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Tanzania Energy Resources-An Overview

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Abstract: Reliable and quality electrical supply with economical cost is the objective of any consumer in any country. Its total power generation and utility level decides one country's growth rate since all industries and developments are mainly based on availability of electricity only. This research paper presents about how much electrical energy resources are available in Tanzania from hydro, natural gas, coal, uranium, wind, geothermal, biomass, tidal and waves. As on 2022 only 37.7% of the total population is having access to electricity in Tanzania. The country does not meet the demand by the power generation. Currently it imports power from the neighboring countries like Uganda, Zambia and Kenya even then the demand is not met out. Also every year the demand is increasing. This paper also suggests medium and long term plans for generation to reduce the supply demand gap.

Keywords: Energy supply, power demand, load forecasting,

1. Introduction

The primary cause of any nation's economic and technological progress is electrical energy. The usage of power directly affects a country's prosperity and standard of living. Tanzania's installed electricity capacity has increased significantly, but the country's power demand has also risen sharply. The power demand is mainly due to the growth of industries as well as due to increase in residential load, which includes intensive use of residential appliances. This leads to higher demand of energy. The present idea is to use renewable energy sources while also making use of already-existing resources like coal and hydro.

The numerous energy sources include 1. Fuels: this category includes solid fuels like coal and wood as well as liquid fuels like petroleum and its byproducts. Gas Fuels: Natural gas and biogas are the two different types of gas fuels. 2. Energy stored in water: At greater levels, the potential energy of water is used to produce electrical energy. 3. Nuclear Energy: Fission of uranium-U^{235}, Thorium-Th^{232} release enormous energy due to fission. However, it has certain drawbacks, including high startup costs, a scarcity of raw materials, challenges with waste management, and a requirement for highly skilled workers to run the facilities. 4. Wind Energy: Wind power is a renewable energy source. Modern wind turbines may operate at speeds as low as 3–7 km/h, although their greatest efficiency is reached between 10–12 km/h. 5. Solar Energy: Electricity is produced using the thermal energy contained in the sun's rays. The main benefit of solar energy is that it is excellent for a human environment that is free of noise and pollution. For lighting, cooking, and water heating, solar electricity is also significantly less expensive. 6. Tidal Power: The Ocean's waves and tides are very energetic. These tides rise and fall, allowing water to be retained during the rise and released during the fall. Hydroelectric facilities with minimal head of water available can function effectively. 7. Geothermal Energy: The core of the planet is molten. Numerous locations on the surface of the globe experience volcanic activity. Hot springs and steam vents emerge from the earth's surface. Such natural wells provide steam that is utilized to create electricity.

This paper discusses about the various energy sources abundantly available in Tanzania and the current status of power demand. Also this paper forecasts the load for three planning horizons and proposes some generation schedule to meet out the demands.

2. Energy Status of Tanzania: Tanzania is hallowed with a variety of renewable energy sources, including geothermal, sun, wind, biomass, and hydropower. This potential has not yet been used to its greatest capacity. Such renewable resources might greatly increase Tanzania's energy supply if they were used effectively, bringing the nation one step closer to the middle-income position envisioned in the Tanzania National Development Vision 2025.

Electricity connection details as on 2022[1] are given in table 1.

Table 1: Electricity Connection details

Electricity availability	% of the population
Electricity nationwide	37.7
Urban	73.2
Rural	24.5
Access to clean cooking	2.3

18 isolated mini-grids make up Tanzania Electric Supply Company Limited's (TANESCO) 82 MW total off-grid generation capacity. 29 MW are provided by two natural gas-powered mini-grids, while the remaining 53 MW are supplied by diesel generators. Tanzania prefers to electrify through grid connections, but recognizes the value that off-grid alternatives might offer given the pace of network construction.

As of the year 2021 Tanzania's total electricity supply was 1605.86 MW [2].

48 transmission substations, 2,063 km of 132 kV, 668 km of 66 kV, 24,165 km of 33 kV, 6,006 km of 11 kV, 71,629 km of 400 and 230 kV lines, and 3,340 km of 220 kV lines make up the transmission and distribution system. The losses in transmission and distribution are currently 16.4%.

As of 2021[3], Tanzania imports power via 10 MW from Uganda, 5 MW from Zambia, and 1 MW from Kenya.

3. Population, Power Demand and Electricity Generation and Distribution Ststus of Tanzania

Population of any country is directly related to the power demand of any country. Generation should be increased accordingly to meetout the demand. In this section all the details are given.

3.1 Demographic and socio-economic factors

According to the 2023 census, Tanzania is home to 67.44 million people [4]. The current population growth rate is 2.96% annually. Based on these findings, the medium-term plan's anticipated population for the five-year period ending in 2028 is 77.42 million. For long term plan which is for period of ten years by 2033 is 87.40 million.

3.2 Electricity demand

Tanzania uses only 110 kWh of power per person annually as of 2020 [5], which is significantly less than the usage of low-income nations. Nevertheless, consumption is rising quickly, mostly as a result of increased productive investments and an expanding population.

Tanzania's electrification status is expected to increase to at least 75% by 2035, according to the Power System Master Plan (PSMP) (2010-35), while connected customer demand is expected to rise significantly as Tanzania reaches middle-income status, as stated in the Tanzania National Development Vision 2025[6].

3.3 Provision of electricity

As of 2021, the nation's commissioned capacity for electricity generation was 1,605.86 MW, of which 1,438.24 MW was provided by the main grid and the remaining 167.62 MW was supplied by imports, smaller networks, and small power producers (SPPs). The capacity of the grid to generate electricity is made up of around 65% thermal energy (33% natural gas and 32% oil), and 35% big hydropower. The remainder is made up of imports and tiny amounts of renewable energy.

The private sector's role is significant and welcomed. Only 59% of the total capacity is supplied by TANESCO, with the remaining 26% and 13% provided by independent power producers (IPPs) and emergency power producers (EPPs), respectively, which they sell to TANESCO on a wholesale basis.

Independent power producers with a capacity less than 10 MW are known as small power producers (SPPs). They make up 2% of the total capacity. They could sell TANESCO or retail customers wholesale electricity. Additionally, it is predicted that private, diesel-based captive generation will reach 300 MW nationwide [7].

3.4 Electricity distribution

Tanzania's electricity system consists of a main grid that covers major roads and urban centers, a number of autonomous mini-grids in outlying towns and villages, and private diesel generating. Additionally, TANESCO purchases power from Kenya, Zambia, and Uganda.

TANESCO owns all of the nation's transmission and distribution lines. SPPs are sometimes in charge of isolated micro- and mini-grids, too.

Off-Grid Electrification: 18 solitary mini-grids make up TANESCO's 82 MW total off-grid generation capability. 29 MW are provided by two natural gas-powered mini-grids, while the remaining 53 MW are supplied by diesel generators.

10 network projects of over TZS 4 trillion (around $2,421 million) in total are included in the Tanzania Five Year Development Plan for the years 2011 to 2016; the PSMP anticipates the strengthening of regional network

integration.

Tanzania has a low rate of rural electrification, with only 24.5% of the rural population having access to power. Twenty diesel-powered mini-grids are run by TANESCO, some of which are linked to neighboring nations. Thirteen towns rely on small-hydro mini-grids run by religious organizations for their electricity, while others use solar home systems (SHSs) that were either purchased privately or were supported by grants. Grid extension is a very difficult and expensive way to electrify rural areas due to the size of the country and low population density in the majority of regions.

The government has established a number of organizations, programs, and initiatives to improve rural communities' access to electricity. According to preliminary findings from the Rural Electrification Investment Prospectus, 33% of rural populations live far from the grid in low-density settlements, 20% live far from the grid but in high-density areas, and roughly 46% live near to it. The challenge of rural electrification is still formidable [8].

3.5 Large hydropower

With an installed capacity of 562 MW and prospective capacity estimations as high as 4.7 GW, hydropower has historically been the foundation of Tanzania's national electrical grid. Rivers in Tanzania are the main source of water for hydropower.

Tanzania wants to increase its large-hydro power capacity. Potentially, increased capacity might reach 4,000 MW, according to estimates. About 45% of the country’s electricity comes from hydro [2].

3.5.1 A little hydropower

Small hydropower resources (up to 10 MW) have a 480 MW estimated potential. Only roughly 15 MW are provided by installed, small-hydro projects that are connected to the grid. The vast majority of small-hydro projects that have been established are privately owned and disconnected from the national electrical grid. The 300 kW to 8,000 kW range is covered by five TANESCO installations. More than 16 have a capacity ranging from 15 kW to 800 kW, and they are owned by religious organizations [9].

3.6 Geothermal energy

Unquantified geothermal potential exists in Tanzania, which is substantial. Analog technique estimates place the potential at over 650 MW, with the majority of opportunities being found in the East African Rift System. Hot springs are the primary on-surface manifestation of most geothermal opportunities. Since the beginning of surface evaluations in 1976, more than 50 sites have been located.

Geothermal energy development will be greatly aided by Tanzania's Scaling-up Renewable Energy Program (SREP). Additionally, it will support a project that was mostly created by the private sector and has the potential to catalyze the production of roughly 100 MW, making geothermal energy an important, dependable, and affordable source of electricity for Tanzania.

3.7 Wind

Promising wind resources are known to exist in a number of Tanzanian locations. Only Kititimo (Singida) and Makambako (Iringa) have been found to have sufficient wind speeds for grid-scale electricity generation in the locations where assessments have been made.

3.8 Solar

Tanzania has high quantities of solar energy, with 2,800–3,500 hours of sunshine annually and 4–7 kWh per m^2 per day of worldwide horizontal radiation. The country's center region has particularly abundant solar resources, and both off-grid and grid-connected solutions are being developed there.

Tanzanian investments in solar energy are currently modest. Tanzania has deployed roughly 6 MW of photovoltaic (PV) solar energy thus far.

3.9 Grid-connected photovoltaic solar energy

Solar PV uses around 1 hectare of land and produces 1,800 MWh (net of losses) annually in central Tanzania. Large portions of electricity might theoretically be produced by solar PV. The potential for grid-tied solar PV could be roughly 800 MW based on a 20% cap on total national production in 2025 [10].

4. Power Generation in Progress:

Hydro

Ruhudji (358 MW), Rumakali (222 MW), and Stieglers Gorge (2,100 MW) all have big hydro projects planned.

The national power grid of Tanzania will get a peak of 2,115 MW if the Julius Nyerere Hydroelectric dam is built [2].

Solar

The Republic of Tanzania intends to produce 6,000 MW of renewable energy by the year 2025, according to President Samia Suluhu Hassan.

A grant agreement worth 10,865.57 million Tanzanian Shillings (USD 4.5 million) was signed by the World Bank (WB) and the Tanzanian government in 2019 to finance the construction of better solar pumping systems in 165 remote Tanzanian settlements. This project will provide access to a sustainable water supply.

5. Load Forecasting and Generation Future Expansion Planning

i) Load Forecasting

The load is forecasted for medium term plan, which is for the period from 2023 to 2028, and long-term plan, which is for the period from 2028 to 2033.

In 2025, the expected demand is 4000 MW. The demand is increasing every year 10 to 15%. It is assumed that load is varying at 15% and based on the above data the forecasted loads are given in table 2.

Table 2: Forecasted load for the years 2028 and 2033

Year	Population (Million)	Load (MW)
2028	77.42	5800
2033	87.40	8800

Generation expansion Planning

The total power installed capacity in 2021 is 1605.86 MW. The above power is generated from different fuels. Table 3 provides further information.

Table 3: Available power details of 2021

Type of Fuel	Percentage	Actual available power (MW)
Natural gas	48.0	770.81
Hydro	31.0	497.82
Petrol	18.0	289.05
Solar	1.0	16.06
Biofuel	1.0	16.06
Uganda	0.62	10.0
Zambia	0.31	5.0
Kenya	0.06	1.0

Expected Generation from the progressing power plants:

Ruhudji hydro project– 358 MW

Rumakali hydro project – 222 MW

Stieglers Gorge hydro project - 2,100 MW

Julius Nyerere Hydroelectric dam – 2115 MW

For medium term plan i.e. at 2028, the forecasted load is 5800 MW. Already available generation from various sources is 1605.86 MW. The additional generation needed is 4194.14 MW.

Hence it is suggested that by 2028 all the above said hydro projects will come into function, the total available generation from them will be 4795 MW. Even with drought some reduction in generation then also the demand can easily be met out.

For long term plan i.e. at 2033, the forecasted load is 8800 MW. Already available generation from various sources is 6400.86 MW. The additional generation needed is 2399.14 MW.

Hence it is suggested that by 2033, the remaining energy should be harvested from natural gas, windmill and solar panels. One windmill produces 2.5 MW. Hence it is suggested to install maximum windmills and the remaining demand may be metout from natural gas and solar panels.

5. Conclusion

This paper gives an overall idea about the electrical energy status of Tanzania. Discussed about the various resources and the load demand and how for it is met out by the various power supply resources. Also presented the load forecasting for medium and long term plans and give the possible generation possibilities.

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