Clean Energy Transition in Tanzania

Powering Sustainable Development

Norwegian Embassy
Dar es Salaam

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Prepared for
Royal Norwegian Embassy in Dar es Salaam

Subject to modifications
Dar es Salaam, Status: April 2022

Executive summary

Over the next decades Tanzania faces two fundamental energy challenges:

1. Achieving universal access to affordable, reliable, sustainable, and modern energy services by 2030, as set out in the United Nation´s Sustainable Development Goal 7; and

2. Increasing the supply of electricity to fuel economic growth and improve livelihoods while avoiding a lock-in to polluting fossil fuels.

Fortunately, the technical and commercial solutions required for Tanzania to leapfrog fossil fuel and build a robust and sustainable power system based on renewable energy already exist. This report lays out an ambitious yet realistic plan for meeting 113 TWh of electricity demand in 2050 through a mix of renewable energy and storage. The estimated USD 100 billion dollars required for investment, operation, and maintenance till 2050 matches the total cost of implementing the Tanzania Power System Master plan - which relies heavily on fossil fuels.

However, several structural barriers are holding back the development of a sustainable power sector in Tanzania. The table below outlines how the Government, the private sector, and development partners jointly can address these barriers and enable a clean energy transition towards 2050.

Table – Key enablers of the clean energy transition in Tanzania

Cost-reflective tariffs and financially sustainable service providers	• Political acceptance of cost-reflective tariffs is an imperative to achieve sector sustainability over time. • TANESCO needs to improve its operational performance. • Tanzania should take a holistic approach to rural electrification that considers the needs and limitation of the integrated grid, and the operations and maintenance (O&M) obligations that follow from grid extensions.
Environment conducive to private sector investments in renewables	• Strengthen regulatory independence and ensure that the Ministry of Energy governs through (consistent) policy. • Utilize auctions to procure significant amounts of low-cost variable renewable energy, particularly solar PV distributed around the country.
Technologies and structures for energy efficiency and system flexibility	• Embed considerations related to flexibility in the least-cost expansion approach. • Operationalize the existing framework for energy efficiency.
Strong policy and regulatory frameworks, competent institutions, and liberalization	• Strengthen regulatory independence and ensure that policy makers govern through policy and not micromanagement of the sector. • Develop a formalized and institutionalized process for grid and generation expansion planning based on an Integrated Resource Plan. • Revitalize the ESI Reform Strategy and Roadmap towards unbundling of TANESCO.

Affordable access and innovative business models	• Take a holistic approach to rural electrification that includes off- and mini-grid solutions. • Formalize a politically acceptable framework for off- and mini-grid electrification that also allows the private sector to recover fair costs and reasonable profits as approved by EWURA. • Consider subsidies to reduce the cost of connection as a supplement to existing electrification efforts.
Robust grids coupled with competence in operations and maintenance	• Strengthen TANESCO capacity within operation and maintenance of distribution grids. • Revert responsibility for on-grid rural electrification to TANESCO, with REA functioning as a fund manager for the Rural Energy Fund.
Decommissioning existing fossil fuel generation capacity	• Given the relatively small system size and limited emissions from fossil fuel combustion, the main focus should be on avoiding investments in additional fossil generation.

The report sets out five short-term strategic initiatives which, if implemented will jump-start the transition:

1. Implement a path to cost-reflective tariffs, and strengthen TANESCO operations
2. Develop a formalised and institutionalised process for generation and transmission expansion planning within the Ministry of Energy
3. Run international auctions to increase investments in low-cost variable renewables
4. Revert to the underlying framework for private mini-grid development, to realise universal connectivity by 2030
5. Take a holistic approach to grid extension and strengthening, by moving responsibility for planning and execution of rural grid extension from REA to TANESCO

A clean Tanzanian power system in 2050

113 TWh
Generation

0 tCO_2e
Emissions

Installed capacity

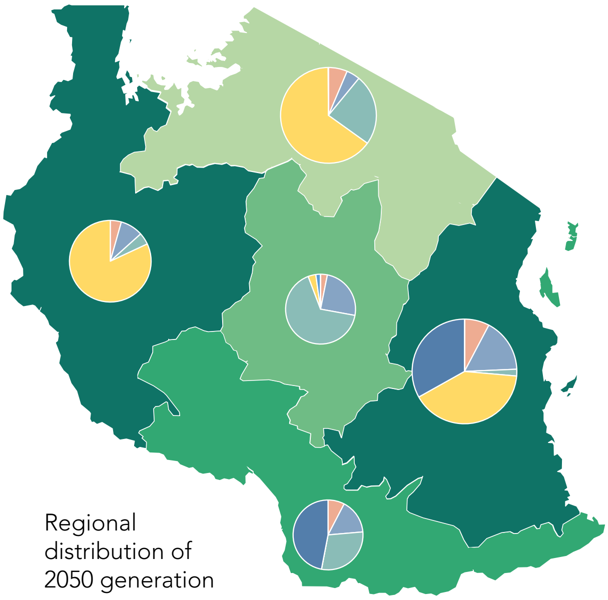
34 GW
Solar PV

8 GW
On-shore Wind

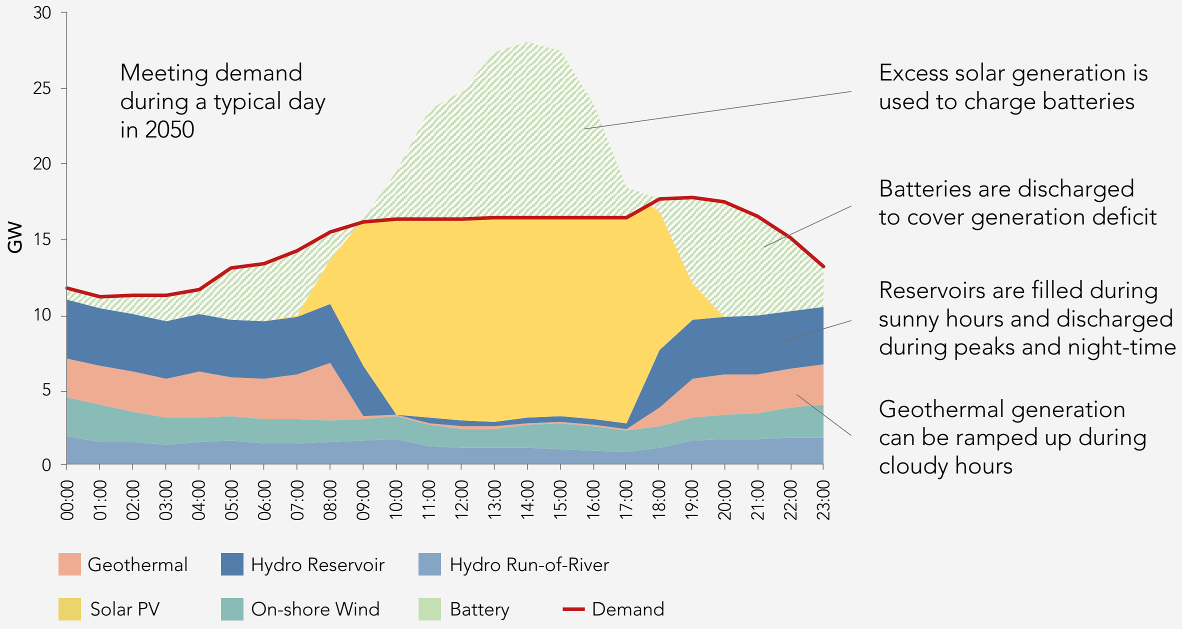
7 GW
Hydro

5 GW
Geothermal

9 GW
Battery



Regional distribution of 2050 generation



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AFD	Agence Française de Développement
AfDB	African Development Bank
CAPEX	Capital Expenditure
CETT	Clean Energy Transition in Tanzania
EU	European Union
EWURA	Energy and Water Utilities Regulatory Authority
IPP	Independent Power Producer
GoT	Government of Tanzania
IRENA	International Renewable Energy Agency
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
MoE	Ministry of Energy
$MtCO_2e$	Mega Tonnes of CO_2 equivalent
O&M	Operations and maintenance
OPEX	Operational Expenditure
PPA	Power Purchase Agreement
PUE	Productive use of Electricity
PV	Photo Voltaic
REA	Rural Energy Agency
REMP	Rural Energy Master Plan
SE4All	Sustainable Energy for All
PSMP	Power System Master Plan
T&D	Transmission and Distribution
TANESCO	Tanzania Electricity Supply Corporation
TREEP	Tanzania Rural Electrification Expansion Programme
TSO	Transmission System Operator
UN	United Nations

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Introduction

Over the next decades Tanzania faces two fundamental energy challenges:

1. Achieving universal access to affordable, reliable, sustainable, and modern energy services by 2030, as set out in the United Nation´s Sustainable Development Goal 7; and

2. Increasing the supply of electricity to fuel economic growth and improve livelihoods while avoiding a lock-in to polluting fossil fuels.

Fortunately, a mix of modern mini- and off-grid solutions have emerged to supplement grid expansion, as have technical and commercial solutions required to leapfrog fossil fuel technologies and build a robust and sustainable power system based on renewable energy. Important co-benefits of a successful clean energy transition will include job creation and improved energy security in line with the African Union´s Agenda 2063.

Taking the Renewable Energy Transition Africa report (KfW, GIZ, IRENA, 2021) as a point of departure, this report zooms in on Tanzania to outline a pathway for the Government and development partners to a clean energy transition in the country by 2050.

More specifically, the insights derived from interviews with a broad set of stakeholders (see Annex A), review of key sector documents, and a built-for-purpose least-cost expansion model are applied to:

1. Explore existing structural barriers to a renewable energy transition;

2. Estimate its related costs and emissions relative to existing sector expansion plans; and

3. Identify enablers that need to be put in place for the transition to become a reality.

It is noted that the report focuses exclusively on the power sector and does not cover other energy-related topics such as clean cooking and upstream petroleum.

The Clean Energy Transition in Tanzania report is prepared by Multiconsult for the Royal Norwegian Embassy in Dar es Salaam. Multiconsult is responsible for all analyses and recommendations.

2 Access and emissions today

Key messages

- Tanzania is well behind schedule to meet its goal of 75 percent connectivity to electricity by 2025.
- The 2018 per-capita emissions from power generation in Tanzania were around one tenth of the average in Africa, and one hundredth of the average for the developed OECD countries.
- A clean development path towards 2050 for the power sector in Tanzania is about avoiding a fossil lock-in as demand increases.

Tanzania was ranked 80th out of the 115 countries scored in the 2021 Energy Transition Index, which benchmarks readiness for the transition to a secure, sustainable, affordable, and reliable energy future (World Economic Forum, 2021). This was up from 92nd place in the 2020 edition, mainly because of improved scores for energy access and security. Even so, the power system in Tanzania mainland faces considerable challenges. This chapter gives a brief overview of the current situation with regards to the two key topics of the report: Connectivity and emissions.

2.1 Energy connectivity

According to data from the United Nations (UN, 2020), the share of Tanzanians households with electricity connectivity increased from 24 percent in 2014 to 38 percent in 2019.

Over the same period the share of connected households in rural areas nearly doubled from 10 to 19 percentage points, in large part due to implementation of the Comprehensive Rural Electricity Plan funded by the Government of Tanzania (GoT) and their development partners.

Even so, Tanzania is well behind schedule to meet its Sustainable Energy for All (SE4All) goal of 75 percent connectivity to electricity by 2025. An electrification rate of 38 percent means that there are still 37 million Tanzanians left to rely on costly and unhealthy alternatives such as kerosene for lighting.

Following years of sustained progress on extending the national grid, it is expected that the ongoing electrification projects will connect the remaining unelectrified villages in Tanzania. Following this, the next ambition of the Government and REA is to electrify all 37,610 unelectrified hamlets by 2030.

Share of population with connection

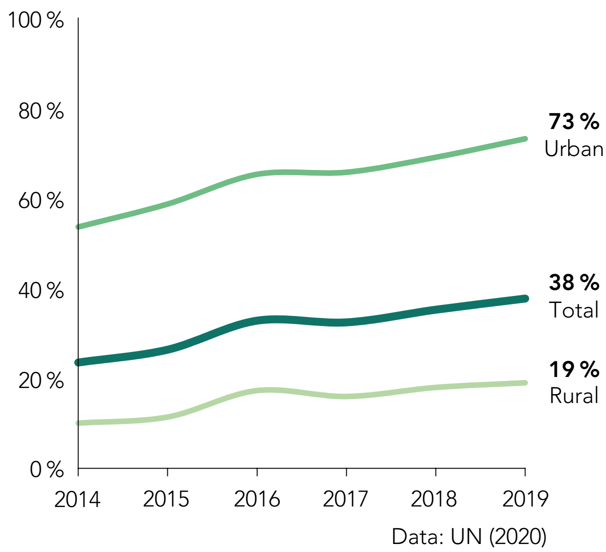


Figure 2-1 – Share of population with connection to electricity

2.2 Emissions

Per capita emissions from fuel combustion in the Tanzania power sector were reduced from 0.047 ton to 0.043 ton per capita between 2014 and 2018. In 2018 the emissions were around one tenth of the average in Africa, and one hundredth of the average for the developed OECD countries (see Figure 2-2).

Total CO_2-emissions from the Tanzanian power sector were also reduced slightly from 2.4 million ton in 2014, to 2.3 million ton in 2018. Over the same period the installed generation capacity increased by 23 percent from around 1,300 MW to approximately 1,600 MW (MoE, 2020a). Tanzania was able to increase its installed fossil fuel generation capacity while reducing emissions because new natural gas capacity largely replaced more costly and polluting fossil fuels such as heavy fuel oil. In fact, natural gas made up approximately 57 percent of the installed capacity in 2019, while hydropower accounted for around 36 percent.

Finally, it is interesting to note that electricity generation only accounts for 22 percent of fossil fuel emissions in Tanzania, while more than half stem from the transport sector (IEA, 2020). Decarbonisation of road transport will further increase electricity demand, underlining the critical role of renewable electricity in a low-emissions future.

This implies that a clean development path for the power sector in Tanzania is less about cutting existing emissions, and more about meeting expected demand growth without locking the country into a high-emissions pathway. The implications of this are explored in the next chapter.

Tons CO2 per capita in 2018

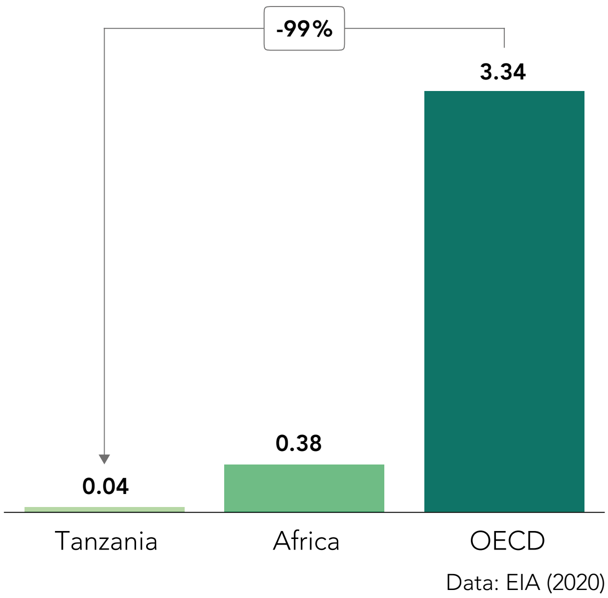
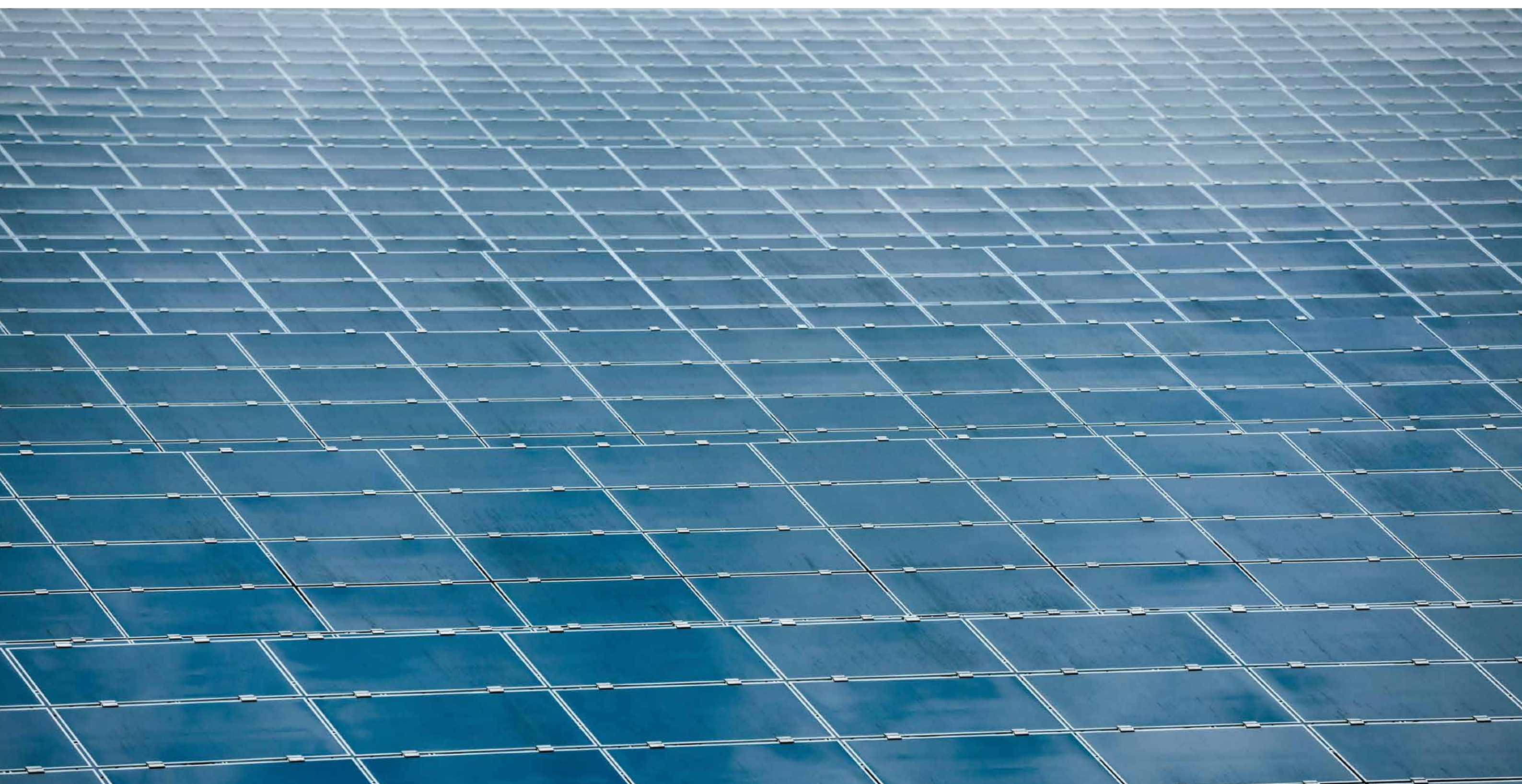


Figure 2-2 – CO_2-emissions per capita from the power sector in Tanzania, Africa average and OECD average



3 The clean energy transition scenario

Key messages

- Universal electricity connectivity by 2030 is possible, provided that modern off- and mini-grid solutions are leveraged, and appropriate access subsidies given.
- Tanzania has excellent renewable energy resources, and can fuel its growing demand with solar PV, hydropower, on-shore wind, geothermal, and battery storage.
- A clean energy transition will have a cumulative cost of more than USD 100 billion until 2050, about the same as the cost of implementing the existing Power System Master Plan.

To explore the costs and benefits of a clean energy transition in Tanzania, a least-cost expansion model (see box on the right) has been tailor made to simulate costs and related emissions of two scenarios for development of the Tanzanian power systems towards 2050:

1 A Power System Masterplan (PSMP) Scenario which adopts the existing plans for sector expansion and the forecasted demand growth as captured in the 2020-update of the PSMP (MoE, 2020b). The PSMP 2020 planning horizon is 2044, and generation expansion from 2044 to 2050 is modelled based on a least-cost generation expansion approach.

2 A Clean Energy Transition Tanzania (CETT) Scenario in which the PSMP 2020 load forecast is adjusted to account for expedited electrification to realise universal connectivity in 2030, and where demand is met by least-cost renewable generation and storage options, in addition to the already installed capacity.

The modelled generation and access expansion, including related costs and emissions of each scenario, serve as a basis for the discussion around what is required for Tanzania to execute a successful clean energy transition.

Economic least-cost expansion modelling

- Optimisation using PyPSA. PyPSA is an open-source toolbox for simulating and optimising modern power systems (Brown et al, 2017). In this study, it is used to model economic least-cost expansion and dispatching for the two scenarios. A wide range of technology and geographic specific data and assumptions pertaining, for example, to costs, production, resources (water, solar and wind), fuels, and distances are made to determine the investments required in order to meet demand hour-by-hour in each of six defined zones of Tanzania by 2030 and 2050. The optimisation accounts for region-specific daily demand profiles and solar and wind resource profiles.
- Interpreting optimisation results. Whereas the results of the PSMP-scenario largely reflect the impacts of operationalising the PSMP 2020, the CETT Scenario is optimised by the set of investments that minimise total system costs (including capital, fuel, and operations and maintenance) for Tanzania mainland under the given constraints.

- Limitations of the study. It is important to understand that there is significant uncertainty related to the applied inputs and assumptions, including future demand, technological developments, and cost of different technologies. Therefore, neither scenario predicts what will happen in the future. Further, whereas the model does consider power transmission between zones it does not include a detailed grid topology. Therefore, no power flow calculations have been made. Nor are the impacts of climate change on the availability of hydropower modelled in the study. These issues would have to be addressed through more detailed studies.

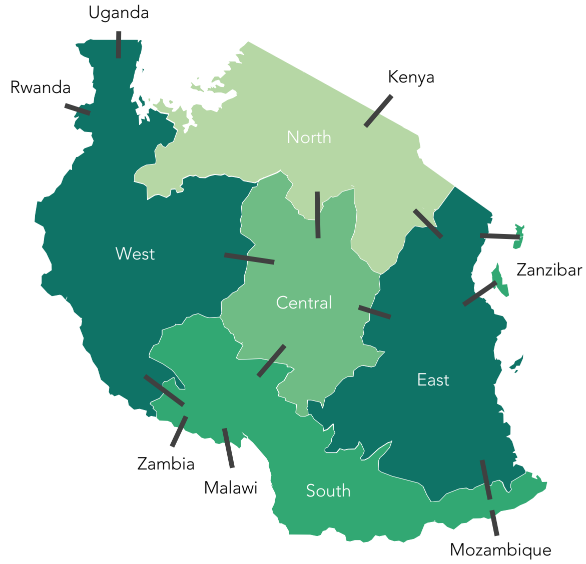


Figure 3-1 – Presentation of the six modelled zones, and their interconnectors

3.1 A clean power system by 2050

This section presents the key assumptions underpinning the tailor-made expansion model, as well as key results for each scenario (PSMP and CETT) in 2030 and 2050, including access and generation expansion, costs, and related emissions.

3.1.1 Geographical structure

For the purpose of the modelling, demand, generation, storage, and transmission of electricity in the 31 regions constituting Tanzania, are allocated to six zones, including Zanzibar (see Figure 3-1).

Transmission lines between zones with a capacity above 220 kV are considered by the model. While detailed modelling for neighbouring countries is not conducted, the model includes transmission interconnectors to Kenya, Malawi, Mozambique, Rwanda, Uganda, and Zambia to allow for imports and exports as forecasted in the PSMP 2020.

3.1.2 Electricity demand

Both generation expansion scenarios build on the regional year-by-year demand for electricity found in the PSMP 2020 which includes demand from access expansion, economic growth, and extraordinary industrial loads[1]. In the CETT scenario, 2030-demand is adjusted upwards to reflect the expedited access expansion required to achieve universal connectivity by 2030 (section 3.2.4). Load profiles for each zone were determined based on GIS data[2].

Figure 3-2 illustrates the net demand (excluding losses) in 2020, 2030, and 2050 broken down by the six zones. Considering the expected access expansion, along with increased electrification of other sectors, including transport, the steep demand growth is hardly surprising.

Applying the technical loss-rates assumed in the PSMP 2020, the total distribution losses are estimated to be 2.2 TWh in 2030 and 11.1 TWh in 2050. The fact that 2050 losses are forecasted to be greater than the total system demand in 2020 underlines the proportions of the forecasted demand increase. A proportional enlargement of Tanzania´s generation and transmission infrastructure will be required to satisfy this increasing demand, but power system expansion will look very different in the two scenarios, as explored over the next sections.

[1] For the period not covered by the PSMP 2020 (2044 to 2050), a moderate demand growth of three percent p.a. is assumed.
[2] Applying the GlobalEnergyGIS tool (Mattsson et al., 2021)

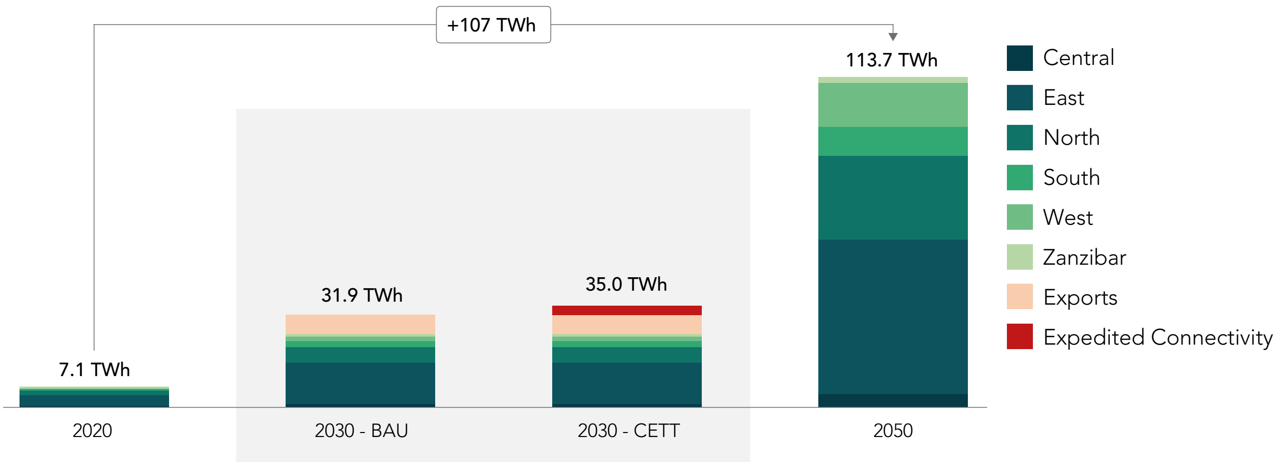


Figure 3-2 – Estimated annual consumption by region excluding transmission and distribution (T&D) losses

3.1.3 Generation expansion

The figure below presents the installed capacity required to meet demand in the PSMP and CETT scenarios respectively in 2030 and 2050. It is interesting to note for 2030 that Tanzania has sufficient flexibility from existing stored hydro and natural gas to absorb significant amounts of variable wind and solar photo voltaic (PV) generation even without investments in battery storage.

The fact that the low-carbon scenario requires three times the installed capacity of the PSMP scenario in 2050 is explained by the lower capacity factor of variable renewables, the phasing out of natural gas at the end of the economic life of existing power plants, and the increased need for balancing resulting from the variability of wind and solar. However, on-shore wind and solar PV are also considerably cheaper per MW than its fossil alternatives so the total costs of the CETT scenario up until 2050 still equals that of the PSMP scenario, even after investing in 8.5 GW of battery storage (see section 3.3).

It is notable that geothermal generation capacity outstrips stored hydro by 2050 in the CETT scenario, highlighting the significant potential for such generation in Tanzania.

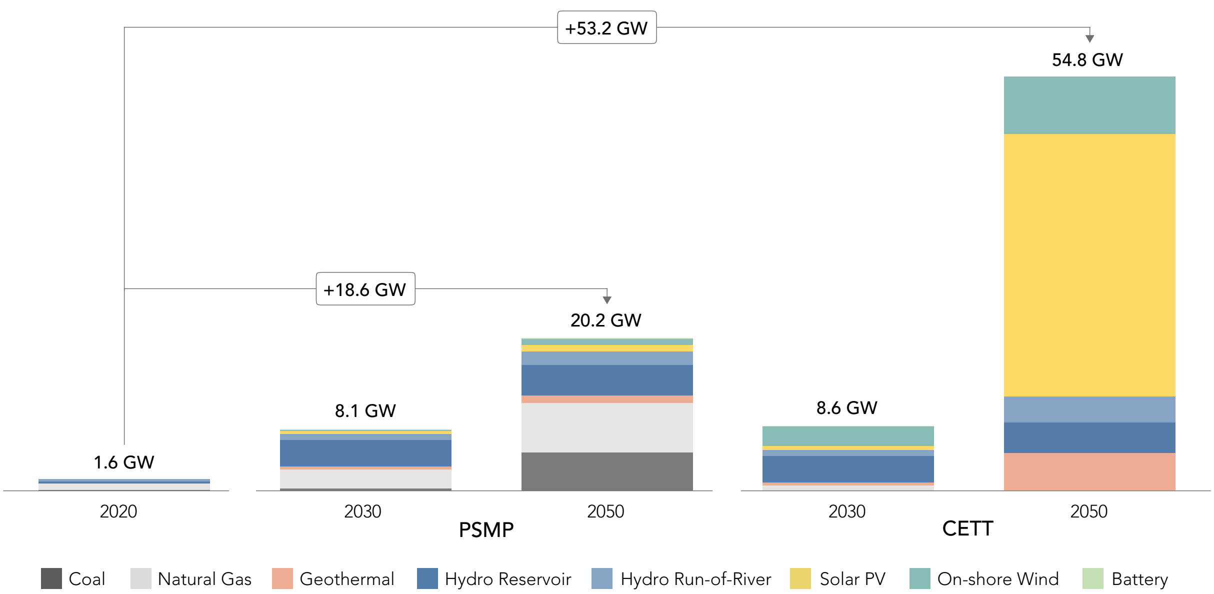


Figure 3-3 – Comparison of installed capacity for PSMP and CETT scenario

Figure 3-4 presents the annual generation in 2050 for each of the two scenarios. It is noteworthy that even with Tanzania´s excellent wind and hydro resources, solar PV still accounts for nearly half of the total generation in the CETT scenario, highlighting its position as the least-cost alternative for the African continent.

The availability of spinning reserves[3] to balance rapid changes in wind and solar generation output is an important concern, not least in an African setting (ESREM, 2021a). This issue is further explored in the following figures, which visualise how the different installed capacities interact to meet demand hour-by-hour through the day in the two scenarios. It is encouraging to note that the CETT scenario has ample spinning reserves available during the whole day even in 2050 because of the batteries and the significant amount of stored hydropower and geothermal capacity available. Clearly, these issues need to be considered on an on-going basis through load-flow modelling as the system expands.

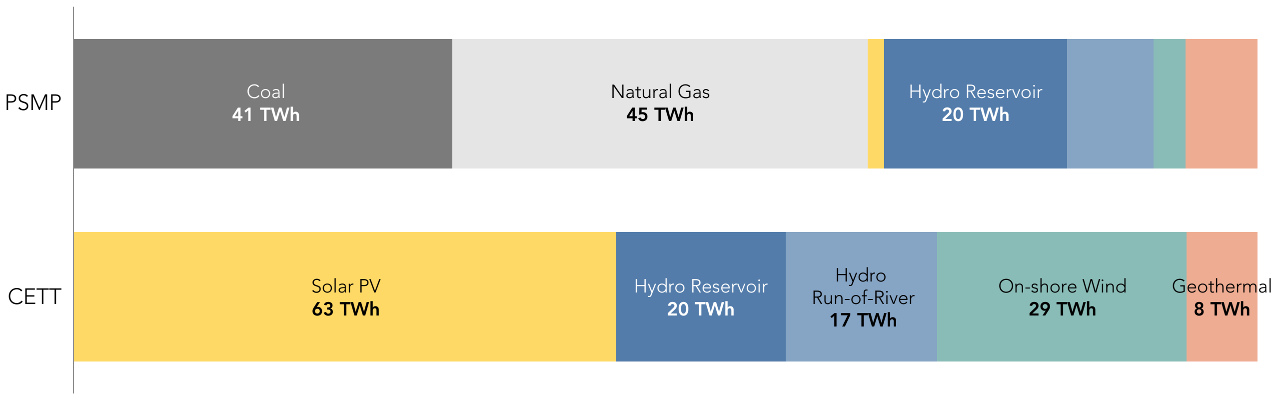


Figure 3-4 – Comparison of annual generation in 2050 between PSMP and CETT scenarios

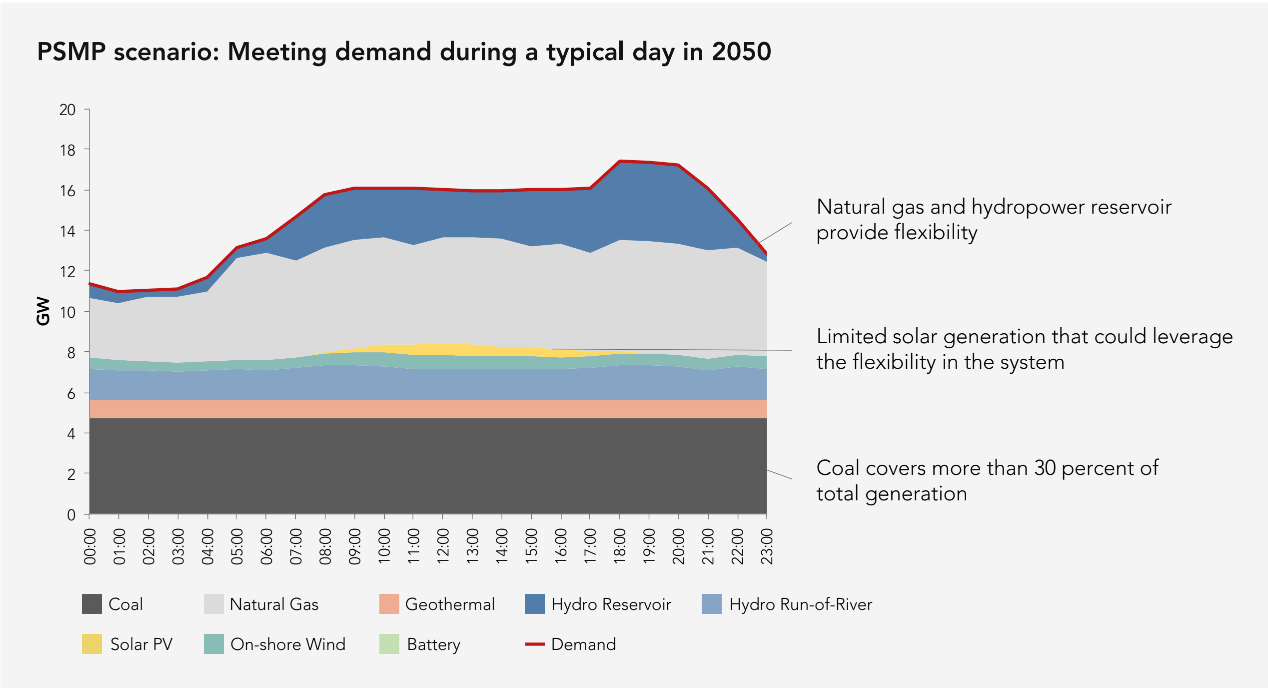


Figure 3-5 – Hour-by-hour generation profile for the PSMP scenario in 2050

[3] Spinning reserves are the extra generating capacity that can be made available by increasing the power output of generators that already are connected to the power system.

CETT scenario: Meeting demand during a typical day in 2050

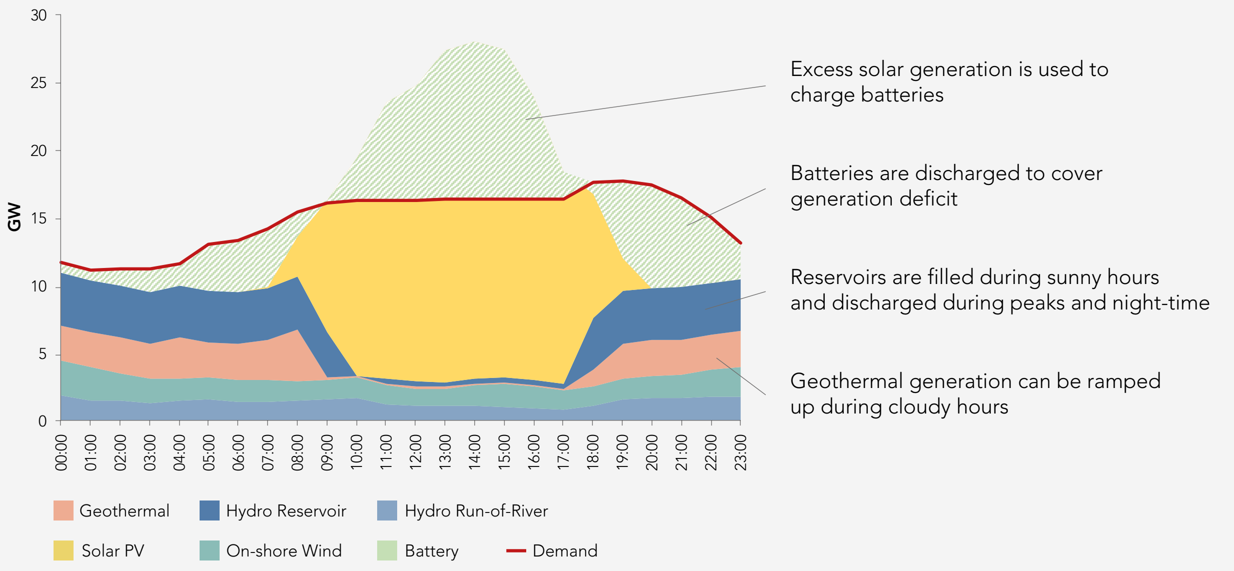


Figure 3-6 – Hour-by-hour generation profile for the CETT scenario in 2050

Finally, Figure 3-7 explores the geographical distribution of generation expansion under the two scenarios in 2050. Notably, while the renewable energy generation capacity installed in the CETT scenario is distributed across the whole country to meet local demand, the PSMP scenario maintains the more centralised generation structure that currently prevails. In addition to the distributed nature of renewable resources relative to fossil fuels such as natural gas, this is also explained by the minimum size of power plants. While natural gas and coal requires power plants of a certain size, variable renewables are easily scaled to demand.

Geographical distribution of generation in 2050

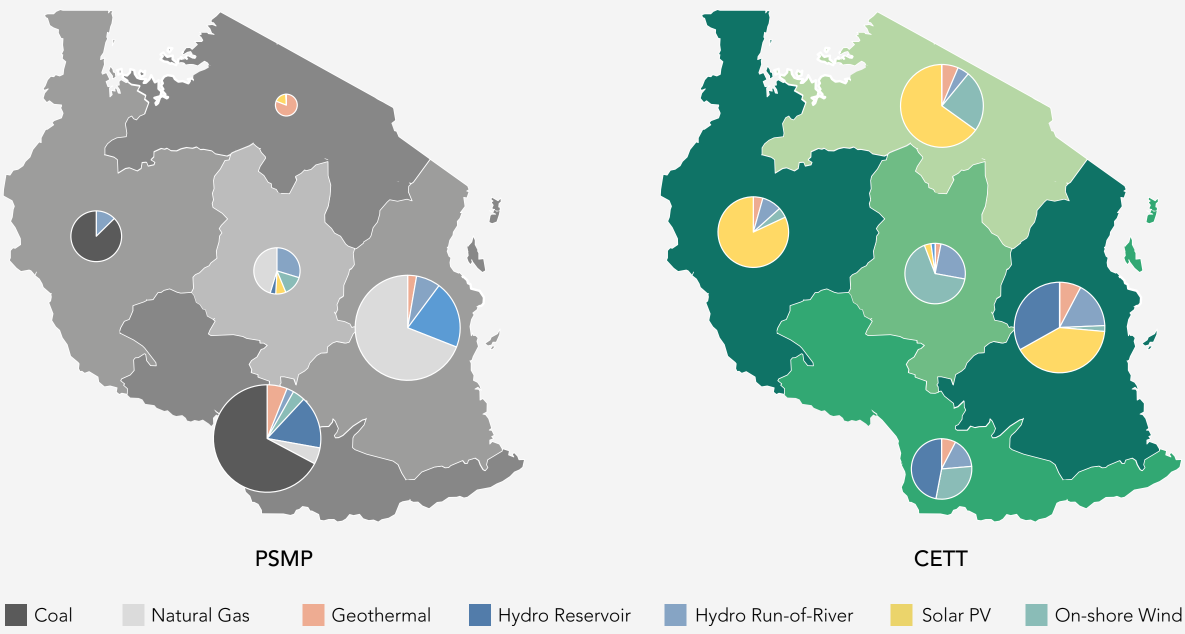


Figure 3-7 – Geographical distribution of generation

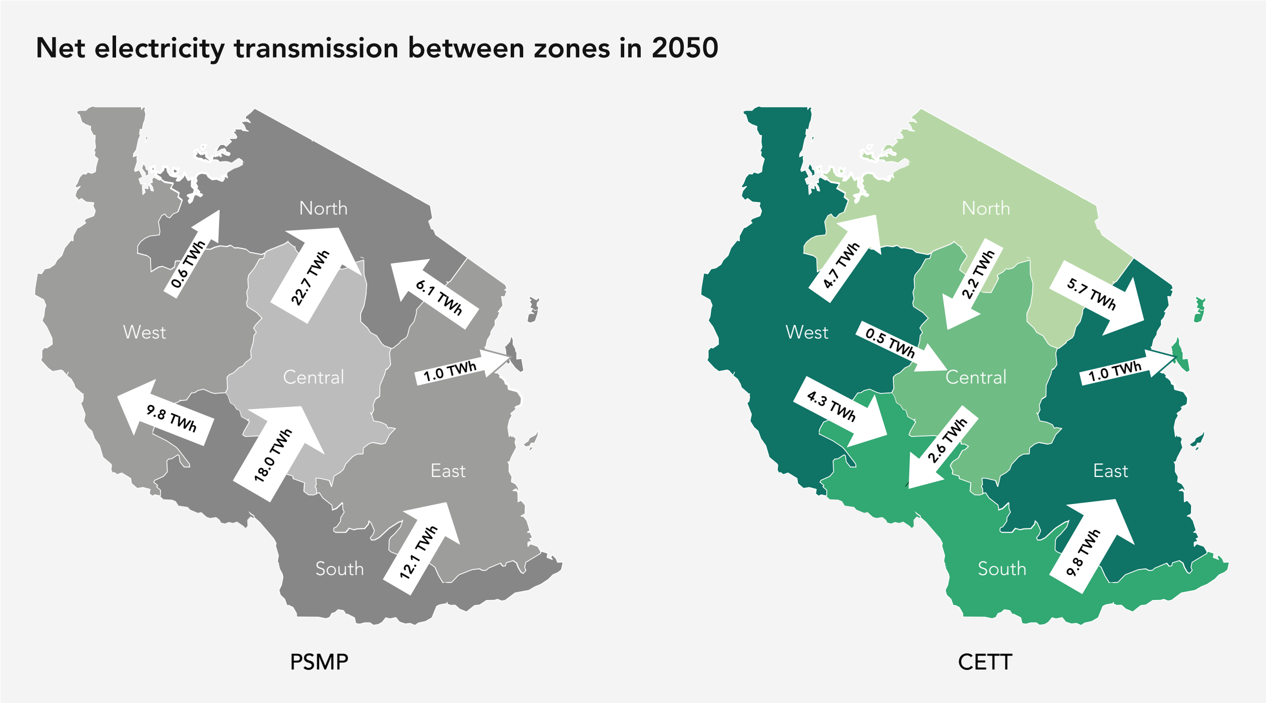


Figure 3-8 – Net electricity transmission between zones

3.1.4 Transmission and distribution

Given their different geographical and technological characteristics it is not surprising that the two scenarios utilise the transmission capacity between zones very differently. Specifically, the more distributed structure of generation in the CETT scenario results in lower annual net exchange of electricity between zones than the PSMP scenario for 2050. This is particularly pronounced in the northern zone, where more than 27 TWh of net annual imports in the PSMP scenario is turned to net export in the CETT scenario.

However, the increased volatility of generation introduced by solar PV and wind means that there is a greater utilisation of the transmission capacity in the CETT scenario to balance regional fluctuation throughout the day.

3.1.5 Emissions

While the PSMP scenario contains considerable investments in coal and natural gas, the CETT scenario is modelled for zero emissions in 2050. The two scenarios therefore result in very different emissions pathways for Tanzania, as detailed in Figure 3-9.

Notably, Tanzania´s national goals for addressing climate change through Nationally Determined Contributions under the Paris Agreement emphasise the importance of low-carbon growth through increased generation of renewable energy.

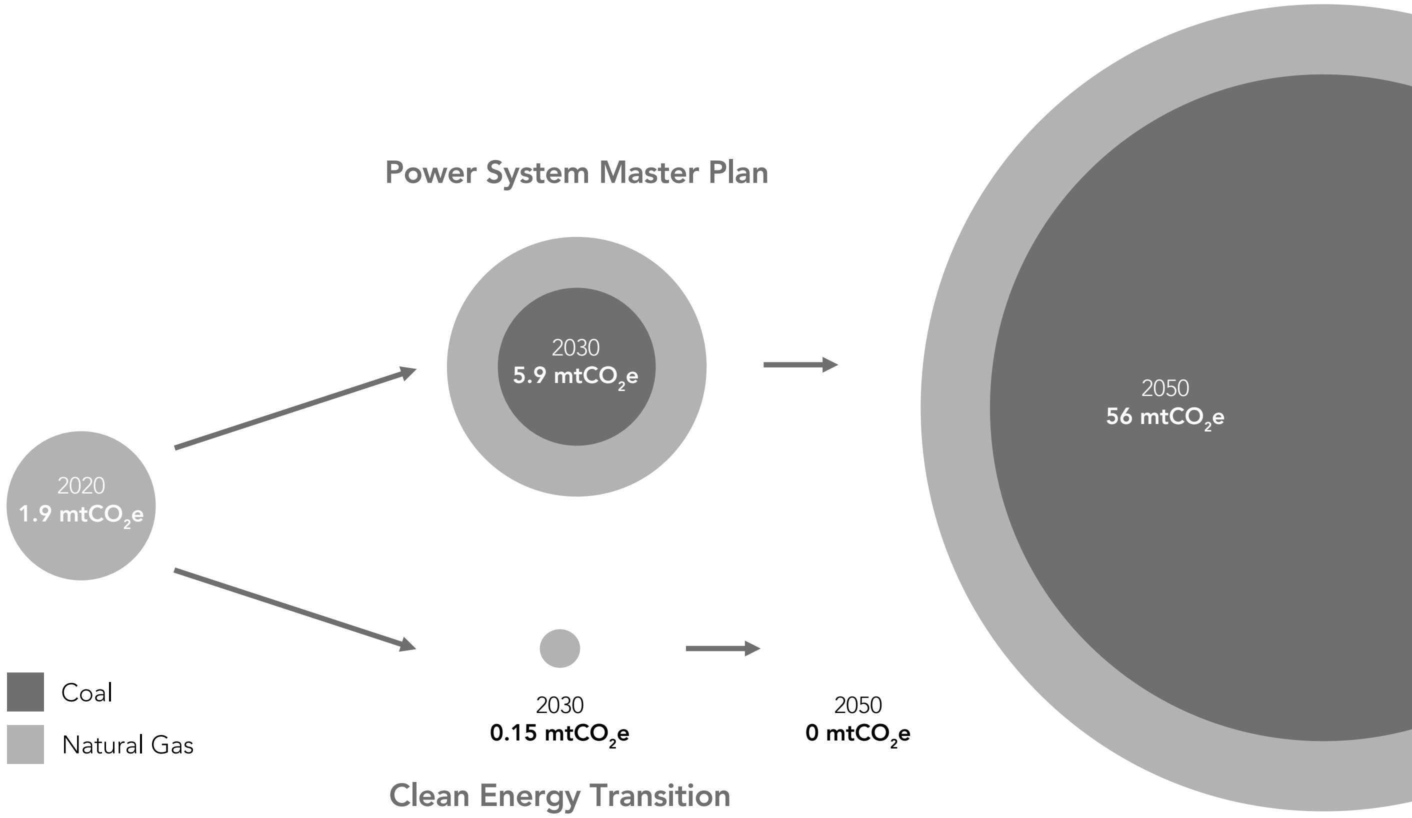


Figure 3-9 – Annual CO_2 emissions from 2020, 2030 and 2050 electricity generation

3.2 Universal connectivity by 2030

As outlined in section 2.1, Tanzania is well behind schedule to meet its goal of 75 percent connectivity to electricity by 2025[4]. The situation is particularly severe in rural areas, where only 19 percent of the population were connected in 2019, and 37,610 hamlets remain without access to electricity (REA, 2022).

The forthcoming Rural Energy Master Plan (REMP) will provide a comprehensive plan for meeting Tanzania´s rural electrification objectives, including cost estimates. Therefore, the following assessments of the resources required to achieve universal connectivity by 2030 are simplified.

The section is organised according to the following three generic groups of unserved households:

1. Households living within reach of the grid that have not yet connected
2. Village and hamlets planned for electrification
3. Scattered households

3.2.1 Households living within reach of the grid that have not yet connected

Given the total 2019 connectivity rate of 38 percent, it is estimated that 8.8 million additional households in areas covered by the existing grid would need to be connected to electricity in their homes for universal connectivity to become a reality by 2030. This is considerably more than is included in the PSMP 2020, which only assumes that universal connectivity will be achieved after 2044.

The share of the costs to be covered by households will depend on the level of subsidies provided. Because the high upfront cost of connection is a barrier for many households, subsidies to lower connection charges are regarded by many as one of the most cost-effective ways to increase electricity access in Tanzania and across the Continent (ESREM, 2021b).

[4] Tanzania´s official goal under the UN Sustainable Energy for All initiative.

3.2.2 Unelectrified villages included in existing plans for rural grid extensions

Tanzania is in the middle of an unprecedented access-expansion, targeting a combined 5,092 villages and 37,610 hamlets. This consolidated push is made through a broad spectrum of different projects with a combined preliminary investment cost of approximately USD 5.4 billion (IED, 2020 and REA, 2022). Also, the investment costs included in the projects generally exclude service line connections and estimates of these costs are therefore added to arrive at a total investment requirement.

In addition to the increased loads, the rural distribution grid emerging from these projects, including medium voltage lines that nearly would reach three times around the equator, will create a significant operational and maintenance challenge for the utility. This is further explored in chapter 4.

While the REMP will make informed recommendations as to how and when these villages can be best electrified, it seems clear that the increasing marginal costs of electrification, along with the strain already imposed on the main grid from increasing rural loads points to mini- and off-grid solutions, will have to be leveraged to achieve universal connectivity by 2030. At a conservatively assumed cost per connection of USD 1,000, including grid and generation investments, mini-grids will be the least-cost option for many rural settlements in Tanzania.

3.2.3 Scattered households

Satellite image analyses conducted for the REMP (IED, 2020) indicate that 30 percent of rural households in Tanzania live too far from the village or hamlet centre to be viable for grid electricity in the near future. In order to meet the SE4All objective of universal access to electricity by 2030 many of these households will have to be electrified by means of affordable and high-quality stand-alone solutions such as solar home-systems.

3.3 Costs and implications of the clean energy transition

The past sections have demonstrated that a sustainable path is available for the Tanzanian power system. One which leads to universal access by 2030 and zero emissions by 2050, all while powering the economic growth required to improve livelihoods across the whole country and bolstering Tanzania´s position as a middle-income country.

A rough estimate indicates clean energy transition will have a cumulative cost for investments, operation and maintenance of the generation, transmission and distribution infrastructure of USD 100 billion until 2050, more than half of which will go to capital investment (CAPEX) in generation infrastructure. This includes the cost of realising universal connectivity, as included in the PSMP 2020. Clearly, Tanzania´s taxpayers and electricity consumers will not be able to finance these investments alone, and a joint effort between the GoT, the international community, and the private sector is required. How this could be operationalised in practice is a key topic of the next chapter.

However, both the Government and their development partners should take note that the fossil fuel dominated development path laid out in the PSMP 2020 is equally expensive, primarily driven by the significant operational expenditure (OPEX) of fossil fuelled power plants. Also, most governments including China have stopped financing coal fired power plants in developing countries. Therefore, the de facto choice facing decision makers is not one between low emissions and development, but rather one between a clean energy transition and stagnation.

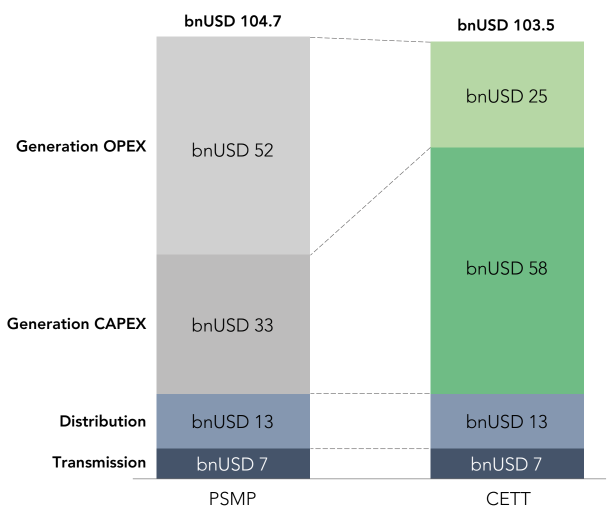


Figure 3-10 – Cumulative cost of sector expansion 2020 – 2050

4 A roadmap to the clean energy transition

Key messages

- Unless a number of barriers are addressed, there is a clear risk that planned investments in fossil fuels will lock Tanzania into a high-emissions development pathway.
- Enabling the clean energy transition requires a consolidated push from the GoT, the private sector, and development partners.
- The positive impacts of the transition will only be realised if an inclusive approach is applied – one that maximises the socioeconomic benefits of electricity.

This chapter looks at how Tanzania can grasp the unique opportunity outlined in chapter 3 to provide its population with sufficient and reliable electricity at affordable prices while keeping CO_2-emissions low. That is: to identify the enablers that need to be put in place for a clean energy transition in Tanzania, and how the benefits of a sustainable energy future can be shared equitably.

4.1 Enablers of the clean energy transition in Tanzania

IRENA, KfW, and GIZ (2021) outline seven key enablers for the renewable energy transition in Africa and its two fundamental energy challenges of universal access and low-carbon growth. These are presented below, along with the key barriers that they are meant to address.

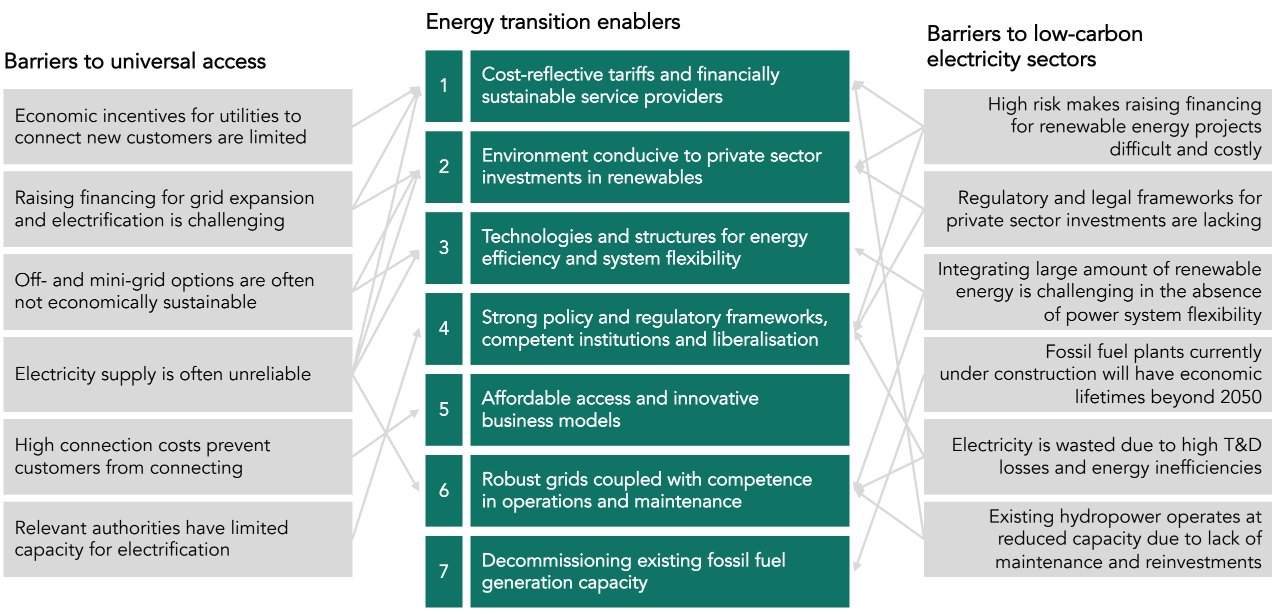


Figure 4-1 – Key barriers to, and enablers of the renewable energy transition in Africa

This section analyses each of these enablers in a Tanzanian context and identifies key initiatives that should be considered based on: i) Stakeholder interviews (see Annex A), ii) review of key sector documents including the 2015 Energy Policy and the 2020 Joint Energy Sector Review (Norconsult, 2020), and iii) the modelling presented in chapter 3.

4.1.1 Cost-reflective tariffs and financially sustainable service providers

Electricity tariffs in most African countries are below cost-reflective levels, meaning that they are lower than the actual cost of generating, transporting, and distributing electricity to consumers. This results in several adverse effects, including:

- A lack of incentives and financing for connecting new consumers. When utilities lose money with every kWh sold, they have limited financial incentive to connect new consumers, particularly poorer households who typically have lower demand.
- Underinvestment in generation and the grid. Underfunded service providers do not generate the revenue that is required to invest in maintaining and strengthening their network.
- High off-taker risk. When there are concerns about the utility´s ability to pay for the electricity it becomes difficult and expensive for Independent Power Producers (IPPs) to raise the required debt and equity.

Tanzania Electricity Supply Corporation (TANESCO) plays the key role in efforts to increase connectivity and improve quality of supply for Tanzanian electricity consumers. However, the utility´s operational sustainability is in question under the current arrangements for funding and financing (Norconsult, 2020). Critically, Tanzanian on-grid retail tariffs are not cost-reflective, a fact that requires urgent action to put the sector on a path to sustainability and enable the utility to support a clean energy transition. TANESCO does not receive direct subsidies from the Government, and the utility´s financial problems are further exacerbated by the large amount of loss-making rural consumers and costly-to-maintain infrastructure that the utility takes over from REA each year. Like many of its peers in the region, TANESCO also has significant room for operational efficiency gains, including through adoption of digital tools.

Beyond the grid, the relatively few privately operated mini-grids that exist in Tanzania have recently not been allowed to charge tariffs that reflect their fair costs and reasonable profits as approved by the Energy and Water Utilities Regulatory Authority (EWURA). In addition to harming the existing operators, this policy has impeded the private sector´s willingness to invest in the important space beyond the grid. Fortunately, the tariff directive driving this state of affairs has recently been retracted, an important step towards a situation where off- and mini-grid space are able to recover their reasonable costs and fair profits.

Strengths	Weakness
• Tanzania has retired more than 200 MW of costly emergency power plants • TANESCO financials have improved over the past years (but remain troublesome)	• Retail tariffs are not cost-reflective • TANESCO lack resources for maintenance of the growing rural distribution grid
Opportunities	**Threats**
• 21% of the rural population would be most economically connected by mini-grids (prospectus) • Scope for efficiency improvements in TANESCO	• Political interference in tariff setting • Large share of new rural customers pay (subsidised) lifeline tariff

Figure 4-2 – SWOT analysis related to cost-reflective tariffs and financially sustainable service providers

4.1.2 Environment conducive to private sector investments in renewables

Clearly, the approximately 50 GW of renewable energy and battery storage required to meet demand in 2050 under the CETT scenario is far beyond what the GoT and its development partners can finance. This gap can only be bridged by private investments and lending, as well as by private-public partnerships. Despite the drastic fall in costs, renewable energy developers in Africa are still facing structural barriers that stem from the significant upfront capital requirements with payback over 20 to 25 years.

Even though its underlying frameworks for private investments in mini-grids and small power plants generally are regarded as sound, Tanzania is falling behind its neighbouring countries when it comes to private investments in the power sector. The 2020 Joint Energy Sector Review recommends the following measures: "(i) ensure the pricing structure provides incentives for promoting investments" and; "(ii) ensuring prudent procurement of energy projects through competitive bidding processes".

Critically, the long-term nature of renewable energy investments means that developers and funders require stability and predictability. In practice, the respective roles of the MoE, EWURA, and TANESCO must be clearly defined and respected.

For Tanzania to be able to attract private generation capacity at prices that are favourable to the consumer it is recommended that the Government adopts and adapts regional best procurement practices. Several neighbouring countries have run successful auctions for solar PV capacity, and achieved very beneficial prices (ESREM, 2021c). A particular benefit of auctions is that they allow the power purchase agreement (PPA) and other key documents to be baked into the tender and accepted upfront by developers that bid, thereby minimising, or even eliminating the scope for direct negotiations. Irrespective of the preferred procurement method it is important that the Government is supported by competent advisors with experience from similar procurement in the region, to ensure that best practices are leveraged to reduce prices.

To increase generation from run-of-river hydro and other small and site-specific generation sources it is further recommended that the Renewable Feed-in tariff framework for small power producers is revisited to ensure a sound process for unsolicited proposals. As for auctions, it is important for the transparency of such procurements that the PPA and other key documents are not made subject to direct negotiations.

Strengths	Weakness
• Apt regulatory framework for off-grid, mini-grid and small power producers • TANESCO procurement of wind and solar PV IPPs is progressing	• Considerable off-taker risk due to TANESCO financial situation • Lack of incentives for promoting investments in the energy sector • Limited experience with IPP procurement
Opportunities	**Threats**
• Falling costs of variable renewable energy • Tanzania has among the best renewable energy resources in the world • Leverage modern least-cost procurement methods for IPPs	• Lack of regulatory independence

Figure 4-3 – SWOT analysis of the enabling environment for private sector investments in renewables

4.1.3 Technologies and structures for energy efficiency and system flexibility

The variability of certain renewable energy sources, such as wind and solar PV may increase the complexity of operating an electricity system and poses technical and economic challenges for their utilisation in power generation. Over the past decades these challenges have been met with a broad spectrum of innovative solutions in different countries and regions (ESREM, 2021a), demonstrating that a high share of renewables is possible within well-functioning power systems.

Over the past decade the Tanzanian power system has evolved from one driven by large hydro, to one dominated by natural gas. Natural gas is a fossil fuel, but one with the benefit of being highly flexible. Generation from a natural gas power plant can be ramped quickly up or down in response to the changing needs of the power system. In the context of variable renewables this is valuable because power generated from stored hydro and natural gas can be used to balance production from low-cost solar PV and wind when the sun does not shine, or the wind does not blow. As the price of storage solutions keeps falling, these are also emerging as a competitive source of emissions free flexibility.

In fact, the modelling for the CETT scenario presented in chapter 3 reveals that Tanzania has spinning reserves available to handle significant amounts of solar and wind. It is, however, important to underline that no load-flow modelling has been made to explore these findings in greater detail. It is therefore critical that due regard is given to the need for balancing reserves throughout the system as the share of variable renewable energy increases.

Regional integration is another possible source of flexibility. Tanzania is in the privileged situation of being a member of both the East- and Southern African power pools, and once the interconnectors with Kenya and Zambia are commissioned, this aspect will be even more important in the analysis of energy resources and generation mix.

Finally, it is noted that several initiatives are under way to operationalise the framework for energy efficiency, including the 20-year Tanzania Energy Efficiency Strategy to be developed with EU funding (EU, 2020). Currently the Ministry of Energy is in the process of preparing Strategy and Action Plan for Energy Efficiency.

Strengths

- Around 93 percent of the existing generation capacity is natural gas and stored hydropower, which gives a lot of flexibility for scaling up variable renewable energy generation

Weakness

- Energy efficiency framework not fully operationalized

Opportunities

- Increased integration with SAPP and EAPP
- Falling prices for new clean technologies that provide flexibility, such as batteries

Threats

Figure 4-4 – SWOT analysis related technologies and structures for energy efficiency and system flexibility

4.1.4 Strong policy and regulatory frameworks, competent institutions, and liberalisation

A third National Energy Policy for Tanzania was published in 2015, aiming to i) improve the business environment to attract more private investments and local participation in the energy sector, ii) promote energy conservation and efficiency; and iii) increase access to modern energy services and the share of renewables in electricity generation mix to enhance availability, reliability, and security of supply (GoT, 2015).

However, the 2020 Joint Energy Sector Review still found that "There is limited capacity for rolling out and enforcing legal and regulatory provisions, for example establishing a clear mechanism for enforcement of the legal framework (including penalties); building capacity for the enforcement of the legal and regulatory provisions; and ensuring local standards of energy sector activities" (Norconsult, 2020).

A first priority in addressing this situation would be to institutionalise a holistic approach to least-cost planning and implementation of generation expansion fit for the clean energy transition. While expansion planning historically has fallen within the purview of TANESCO as the de-facto monopolist with oversight from EWURA, an increasing share of privately owned generation will change this equation. Going forward it may therefore be more natural for the MoE to be responsible for expansion planning and allocating new projects to TANESCO and the private sector respectively based on priorities set out in an Integrated Resource Plan fit for the clean energy transition.

Such a move could be a first step towards revitalisation of the ESI Reform Strategy and Roadmap (2014-2025), and liberalisation of electricity sectors by functional unbundling of TANESCO into a generation company, a Transmission System Operator, and one or more distribution companies. The ultimate objective of unbundling is to facilitate increased private sector participation in electricity markets, while improving efficiency and reducing costs. Liberalisation will further increase the need for regulatory independence to oversee that existing laws and regulations are being followed, and efficiency gains achieved.

Finally, it should be noted that Tanzania has a regulatory framework in place for net metering. Unfortunately, it is not being utilised, meaning that Tanzania is losing out on important small-scale and decentralised investments in renewable energy.

Strengths	Weakness
• Proper regulatory framework for off-grid, mini-grid and small power producers	• Lack of holistic sector expansion process • Lack of transparency in concessionary processes • Net metering framework not operational
Opportunities	**Threats**
• Unbundling of TANESCO to increase • efficiency, private sector investment and improve service quality • Update NEP in case of important developments • Institutionalise least-cost expansion process	• Lack of regulatory independence

Figure 4-5 – SWOT analysis for strong policy and regulatory frameworks, competent institutions, and liberalisation

4.1.5 Affordable access and innovative business models

Tanzania has, as documented in chapter 2, made significant advances in rural grid extension over the past decades. However, the cost per connection has already reached USD 740 for certain projects (IED, 2020), and the marginal cost of new connections will grow as ever more peripheral settlements are targeted. Fortunately, Tanzania is well placed to leverage the technological and business innovations that have taken place in the off- and mini-grid space over the past decade.

The cost of electrifying all 37,610 hamlets in Tanzania (section 3.2.4) cannot come from public funds alone. A functioning market for mini- and off-grid solutions is therefore a prerequisite for universal connectivity by 2030. However, off- and mini-grid options entail a different set of challenges than grid expansion. For example, while grid electrification benefits from direct and indirect subsidisation, consumers connected to mini-grids are often required to cover the entire cost through a tariff which normally is higher than the those paid by grid customers. Even though mini-grids offer substantially lower energy costs than polluting alternatives such as kerosene, this de-facto price discrimination has not been politically acceptable in Tanzania. The tension culminated in the aforementioned tariff directive requiring private mini-grid operators to cap their tariffs at TANESCO-levels. As a result - and in spite of a sound underlying regulatory framework - access expansion through mini-grids in Tanzania has been slow over the past years.

In practice, policy makers and their development partners need to either a) accept differentiated costs of service for on- and mini-grid connections, or b) provide substantial subsidies to bridge this gap. Fortunately, the most recent policy signals from the Ministry of Energy are highly encouraging, and it now looks like the tariff issues have been resolved. Even so, it is critical that the private sector is given a clear understanding of which villages will be subject to grid extension and when, so that they are able to target areas that are suitable for electrification through mini-grids.

As noted in section 3.2.4, around 30 percent of rural households in Tanzania live too far from the village or hamlet centre to realistically be connected to the grid in the near future. Therefore, it is critical that efforts are stepped up to ensure access to affordable, reliable, and safe stand-alone solutions such as solar home-systems. This includes enhanced enforcement of existing rules and regulations, such as the Lighting Global Quality Standards which are already applicable in Tanzania.

Finally, given that approximately 5.8 million Tanzanian households living within reach of the grid are estimated to remain without connectivity in 2030, subsidising the cost of connection may arguably be the most cost-efficient way to let more Tanzanians share in the benefits of electricity.

Strengths	Weakness
• Consolidated efforts for grid electrification, spearheaded by project such as Turnkey and Densification	• Lack of coherent approach to off-grid solutions • Scope for private mini-grid operators remains unclear
Opportunities	**Threats**
• Leverage new innovative technologies and business models • Lower-cost mini-grids and stand-alone systems can be provided by the private sector	

Figure 4-6 – SWOT analysis for affordable access and innovative business models

4.1.6 Robust grids coupled with competence in operations and maintenance

The poor technical state of many African electricity grids, coupled with design issues such as long distribution lines and a lack of preventive maintenance results in high transmission and distribution losses, as well as unsatisfactory security of supply. In fact, estimates show that outages and load shedding reduce Africa's annual GDP by two per cent as a result of business disruption and lost profits (IRENA, 2015). As discussed in section 4.1.3, aging and inadequately maintained grid infrastructure may also serve as a barrier to the integration of more renewable energy in the electricity mix.

In a Tanzanian context, the extensive rural distribution grid that has been established over the past years constitutes a particular concern with regards to long-term operation and maintenance. The electrification of all remaining villages and hamlets alone will deploy enough medium voltage grid to reach nearly three times around the equator (IED, 2020 and REA, 2022). Due to the current structure of the sector, this new grid has been planned and will be constructed under the auspices of REA, to be handed over to TANESCO at commissioning. Proper maintenance of this infrastructure will require significant resources over time that, given the current resource situation of TANESCO, is likely to become a considerable challenge.

In addition to the recommendations set out in section 4.1.1 related to strengthening of TANESCO´s financial situation, it is therefore imperative that the utility´s capacity for operation and maintenance of rural distribution grids is significantly strengthened to avoid a rapid deterioration of the distribution grid that Tanzanian electricity consumers (through the REA levy) and development partners have co-funded over the past years.

Since its establishment, REA, supported by the MoE has made impressive progress in rural electrification. This success has, however, not come without a cost. It is time to increase the emphasis on sustainability of rural distribution infrastructure and how rural demand impacts the larger grid. On the structural side it is therefore recommended that the responsibility for planning and execution of grid-extensions is returned to TANESCO, to ensure a holistic approach to grid expansion where decisions on future investments are made in the context of the needs and limitations of the larger grid. This means that the mandate of REA once again would be that of a fund manager considering and approving applications from TANESCO and the private sector for funding of rural electrification projects.

Strengths • 76 percent of Tanzanians live within reach of the grid • A number of transmission projects have been completed recently or are under construction	**Weakness** • Frequent outages • Limited resources for O&M, particular of rural distribution grids • Limited O&M capacity in TANESCO
Opportunities • Availability of cheap international finance • Build capacity on O&M within TANESCO • New technologies, tools and systems for improved and more efficient O&M	**Threats** • Sector coupling (e.g. electrification of transport) will require a stronger grid

Figure 4-7 – SWOT analysis for robust grids coupled with competence in operations and maintenance

4.1.7 Decommissioning existing fossil fuel generation capacity

To meet the Paris Agreement, African governments, like all governments, should avoid investing in any additional fossil fuel-based generation assets and phase out subsidies for fossil fuel-based electricity generation.

The modelling presented in chapter 3 clearly demonstrates that given its excellent potential for renewable energy, Tanzania does not need further investments in costly and polluting fossil fuels to meet its future demand. On the same basis it is also recommended that the existing natural gas power plants are not replaced once they have reached the end of their economic lives.

4.2 The need consolidated for action

The table below summarises the identified enablers to the clean energy transition in the form of recommendations to guide the way towards a modern, reliable, and clean power system in Tanzania by 2050.

Table 4-1 – Overview of implications and way forward on clean energy transition enablers

Cost-reflective tariffs and financially sustainable service providers	• Political acceptance of cost-reflective tariffs is an imperative in order for the sector to achieve sustainability over time. • TANESCO needs to improve its operational performance. • Tanzania should take a holistic approach to rural electrification that considers the needs and limitation of the integrated grid, and the O&M obligations that follow from grid extensions.
Environment conducive to private sector investments in renewables	• Strengthen regulatory independence and ensure that the Ministry of Energy governs through (consistent) policy. • Utilise auctions to procure significant amounts of low-cost variable renewable energy, particularly solar PV distributed around the country.
Technologies and structures for energy efficiency and system flexibility	• Embed considerations related to flexibility in the least-cost expansion approach. • Operationalise the existing framework for energy efficiency.
Strong policy and regulatory frameworks, competent institutions, and liberalisation	• Strengthen regulatory independence and ensure that policy makers govern through policy and not micromanagement of the sector. • Develop a formalised and institutionalised process for grid and generation expansion planning based on an Integrated Resource Plan. • Revitalise the ESI Reform Strategy and Roadmap towards unbundling of TANESCO.
Affordable access and innovative business models	• Take a holistic approach to rural electrification that includes off- and mini-grid solutions. • Formalise a politically acceptable framework for off- and mini-grid electrification that also allows the private sector to recover fair costs and reasonable profits as approved by EWURA. • Consider subsidies to reduce the cost of connection as a supplement to existing electrification efforts.
Robust grids coupled with competence in operations and maintenance	• Strengthen TANESCO capacity within operation and maintenance of distribution grids. • Revert responsibility for on-grid rural electrification to TANESCO, with REA functioning as a fund manager for the Rural Energy Fund.
Decommissioning existing fossil fuel generation capacity	• Given the relatively small system size and limited emissions from fossil fuel combustion, the main focus should be on avoiding investments in additional fossil generation.

4.3 Sharing the benefits of the energy transition

Based on the findings of chapter 3, it is clear that a clean energy transition will bring significant economic benefits to Tanzania. As with any societal change, however, it is not a given that these benefits will be equitably distributed among the population. Because of the important role of electricity in advancing other Sustainable Development Goals, such as those for gender, health, and education, the potential impact of access expansion will only be realised if an inclusive approach is applied – one that that leaves no one behind and maximises the socioeconomic benefits of electricity.

4.3.1 Productive use of electricity

In addition to lowering the cost of electricity to households, the clean energy transition also holds the promise of increased competitiveness and job creation through productive use of electricity (PUE). The PUE component of the Norwegian funded Rural Electrification Densification Project Phase 1 clearly demonstrated a considerable potential for local entrepreneurs to create new employment in rural areas (E4I, 2019). The 349 entrepreneurs across 59 villages who were recruited, created more than 214 permanent new jobs and increased their electricity consumption by 80 percent.

Several barriers to PUE were identified and addressed in the design. These include:

- Knowledge about electricity and how it can be utilized for productive use;
- Access to capital for investments; and
- Business mentoring.

Both the Government of Tanzania and its development partners need to apply these lessons learned in their continued endeavours to expand access.

4.3.2 Addressing the gender divide

Electricity access is gendered, with women in most developing countries experiencing energy poverty differently and more severely than men (Petrova and Simcock, 2021). Specifically, women are commonly responsible for household activities, including energy provision. It follows that without access to modern energy services, many women and girls spend much of their time on collecting biomass fuels, which constrains them from accessing decent wage employment, educational opportunities and livelihood enhancing options. Also, women typically spend more time in the house, and suffer disproportionally from problems related to indoor air pollution caused by kerosene and other polluting sources of lighting. Women also have a harder time obtaining credit for investments, and so are less able to benefit from PUE activities (E4I, 2019).

The Sustainable Energy for All Gender Action Plan (MoE, 2018) is a strategic tool for the gender responsive SE4ALL initiative in Tanzania. It aims to guide all stakeholders in designing and implementing the SE4ALL initiative while promoting gender equality and women's empowerment. Key issues related to gender and renewable energy include:

- Ensuring that gender issues are mainstreamed in governance and decision-making processes related to policy development, implementation and monitoring, service delivery, and financing;
- Increasing women's participation and leadership in energy governance and energy institutions at the local and national levels; and
- Promoting gender equity in planning, designing, producing, supplying, and managing sustainable energy solutions.

4.3.3 Biodiversity and social safeguards

In addition to the negative impacts of climate change, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in its 2019 report concluded that nature is declining globally at rates unprecedented in human history and that "transformative changes are needed to restore and protect nature" (IPBES, 2019). It is therefore critical to ensure that the considerable infrastructure investments required for the clean energy transition, such as new generation capacity and transmission lines do not cause unacceptable environmental and social impacts, whether cumulative or project specific. It is also important that identified adverse impacts are avoided or mitigated through improvements in the planning phase.

For major infrastructure projects, Tanzanian law requires that Strategic Impact Assessments are developed. These assessments are intended to precede decision-making and allow for the identification of alternatives before the project undergoes a full Environmental and Social Impact Assessment. Both studies entail a comprehensive stakeholder engagement process to ensure that relevant parties are heard. Compliance with national regulations and international best-practice in this area will, in addition to promoting sustainable outcomes, also facilitate access to finance by contributing to making the projects bankable.

4.4 Financing the clean energy transition

As outlined in section 4.1.2, approximately USD 100 billion in investments is required to meet Tanzania´s growing energy demand towards 2050 with renewable generation. This is far greater than the funds available from public sources, such as the rural electrification levy, direct allocations over the national budget, and direct support from development partners.

To close this funding gap and to achieve long-term sustainability for the sector, it is key to:

- Unlock private investments. Creating a balanced, transparent, and predictable framework for private sector participation is the most important step toward attracting significant private investments in generation and mini-grids. Building on this framework, development partners can help overcome credit market failures through deployment of proven de-risking instruments such as guarantees, credit facilities, and risk capital.
- Make tariffs cost reflective. Until electricity consumers pay the actual cost of generating, transmitting, distributing, and supplying electricity, the power system will not be sustainable. Making TANESCO a financially viable and credit-worthy utility that is able to finance required investments and maintain its infrastructure is, therefore, the single most important measure that the GoT can make to finance the clean energy transition.

5 Five strategic actions for a clean transition

Key messages

- The current support provided by development partners is fragmented and insufficient to address the structural issues facing the power sector.
- A clean energy transition for Tanzania will require the consolidated efforts of the Government, the private sector, and development partners.
- Five strategic priorities are identified to kick-start the clean energy transition in Tanzania.

A clean energy transition for Tanzania will require the consolidated efforts of the Government, the private sector, Civil Society Organisations, and development partners. Based on the findings of previous chapters, five strategic initiatives are proposed to put the sector on an ambitious yet realistic path towards universal access and low-carbon growth:

1. Implement a path to cost-reflective tariffs, and strengthen TANESCO operations
2. Develop a formalised and institutionalised process for generation and transmission expansion planning within the Ministry of Energy
3. Run international auctions to increase investments in low-cost variable renewables
4. Revert to the underlying framework for private mini-grid development, to realise universal connectivity by 2030
5. Take a holistic approach to grid extension and strengthening, by moving responsibility for planning and execution of rural grid extension from REA to TANESCO

A review of the major on-going programmes and initiatives funded by development partners concludes that current efforts are too fragmented to truly address the structural issues facing the sector (Annex C). Few of the enablers outlined in chapter 4 are targeted, with the lion´s share of resources going towards rural grid extensions. Therefore, each of the strategic initiatives has recommendations on the role of development partners.

1 Implement a path to cost-reflective tariffs, and strengthen TANESCO operations

Without a financially sustainable and operationally capable utility Tanzanians will not see the desired improvements in quality of supply, nor will the sector be able to expand in support of Tanzania´s emergence as a middle-income country.

There is an urgent need for political acceptance of cost-reflective tariffs that allows for increased spending on maintenance and economically viable investments, while also boosting investor confidence in the sector. A new Cost of Service Study may be required to establish cost-reflective tariffs and a viable path to sector sustainability but, given the financial situation of the sector, decision makers should not wait for the outcome of such a study to start a gradual tariff increase.

Meanwhile, in order to improve operational efficiency and quality of supply, TANESCO should be provided with the technical assistance required to benefit from regional best practice for utility operations, including the operationalisation of new digital tools.

A few interventions are already underway in this area (Annex C), but an assessment should be made as to whether these need to be complemented with other initiatives to achieve the desired effects.

Finally, the ESI roadmap should be revitalised and implemented in the medium-term to re-structure the sector in preparation for the clean energy future, including the unbundling of TANESCO, to improve efficiency and improve the investment climate.

Role of development partners

- Provide financial support to generation and transmission projects which, in addition to meeting international environmental and social standards, also are prioritised based on least-cost expansion principles.
- Provide financial support for a high-quality TANESCO cost of service study, contingent on proven political will, to accept a pathway to cost-reflective tariffs in the sector.
- Initiate a broad and coordinated technical assistance and capacity building programme to increase TANESCO financial and technical performance, including operationalisation of digital tools.

2 Develop formalized and institutionalized process for generation expansion planning within the Ministry of Energy

The findings of chapter 3 highlight that, irrespective of which 2050-scenario comes to fruition, the sector has substantial investment needs. However, the Joint Energy Sector Review characterises the current approach to sector expansion as "ad-hoc" and "not adhering to least-cost expansion principles" (Norconsult, 2020).

This highlights the need to develop formalised and institutionalised processes for generation and grid expansion planning building on load-flow modelling and adhering to least-cost principles. Given the ambition to increase private sector participation it is deemed appropriate that the responsibility for planning and procurement of new generation capacity is embedded formally within the Ministry of Energy. Development of an Integrated Resource Plan owned by the MoE would be a natural first step in this direction.

Role of development partners

- Provide the technical assistance and capacity building required for the Ministry of Energy to redefine its approach to generation expansion, including the funding of an Integrated Resource Plan-study.
- Target investment support to generation and transmission projects which, in addition to meeting international environmental and social standards, also are prioritised based on least-cost expansion principles.

3 Run international auctions to increase investments in low-cost variable renewables

A key finding of this study is that Tanzania, unlike many of its peers in the region, has ample flexibility available in its power system. This is fortunate, because it means that even without investments in energy storage, the system can absorb a significant amount of low-cost variable renewable energy while improving supply security.

Running large-scale international auctions for procurement of wind power and solar PV would be the best way to bring much needed private investment to boost the generation capacity in the Tanzanian power system, and a natural part of the least-cost expansion approach outlined in the previous chapters. In addition to the low prices obtained, auctions have proved to deliver open and transparent procurement processes across the region. The GoT should make sure that it is supported by experienced transaction experts to avoid asymmetries of information and ensure that Tanzania benefits from regional experience.

Role of development partners

- Provide the technical assistance and capacity building required for Tanzania to run a large-scale auction for solar PV and/or wind power capacity from the private sector.
- Make available guarantees, technical support facilities, and financing from development finance institutions to unlock the required private sector investments.

4 Leverage off- and mini-grid solutions to realize universal connectivity by 2030

Ensuring universal connectivity in Tanzania by 2030 is, as seen in chapter 3, a monumental challenge, and one that cannot realistically be solved leveraging only the resources of the GoT and its development partners. It is therefore recommended that the full force of the private sector is reenlisted in deploying modern mini-grids to areas that realistically will not be served by grid extension before 2030.

The technical and business solutions required for mini-grid operators to achieve operational and financial sustainability exist, and this is therefore mainly a question of allowing the private sector to recover its fair costs and reasonable profits as approved by EWURA. The forthcoming REMP also needs to provide clear guidance on which villages will not be covered by grid-extension in the years to come, in order to provide the private sector with clarity and predictability on which areas to target. This will provide the beneficiary population with electricity that, though admittedly more expensive than on-grid electricity, will reduce their electricity costs drastically compared to kerosene and the other sources of lighting that they are currently using.

Further, it is recommended that the Government recognises the role that modern off-grid solutions such as solar home systems with storage can play in the electrification of areas far removed from the grid. Political acceptance of such solutions, and their inclusion in a holistic approach to rural electrification, will be an important step towards achieving universal access by 2030.

Role of development partners

- The private sector solutions exist, so given political will there is limited role/need for development partners.

5 Take holistic approach to grid extension and strengthening, by moving responsibility for planning and execution of rural grid extension to TANESCO

The expanding mandate of REA, which now includes rural electrification planning and project execution in addition to its role as a fund manager, has resulted in a fragmented approach to sector expansion. Therefore, efforts need to be re-focused on TANESCO to achieve a holistic approach to rural electrification that considers the needs and limitation of the greater grid, and the O&M obligations that follow from grid extensions. It is therefore recommended that the mandate of REA is fund manager only, charged with utilising the Rural Energy Fund to finance/ subsidise initiatives in the rural energy space, including electrification efforts by TANESCO and the private sector.

Role of development partners

- Support capacity building within TANESCO on planning, operations, and maintenance of rural distribution grids.
- Provide financial and organisational support to the transition of responsibilities for implementation of rural electrification projects from REA to TANESCO.
- Ensure that funds allocated for rural electrification are directed to projects that meet key sustainability criteria, including a credible plan for future operations and maintenance.

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Annex A – List of stakeholders interviewed

	Organization	Name	Position
1	Ministry of Energy	Mr. Christopher Nyondo	Principle Engineer, Electricity Sub-sector
2	Energy and Water Utilities Regulatory Authority (EWURA)	Mr. Ng'anzi Kiboko	Manager Electricity Generation & Market
3	TANESCO	Mr. Erasto Chiswani	Investment Engineer
		Mr. Marianus Mgendera	Planning Economist
		Mr. Gwalusano Mwaipopo	Project Manager
		Eng. Samwel L. Kessy	Manager Research
4	HakiRasilimali	Racheal Chagonja	Executive Director
5	Royal Norwegian Embassy	H.E. Elisabeth Jacobsen	Ambassador
		Morten Heide	Energy Counsellor
		Neema Michael Shayo	Energy Advisor
		Tajiel Urioh	Energy Advisor
6	EU delegation	Massimiliano Pedretti	Energy Portfolio Manager
7	World Bank	Mbuso Gwafila	Senior Energy Specialist
		Jenny Maria Hasselsten	Energy Specialist
8	Swedish Embassy	Stephen Mwakifwamba	National Programme Officer for Energy, Environment and Climate
		Daniel Tiveau	Counsellor Programme Officer for Environment, Climate and Energy
9	African Development Bank	Mohamed Ally Sauko	Senior Energy Expert
10	Agence Française de Développement	Vincent Joguet	Programme Officer
11	RP Global (Solar developer)	Jacopo Pendezza	Project Development Manager

Annex B – Methodology note on energy system modelling

The model developed for this study is based on the PyPSA (Python for Power System Analysis) framework, performing total energy system least-cost investment optimisation as well as least-cost dispatching (Brown et al., 2017). PyPSA is an open source toolbox for simulating and optimising modern power systems.

Planning horizons. We consider two planning horizons in our modelling: 2030 and 2050. For both years, we run the least-cost investment optimisation for the entire year on an hourly basis.

Scenarios. Two scenarios are considered in the optimisation, the Power System Master Plan case (as the business-as-usual case), and the Clean Energy Transition Case.

- A Power System Masterplan (PSMP) Scenario which adopts the existing plans for sector expansion and the forecasted demand growth as captured in the 2020-update of the PSMP (MoE, 2020b). The PSMP 2020 planning horizon is 2044, and generation expansion from 2044 to 2050 is modelled based on a least-cost generation expansion approach.
- A Clean Energy Transition Tanzania (CETT) Scenario in which the PSMP 2020 load forecast is adjusted to account for expedited electrification to realise universal connectivity in 2030, and demand is met by least-cost renewable generation and storage options, in addition to the already installed capacity.

On-grid only. The energy system modelling exercise only considers on-grid generation and demand. Generation and demand from off-grid sources is considered separately, and not included in the optimisation. As such, all assumptions refer exclusively to on-grid.

Limitations. It is important to understand that there is significant uncertainty related to the applied inputs and assumptions, including future demand, technological developments, and cost of different technologies. Therefore, neither scenario predicts what will happen in the future. Further, the model does co-include a detailed grid topology. Therefore, no power flow calculations are made. Nor are the impacts of climate change on the availability of hydropower modelled in the study. These issues would have to be addressed through more detailed studies.

A detailed methodology note, including a full list of inputs and assumptions, is available online. The note can be accessed via the QR code below, or via the following link: http://www.bit.ly/cett-methodology

Annex C – Overview of selected donor initiatives

Development partners are supporting a plethora of projects, programmes, and initiatives in the Tanzanian energy sector. Rather than listing all of them, this annex provides a brief overview of selected initiatives with particular relevance to the topics of this report.

On-grid generation expansion

In terms of generation expansion, the support provided by the African Development Bank (AfDB) Agence Française de Développement (AFD), and the Government of Norway to the planned 87 MW Kakono HPP on the Kagera river in Northern Tanzania is the largest on-going commitment. AFD also supports the on-going TANESCO procurement of solar projects.

Among a number of smaller interventions, we find the 11 MW of hydropower and solar PV in rural areas to be constructed by IPPs and funded by a World Bank credit which are nearing financial closure under their Tanzania Rural Electrification Expansion Programme (TREEP).

Transmission grid expansion and interconnectors

In addition to the African Development Bank´s (AfDB) support for the Transmission project from Chalinze to Dodoma, the World Bank and AFD both provide support for the extension of the backbone 400 kV transmission grid to Zambia. The AFD is also supporting the upgrade of several TANESCO substations, as well as investments in fibre optics and SCADA for the TANESCO grid.

Distribution grid expansion and rural electrification

A number of development partners support the ongoing efforts for rural electrification, primarily through grid-extensions. These include:

- The World Bank TREEP which has realised more than 585,000 rural connections. In addition, the World Bank´s Tanzania Renewable Energy CDM Programme of Activities has helped finance five renewable energy mini-grids, a few of which are connected to the main-grid.
- The Rural Electricity Densification Project 2A and 2B are both nearing implementation, aiming to increase connectivity rates around the existing distribution grid. Round 2A is co-founded by the EU, the Government of Sweden, and the Government of Norway, while AFD supports implementation of 2B.
- The EU, along with the governments of Sweden and the United Kingdom also support the expansion of mini-grids.
- The AfDB also supports distribution projects in five regions.

A review of all planned and on-going electrification projects conducted as part of the on-going REMP study revealed that a number of villages are targeted for electrification by two or more projects, highlighting the need for donor coordination (IED, 2020).

Energy efficiency

The EU is supporting the implementation of an Energy Efficiency Action Plan, with a total commitment of approximately EUR 8 million. The programme includes, for example, the definition of minimum energy performance standards, as well as energy audits of large customers.

Technical support and capacity building

Most of the on-going infrastructure interventions also include technical assistance and capacity building components. In addition, both the EU and Norway have dedicated capacity building programmes in place to support TANESCO.

Need for a new and consolidated approach

Even though this is not a complete overview of existing development projects in the sector, it arguably presents a fair picture of where development partners are spending their resources. Even though the initiatives do address a number of the enablers described in chapter 4, the approach seems fragmented and generally not suited to address the structural issues raised.

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