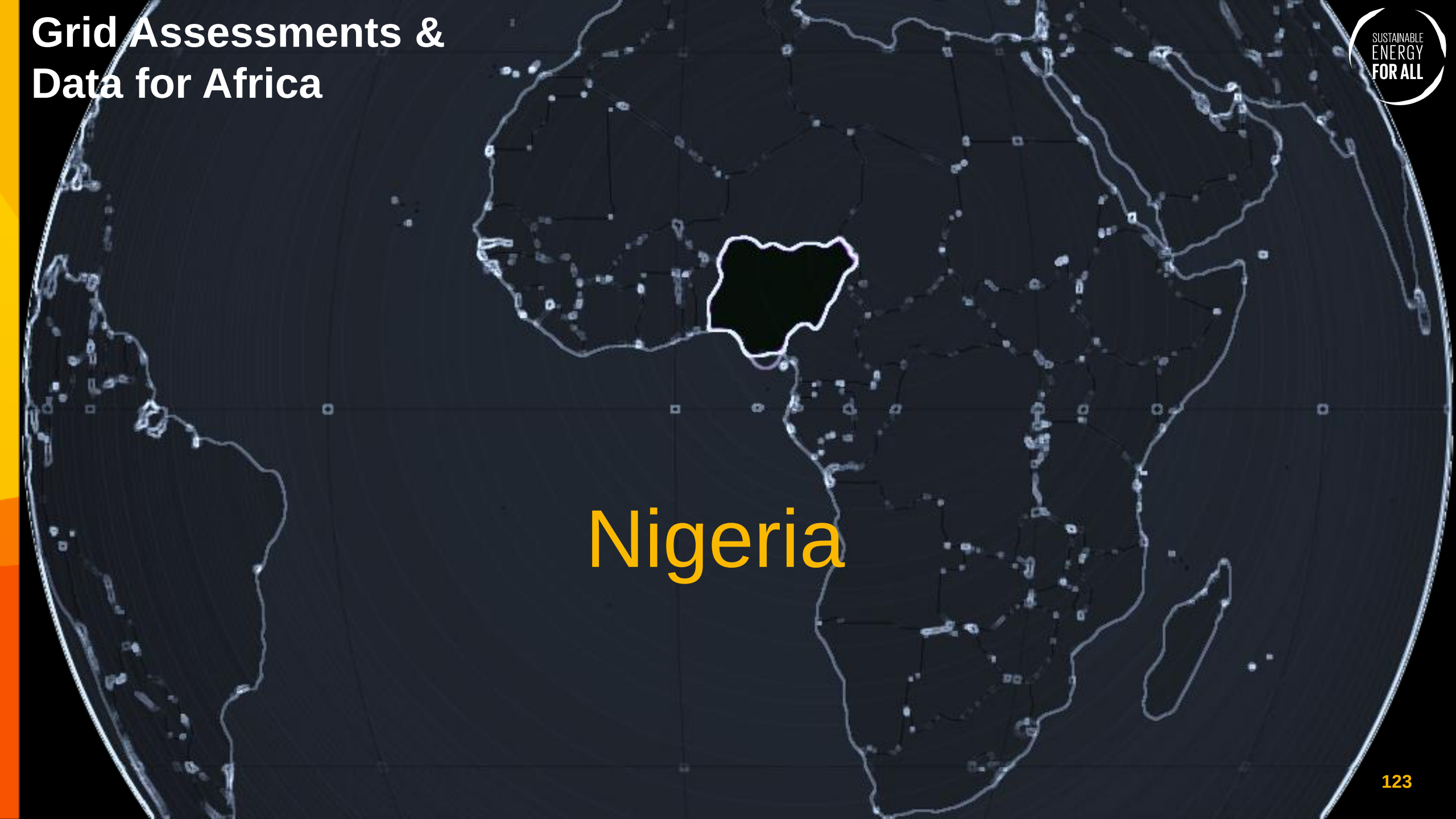
Challenges

- Grid service performance and progress (e.g., SAIFI and SAIDI) are not publicly available.
- Although affordability of on-grid electricity service is good, electricity access is still only 55%, with rural access to electricity at 43% and urban at 98%. The current electricity consumption per capita level is extremely low, and its growth rate is lower than the GDP per capita growth, on grid electricity access will enable increased use of energy for development and services.
- The extremely high dependance on hydro power can pose an increasing security risk with water scarcity related to climate change and population growth, in addition to water disputes with neighboring countries.

Conclusion

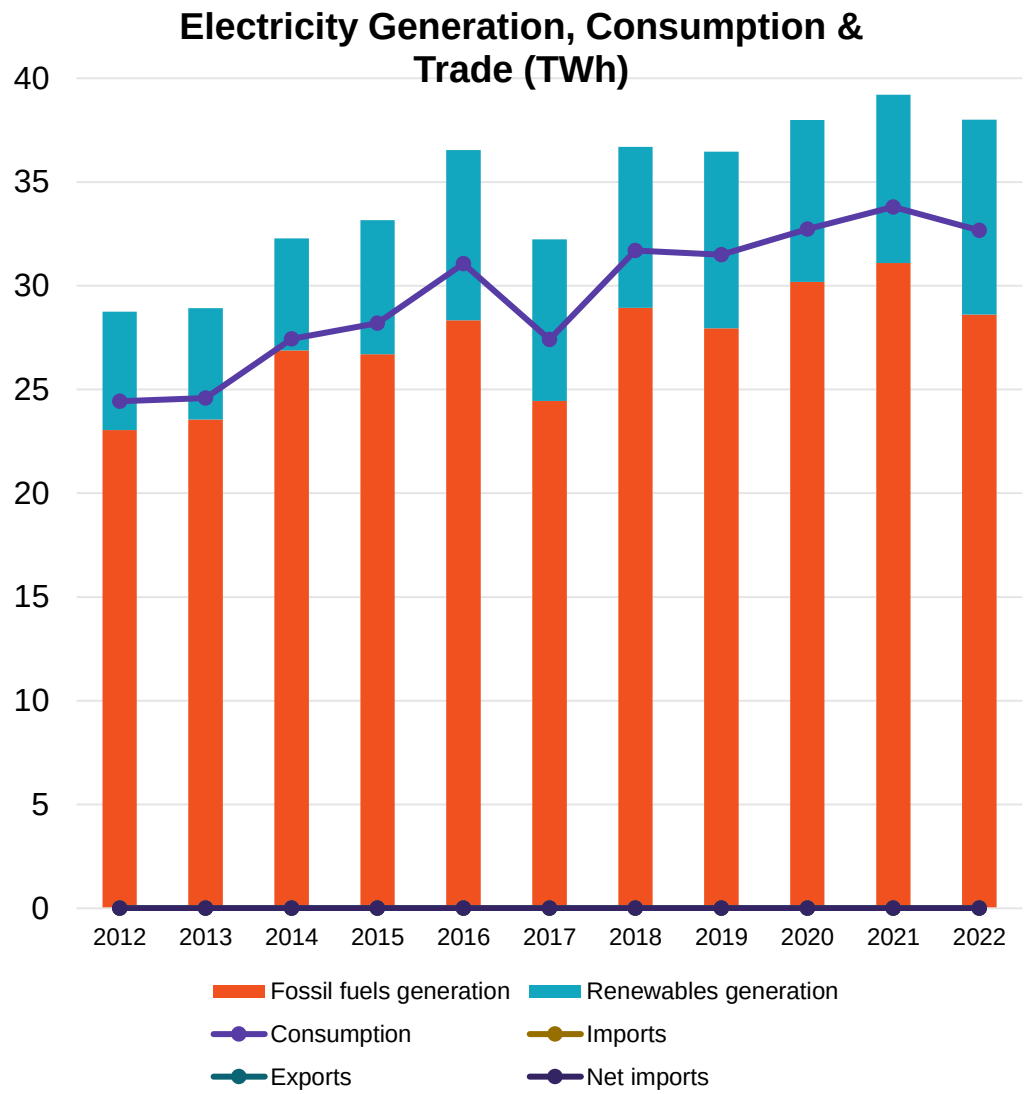
- Grids investment in Ethiopia needs to focus on increasing electricity access through minigrids and grid extension.
- It will be highly cost effective to prioritize reducing high grid losses.
- While Ethiopia has a strong clean energy mix at the moment, overcoming energy poverty with increasing both supply and consumption while diversifying the energy and power mixes with VRE is essential.

Grid Assessments & Data for Africa



Power Sector Overview

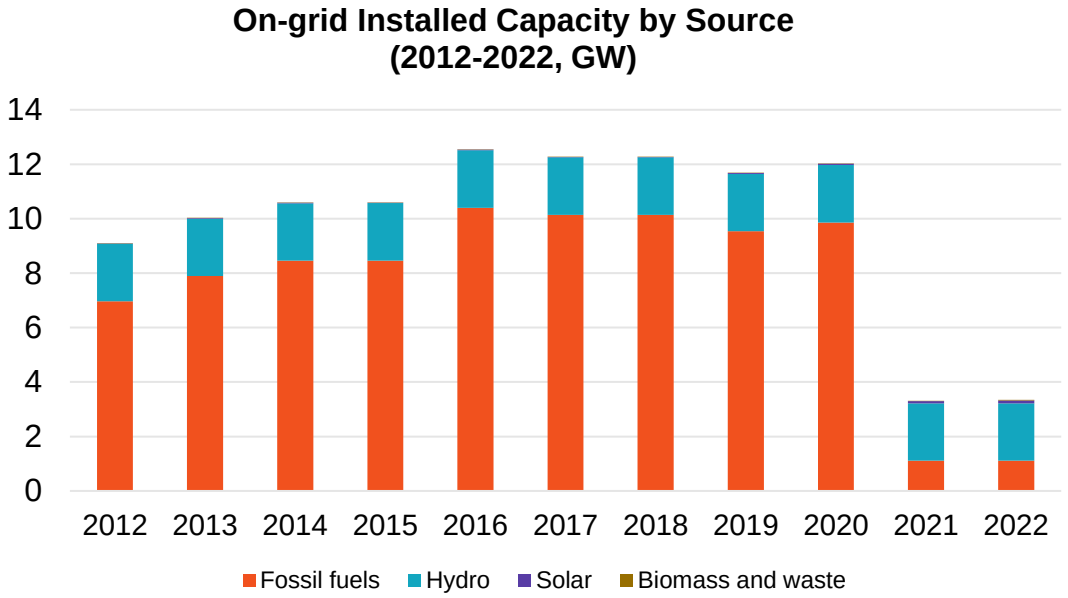
		2022	2020
Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	3.3	12.0
	% of fossil fuel power capacity (2022)	33.2%	81.9%
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2015-2020)	--	2.6%
	Annual total grid-connected power generation (TWh) (2022)	38.0	38.0
	% of fossil fuel power generation (2022)	76.2%	79.5%
	5-year CAGR of total grid-connected power generation (2015-2020)	3.3%	2.8%
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	32.7	32.7
	5-year CAGR of electricity net consumption	2.9%	3.0%
Power Trade	Power Import (% of net consumption) (2022)	0.0%	0.0%
	Power Export (% of net consumption) (2022)	0.0%	0.0%
	Power Export (% of generation) (2022)	0.0%	0.0%

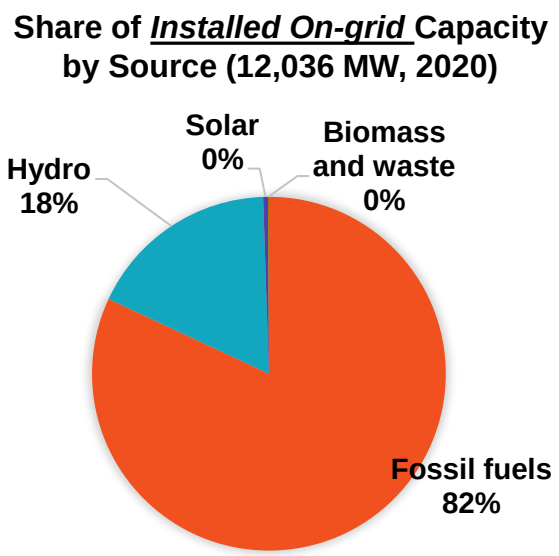


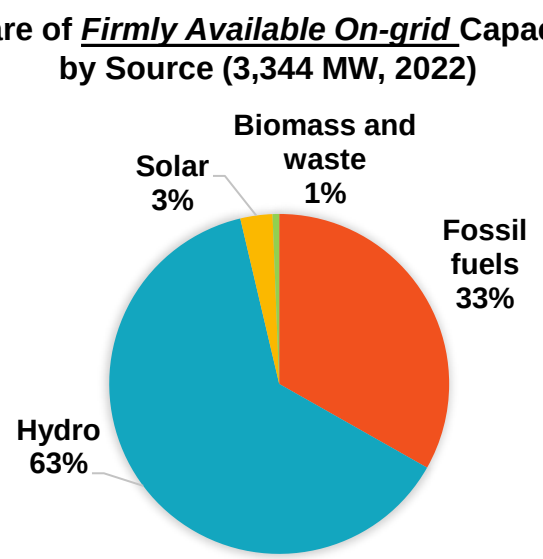
Fossil fuel (natural gas) dominates on-grid electricity generation (75% in 2022), while large hydropower mostly delivers the rest of electricity.

Data Source: US EIA International database – Electricity

Power Sector Overview







The international electricity database of the United States Energy Information Administration (US EIA) shows a large discrepancy of installed capacity of Nigeria before 2020 and after 2021, while total electricity generation of on-grid system shows consistency over the years up to 2022 (see the previous slide). An IRENA report (2023) states "**The total installed capacity of grid-based systems is around 13 GW**" which is consistent with the US EIA data **before 2020**, but hugely different from the US EIA **2022** system size data of 3.3 GW shown in the left and right figures above. Meanwhile, the same IRENA report mentions "**today's available on-grid peak generation varies and hovers around 4.5 GW**. **Unavailability of gas, machine breakdowns, seasonal water shortages and limited grid capacity** have severely limited the operational performance of these power plants (Yetano Roche *et al.*, 2020, cited in the IRENA report)." In addition, **transmission capacity of the country is reportedly around 8.6 GW in 2022, which is far below the total installed capacity of 13 GW,** the IRENA 2023 reports. Considering these evidences, the US EIA 2021 and 2022 data of installed capacity indicate the firmly available on-grid capacity, connected for delivery to the country's grid network, while the US EIA data before 2020 include the installed capacity which were built but not being able to deliver electricity services with various reasons. **In short, discrepancy between grid-connected installed capacity and firmly available capacity due to the lack of ability to deliver electricity including grid capacity has resulted in acute shortage of grid-electricity and Nigeria has heavy reliance on fossil fuel generator sets to meet daily demand as well as peak power capacity.** As a result, Nigeria today heavily relies on back-up generator sets, mostly using fossil fuels such as oil and diesels, making the country the largest importer of such generators in Africa and one of the largest in the world.

Data Source: US EIA International database – Electricity

Power Sector Overview

Power Sector in General	Unbundling Status	Unbundled (Legal)
	Private participation	Yes
	Power Generation	Yes (liberalized for all on-grid, mini-grid and SHS)
	Transmission (System Operation)	No (SOE) Transmission Company of Nigeria (TCN) performs the SO function. Upon acquiring its license, it will operate as an independent company in future.
	Distribution / Retails	Yes (liberalized for all on-grid, mini-grid and SHS)
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - single off-taker (Nigerian Bulk Electricity Trading (NBET) Plc as the sole trader of electricity)
	Market integration with neighboring systems	No
	Regional pool participation	Yes (WAPP)
Regulated status	National / Independent regulatory body	Yes (since 2005)

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	12036 (installed capacity, 2020) 3344 MW (firm capacity, 2022)	56 GW, including off-grid solar of 13 GW (2030) (IRENA projection)
	Annual Growth Ratio (%)	-22.9% (2017-2022)	13.6% (on-grid capacity, 2020-2030) 16.6% (total capacity,2020-2030)
	VRE (MW)	37 MW (2022)	5824 MW (2030)
	Ratio of VRE (%)	1.1% (2022)	10.4% (2030)
Electricity Demand	**Peak Demand (MW)**	5800 MW (2022)	N/A
	Annual Growth Ratio (%)	---	N/A
Supply vs Demand	**Reserve Margin (%)**	-73.4% (2022)	N/A
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	-0.23% (2017-2022)	N/A
Transmission	**Transformer capacity** of transmission lines	8229 MW (estimated Sep. 2022)	N/A
	Annual Growth Ratio (%)	N/A	N/A
	Circuit length of transmission lines	N/A	N/A
	Annual Growth Ratio (%)	N/A	N/A

- Although consistent national power system development plans / master plans are not available, IRENA's recent scenario analysis (2023) projects 43GW of on-grid installed capacity in 2030 with the present plan. VRE share is expected to increase approximately 10 times (on-grid + off-grid total capacity).

Data Sources: USEIA; IRENA (2023) (see Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	65.4%
VRE share in power mix (2022)	3.1%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	14.1%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	3.6%
System flexibility (WEF 2024 indicator, 0-100)	98.1
Demand projection (2030)	192 TWh (IRENA)
Generation supply target (2030)	56 GW (total) 43 GW (on-grid) (IRENA)
Grid target / strategy in national policy / planning or NDC	No
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	8229 MW
Transformer capacity (MVA, 2022)	N/A
Annual average growth in transmission line length (over 5 years)	N/A
Current interconnections capacity (MW, known)	872
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes (limited with EPC but changes in progress)
Grid loss (total, %, 2022)	14.2%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	N/A
SAIDI (2023)	
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	60.5%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	144.5
Average residential tariff (USD/kWh)	0.127 (2022) 0.091 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	N/A
Annual average growth in distribution line length (over 5 years)	N/A
Distribution grid loss (%)	25.0% (2022)

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries. (See Appendix 2)

Key Findings

Progress

- Nigeria has detailed system assessments and planning done by TCN and the country's Multi-Year Tariff Order (MYTO) provide a basis for transmission investment recovery.
- The 2018 grid codes provide good technical requirements for both synchronous and non-synchronous generators (Power Park Models), while providing priority dispatch for RE with merit order principle.
- Nigeria has excellent flexibility to include VRE in its power profile, with significant gas and hydro power in electricity generation mix.

Challenges

- Despite the 13GW of existing power plant installed capacity, transmission capacity is far below this level. As a result, the security and reliability of power supply is very low as reserve margin is negative.
- The discrepancy between grid-connected installed capacity and firmly available capacity due to the lack of grid capacity results in a shortage of grid-electricity and heavy reliance on fossil fuel generator sets to meet daily demand and peak power capacity.
- Electricity access needs to expand very rapidly, considering its strong population growth. As electricity consumption per capita via on-grid service is quite low, higher tier access provision via grid expansion is critical, along with initial electricity access provision with off-grid technologies.
- The country currently heavily relies on fossil fuels (gas power) for electricity generation, making an urgent necessity to reduce this dependance while increasing VRE from both energy security and environmental perspectives.

Conclusion

- The Nigeria energy transition plan indicates 8.4 million people are far from existing grid infrastructure and need to be connected to mini grids.
- 5.4 million people in densely populated regions need grid strengthening.
- There are significant opportunities to reduce grid losses with regulatory and market interventions.
- Nigeria needs to invest in 95 GW transmission and distribution network by 2060 for a net-zero power system.

Grid Assessments & Data for Africa

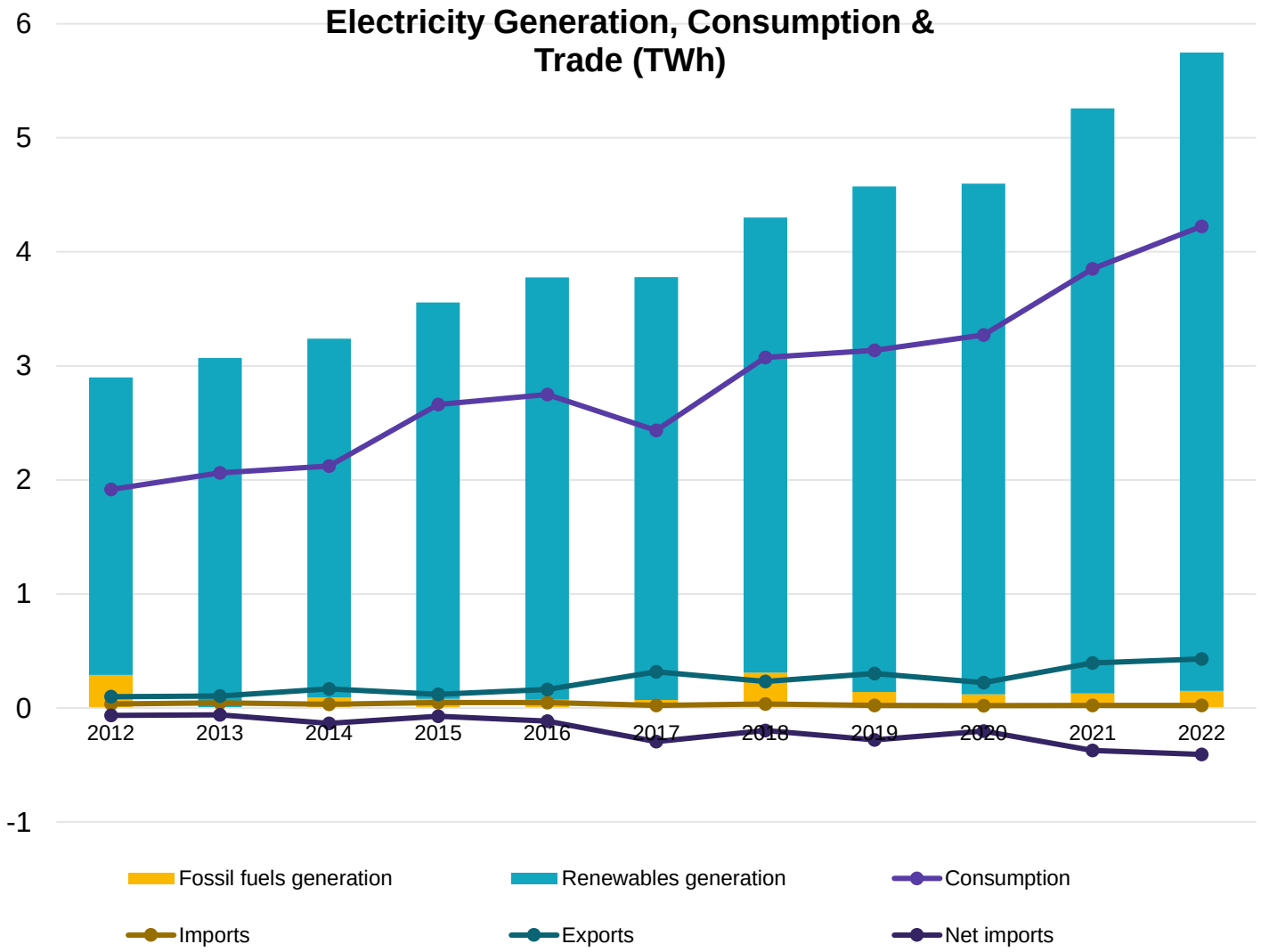
Power Sector Overview

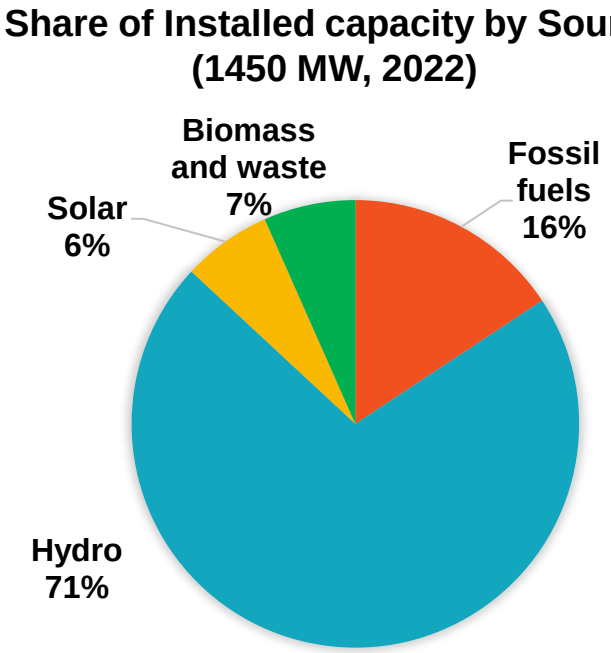
Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**1.5**
	% of fossil fuel power capacity (2022)	**15.7%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	7.6%
	Annual total grid-connected power generation (TWh) (2022)	**5.7**
	% of fossil fuel power generation (2022)	1.0%
	5-year CAGR of total grid-connected power generation (2017-2022)	**8.7%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**4.0**
	5-year CAGR of electricity net consumption (2017-2022)	**10.3%**
Power Trade	Power Import (% of net consumption) (2022)	0.6%
	Power Export (% of net consumption) (2022)	5.9%
	Power Export (% of generation) (2022)	8.5%

Uganda decided to return to vertical integration structure to pursue efficiency in the 2022 Amendment of Electricity Act.

Power Sector in General	Unbundling Status	Unbundled (Legal) **(will be vertically integrated again)**
	Private participation	Yes
	Power Generation	Yes On-grid with IPP participation
	Transmission (System Operation)	No (SOE) Uganda Electricity Transmission Company Ltd (UETCL 100% SOE) as the single operator
	Distribution / Retails	Yes. (Nine distribution private companies)
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - Uganda Electricity Transmission Company Ltd (UETCL) as a single buyer of bulk electricity
	Market integration with neighboring systems	No
	Regional pool participation	Yes (EAPP)
Regulated status	National / Independent regulatory body	Yes (since 2000)

Power Sector – Generation





- While fossil fuel occupies about 16% of installed capacity, its power generation amount is around 1% and the rest is generated by renewables, showing a very good clean energy profile. Hydro power capacity dominates the power mix, while solar and biomass also contribute significant amount.
- Uganda shows strong growth in both electricity generation and consumption.
- The country is also actively exporting power to neighboring countries.

Data Source: US EIA International database – Electricity

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	1450 MW (2022)	2300 MW (2030)
	Annual Growth Ratio (%)	7.6% (2017-2022)	5.9% (2022-2030)
	VRE (MW)	94 MW (2022)	N/A
	Ratio of VRE (%)	6.5% (2022)	N/A
Electricity Demand	**Peak Demand (MW)**	843 MW (2022)	1644 MW (2030)
	Annual Growth Ratio (%)	---	8.7% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	33.6% (2022)	39.9% (2030)
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	-1.5% (2017-2022)	-2.8% (2022-2030)
Transmission	**Transformer capacity** of transmission lines	6666 MVA (2024)	17210 MVA (2030)
	Annual Growth Ratio (%)	19.8% (2017-2022)	12.6% (20220-2030)
	Circuit length of transmission lines	N/A	N/A
	Annual Growth Ratio (%)	N/A	N/A

- Uganda is projecting approximately 1.6-fold increase of power capacity between 2022 and 2030, requiring 5.9% annual growth ratio with the least cost expansion plan.
- Peak demand is projected to increase twice during the period with annual growth ratio of 8.7%.
- In terms of transmission grid, 258% increase is projected in transformer transfer capacity with annual growth ratio of 12.6% between 2022 and 2030.

Data Sources: USEIA; Electricity Regulatory Authority (ERA) (2021b) Least Cost Electricity Expansion Plan 2020-2030, Ministry of Energy and Minerals Development (Annual report FY2022-2023, Statistical Abstract 2023 (see Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	77.4%
VRE share in power mix (2022)	6.5%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	16.2%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	10.3%
System flexibility (WEF 2024 indicator, 0-100)	N/A
Demand projection (2030)	1644 MW
Generation supply target (2030)	2300MW
Grid target / strategy in national policy / planning or NDC	Yes
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	N/A
Transformer capacity (MVA, 2022)	6445.5 MVA
Annual average growth in transmission line length (over 5 years)	N/A
Current interconnections capacity (MW, known)	2400 (?)
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	No / No
Private participation / investment in transmission asset development (Y/N)	Yes (with EPC and IPT models)
Grid loss (total, %, 2022)	19.2%
RE Priority dispatch (Y/N)	Yes
SAIFI (2023)	N/A
SAIDI (2023)	
Consumer tariff subsidy / pricing support (Y/N)	Yes

Indicator	Data
Electricity access (2022)	47.1%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	84.0
Average residential tariff (USD/kWh)	0.222 (2022) 0.217 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	70565 km (2024)
Annual average growth in distribution line length (over 5 years)	6.0% (2019-2024)
Distribution grid loss (%)	17.6% (2022)

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries. (See Appendix 2)

Key Findings

Progress

- Strong political commitments are observed for the energy transition with the clear grid target.
- The country also has power export supported by its interconnector capacity, which is also witnessing a steady increases.
- Uganda shows strong political commitment, grid development planning, and environmental and social impacts mitigation.
- Transmission and interconnector asset development shows strong growth trend with established network development planning framework and procedures.

Challenges

- Grid service performance and progress (e.g., SAIFI and SAIDI) are not publicly available.
- Technical regulations for grid operation need enhancement to support greater VRE integration, as current grid codes have yet to formally incorporate the 2017 interconnection codes and wheeling agreement study, which offer a strong technical foundation for such integration.
- Economic regulations related to transmission investment recovery, grid part of tariff determination methods, and cost reflectiveness are weak.
- On-grid access remains limited and there is low individual electricity consumption, with both tariff and connection affordability issues, and a need for significant improvements in access and power reliability

Conclusion

- Upgrading grid codes to formally incorporate the 2017 interconnection codes and wheeling agreement study is essential for diversifying clean energy sources and reducing heavy reliance on hydropower
- Economic regulations, technical regulations, grid operations, need to be strengthened to enhance the enabling environment for network investment.
- Grids in Uganda need to focus on closing access challenges through mini-grid deployment and strategic transmission expansion.
- Data collection can be improved on grid interruption frequency and duration.

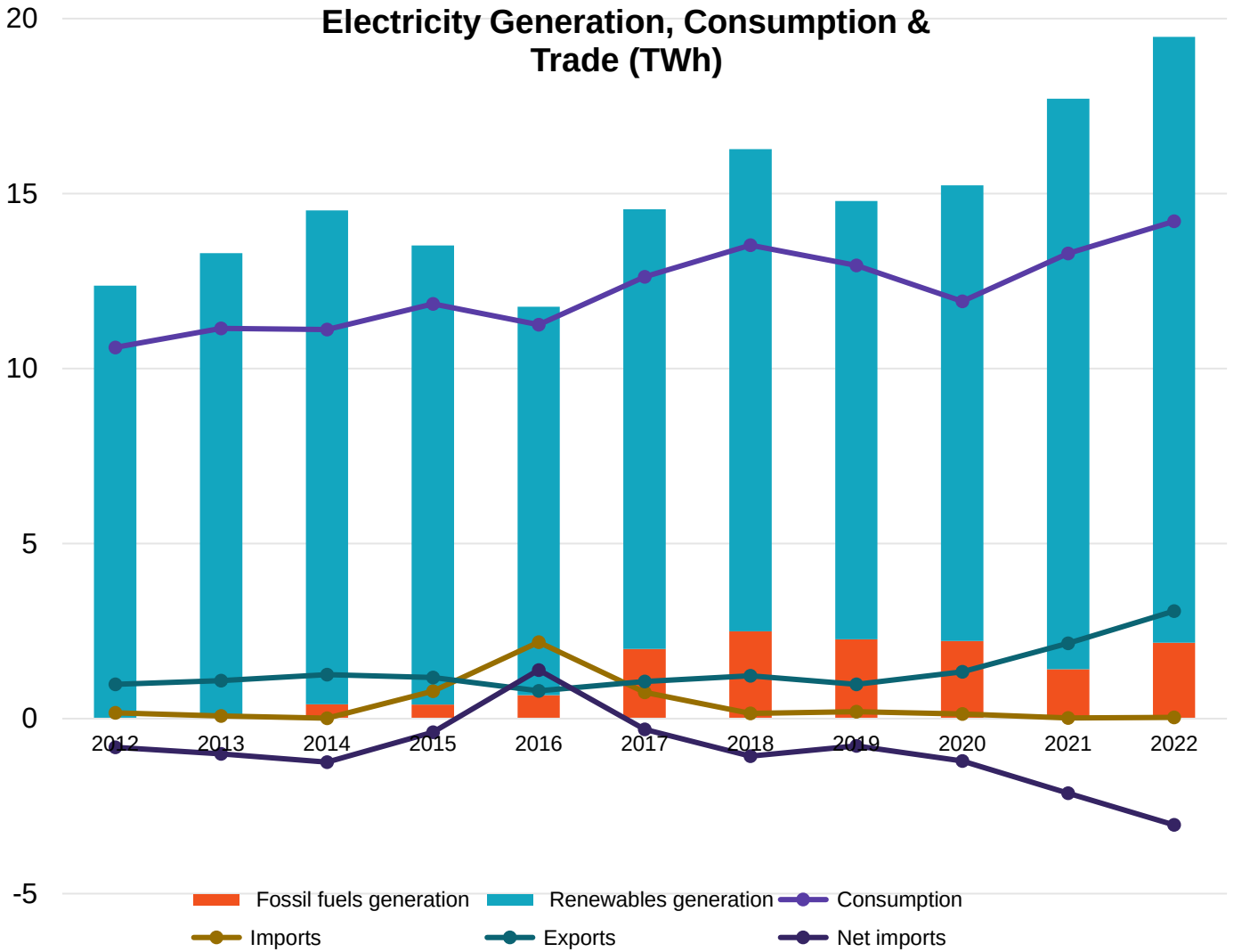
Grid Assessments & Data for Africa

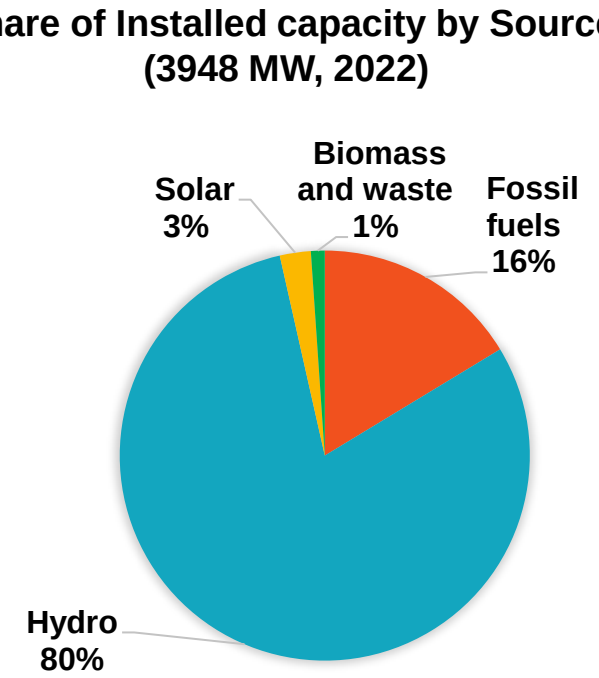
Power Sector Overview

Power Generation	**Total grid-connected power capacity (system size) (GW) (2022)**	**3.9**
	% of fossil fuel power capacity (2022)	**16.3%**
	5-year CAGR of total grid-connected power generation capacity (utility-scale) (2017-2022)	5.8%
	Annual total grid-connected power generation (TWh) (2022)	**19.5**
	% of fossil fuel power generation (2022)	11.1%
	5-year CAGR of total grid-connected power generation (2017-2022)	**6.0%**
Power Consumption	**Annual total electricity net consumption (TWh) (2022)**	**15.0**
	5-year CAGR of electricity net consumption (2017-2022)	**3.5%**
Power Trade	Power Import (% of net consumption) (2022)	0.2%
	Power Export (% of net consumption) (2022)	11.1%
	Power Export (% of generation) (2022)	14.4%

Power Sector in General	Unbundling Status	Vertically integrated (SOE - Zambia Electricity Supply Corporation Limited (ZESCO))
	Private participation	Yes
	Power Generation	Yes (Both on-grid with IPP and off-grid)
	Transmission (System Operation)	No / Yes (SOE ZERCO as the SO of the national grid. However, two private companies operate transmission and distribution grid in their respective serving mining regions.)
	Distribution / Retails	Yes (SOE ZERCO, two vertically integrated private companies as distributor) plus mini-grid developers and SHS companies
Market Structure	Wholesale open / competitive market trading in energy, balancing, and / or ancillary services	No - ZESCO as single-buyer
	Market integration with neighboring systems	No
	Regional pool participation	Yes (SAPP)
Regulated status	National / Independent regulatory body	Yes (since 1997)

Power Sector – Generation





- Although renewable energy dominates the electricity generation over the years, fossil fuel power generation is growing in recent years. Electricity consumption shows slower growth than power generation. Power trade displays strong surplus, with Zambia providing around 15% of its power generation to neighboring countries.
- Hydro power dominates installed capacity with 80% share, while the shares of other renewable energy (solar and biomass and waste) are very low.

Data Source: US EIA International database – Electricity

Electricity – Current Status vs 2030

Indicators		2022 or Latest data	2030 Projection or Target (Reference Case)
Electricity Supply	**Installed Capacity (MW)**	3948 MW (2022)	10013 MW (2030)
	Annual Growth Ratio (%)	5.9% (2017-2022)	12.3% (2022-2030)
	VRE (MW)	97 MW (2022)	3304 MW (2030)
	Ratio of VRE (%)	2.4% (2022)	33% (2030)
Electricity Demand	**Peak Demand (MW)**	2375 MW (2022)	5422 MW (2030)
	Annual Growth Ratio (%)	---	10.9% (2022-2030)
Supply vs Demand	**Reserve Margin (%)**	39.9% (2022)	84.7% (2030)
	5-year CAGR of power generation (%) – 5-year CAGR of electricity consumption (%)	2.5% (2017-2022)	1.4% (2022-2030)
Transmission	**Transformer capacity** of transmission lines	10407 MVA (2022)	12641 MVA (2030)*
	Annual Growth Ratio (%)	N/A	3.2%
	Circuit length of transmission lines	12705 km (2022)	N/A
	Annual Growth Ratio (%)		N/A

- Zambia is projecting approximately 2.5-fold increase of power capacity between 2022 and 2030, requiring 12.3% annual growth ratio, based on the 2023 Integrated Resource Plan. VRE share is expected to increase more than 13 times. These annual growth ratios are much higher than the past trends.
- Peak demand is projected to increase 230% during the period with annual growth ratio of 10.9%.
- In terms of transmission grid, the Integrated Resource Plan- Transmission Planning projects 21% increase in transformer capacity between 2022 and 2030.

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Note: *Calculated with 2234 MVA increase planned between 2022 and 2030 based on Transmission Development Plan 2022 and 2030 maps in IRP.
Data Sources: USEIA; Ministry of Energy (2023c, 2023d, 2023e) Integrated Resource Plan (IRP) – Transmission Planning, Demand Forecast, and Power Generation module reports (see Appendix 2)

Key Indicators

Indicator	Data
RE share in power mix (2022)	82.6%
VRE share in power mix (2022)	2.4%
Average annual growth in VRE penetration in installed capacity, (2017-2022)	295.3%
RE curtailment ratio (%)	N/A
Average annual growth in electricity demand (over 5 years, 2017-2022)	3.5%
System flexibility (WEF 2024 indicator, 0-100)	94.2
Demand projection (2030)	5422 MW (peak)
Generation supply target (2030)	10013 MW
Grid target / strategy in national policy / planning or NDC	Yes
Independent regulatory body (Y/N)	Yes

Indicator	Data
Transmission circuit length (km, 2022)	N/A
Transformer capacity (MVA, 2022)	10407 MVA
Annual average growth in transmission line length (over 5 years)	9.6% (one year, 2022-2023)
Current interconnections capacity (MW, known)	2090
VRE in connection queue (MW)	Not reported
Economic regulations - grid tariff determination and its cost reflectiveness (Y/N)	Yes / Yes
Private participation / investment in transmission asset development (Y/N)	Yes
Grid loss (total, %, 2022)	10.3%
RE Priority dispatch (Y/N)	No
SAIFI (2023)	4.9
SAIDI (2023)	51.2
Consumer tariff subsidy / pricing support (Y/N)	No

Indicator	Data
Electricity access (2022)	47.8%
ESIA process for transmission projects (Y/N)	Yes
Established public consultation / compensation framework and procedure (Y/N)	Yes

Indicator	Data
Electricity consumption per capita (kWh/yr/capita, 2022)	747.7
Average residential tariff (USD/kWh)	0.052 (2022) 0.054 (2023)

Indicator	Data
Distribution transformer capacity (MVA)	N/A
Distribution overhead and cable length (km)	12500 km (2022)
Annual average growth in distribution line length (over 5 years)	N/A
Distribution grid loss (%)	N/A

Note: RE Renewable Energy; VRE Variable Renewable Energy
Data Sources: USEIA; BNEF Climatescope; World Bank Development Indicators; IEA/IRENA/WHO/USSD/World Bank ESMAP-Tracking SDG7; and National documents of respective countries. (See Appendix 2)

Country Overview

Progress

- Grid development, generation and transmission planning and least cost analysis is being conducted for unelectrified regions.
- Interconnector asset development and planned projects to 2030 show strong growth trends.
- The existing hydro power and good interconnector presence offer an excellent starting point by providing good flexibility for VRE deployment and integration.

Challenges

- National transmission grid needs upgrading due to the existing aging assets.
- Current economic regulations related to transmission investment recovery and cost reflectiveness are quite weak, although grid tariff determination method formula is available.
- The country's grid codes do not have clear established dispatching rules, priority dispatch to renewables, nor dedicated curtailment management rules. Real-time dispatch, high quality variable renewable forecasting, or curtailment compensation rules are not in the current codes either.
- The 2023 Integrated Resource Plan has detailed transmission plan for 30 years ahead, but it does not consider transmission expansion for increasing renewable energy integration, regional power trading within SAPP, and increasing industrial and agricultural demand.

Conclusion

- Grids in Zambia need to focus on closing access challenges through mini-grid deployment and strategic transmission expansion.
- While regional interconnectors offers strength, domestic transmission assets have aging issues.
- Improvement of economic and technical regulations is essential for utilizing the existing assets wisely with advanced operations while progressing the asset upgrade.
- More robust planning that consider stronger VRE integration, increasing demands and regional trades, utilizing its well-established planning framework and procedures, becomes important as well.

SUSTAINABLE ENERGY FOR ALL

Appendix 2 | Data Sources & References

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