SUSTAINABILITY, INCLUSIVENESS AND GOVERNANCE OF MINI-GRIDS IN AFRICA (SIGMA) RESEARCH PROJECT

REGULATORY FRAMEWORK AND TARIFF ASPECTS OF ELECTRICITY MINI GRIDS IN TANZANIA

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The views expressed in this report are those of the authors and do not necessarily represent the views of the institutions they are affiliated to or the funding agencies.

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FEEDBACK

If you have any comments, suggestions, or feedback, please send them to the SIGMA project lead by email: s.c.bhattacharyya@surrey.ac.uk

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ABSTRACT

Tanzania is implementing its Sustainable Energy for All Action Agenda 2030 (SEforAll, 2010), which embraces the acceleration of the country's modern energy access to meet Sustainable Development Goal (SDG) 7. As of the year 2021/22, national electricity access increased to 45.8% up from 39.9% in 2019/20 and 32.8% in 2016/17 (URT 2023a, URT 2020 and URT 2017). The figures indicate that Tanzania has low levels of electrification, thus much effort is needed to address the matter. Low electrification level is attributed to different aspects including the large distances involved, low incomes, and complex geographical features, which make distribution and connectivity to the national grid expensive. Decentralised grids may be a more cost-effective solution in the interim until full grid coverage is achieved (Ahlborg & Hammar 2011). In this regard, it is a fact that electrification by mini-grids will continue to be an option for connecting remote areas located far from the national grid, and for villages located in islands. The current strategy is for the private sector to complement the government's efforts in electrification of the country. In that regard, the Tanzanian government has put in place a conducive and innovative environment for Small Power Producers (SPPs) and Very Small Power Producers (VSPPs) to participate in the electrification of rural areas of the country by mini-grids. In 2008, the country introduced a renewable energy electrification by SPP regulatory framework, which incorporated a tariff setting mechanism for mini grids to sell power to the national and isolated grids owned by the public utility. The framework is governed by the national energy policy, various acts, regulations, and rules which have improved it over the years of its existence.

The SPP framework was responsible for the accelerated deployment of mini-grids between 2008 and 2015 (Odarno et al. 2017). Beyond 2015, the framework, in particular tariff-related aspects, seemed not to work as earlier expected due to political interventions given by government leaders that saw a number of mini-grids that closed their operations, a halt to a number of projects under development and decreased electrification by mini-grids. Due to such circumstances, the withdrawal of funding by some development partners was experienced.

In this paper, regulatory framework, and tariff aspects of electricity mini-grids in Tanzania are analysed based on a cross-section survey involving 18 purposive selected mini-grids. The study used interviews and focus group discussions to collect qualitative data from mini-grid stakeholders- operators, investors, government policy implementers, regulators, and various categories of energy end users. Applying the thematic analysis approach using ATLAS.ti software, the study found that transparent regulations play a crucial role in achieving national electrification goals through renewable mini-grids. The key aspects include multi-step project approval processes and the significance of adhering to established rules for grid compatibility, interconnection, and technical standards. In addition, the study found that electricity

tariff-related aspects in Tanzania are a sensitive and controversial issue, with diverse viewpoints that are challenging to reconcile. To comprehend the problem, one needs to review the tariff setting methodology, prevailing tariff types, and levels used by different business models. The study recommends that the Tanzanian government consider subsidising VSPP operators to address the controversy surrounding very high regulated and unregulated VSPP tariff levels. This subsidy would align their tariffs with prevailing rates in the national grid and some SPP mini-grids, addressing social and equity considerations.

Key words: *Electrification, mini-grid regulation, sustainability, inclusiveness, and governance.*

ACRONYMS/ABBREVIATIONS

AMR	Automatic Meter Reader
BoT	Bank of Tanzania
CBOs	Community Based Organizations
CT	Current Transformer
ESIA	Environmental and Social Impact Assessment
EWURA	Energy and Water Utilities Regulatory Authority
FIT	Feed-In Tariff (Standardised Small Power Purchase Tariff)
GDP	Gross Domestic Product
GWh	Giga Watt Hour
IPP	Independent Power Producer
kVA	Kilo Volt Ampere
kW	Kilo Watt
kWh	Kilo Watt Hour
LED	Light-emitting diode
MFP	Mult Function Platform
MoE	Ministry of Energy
MW	Mega Watt
MWh	Mega Watt Hour
NBS	National Bureau of Statistics
NEMC	National Environment Management Company
NGOs	Non-Government Organizations
PPA	Power Purchase Agreement
PV	Photo Voltaic
REA	Rural Energy Agency
REF	Rural Energy Fund
RERE	Renewable Energy for Rural Electrification
SDG	Sustainable Development Goal
SEforAll	Sustainable Energy for All Action
SMEs	Small and Medium Enterprises
SPP	Small Power Projects
SPPA	Standardised Power Purchase Agreement
SPPT	Standardised Small Power Projects Tariff
SREP	Scaling up Renewable Energy Program

TANESCO	Tanzania Electric Supply Company
TANWAT	Tanganyika Wattle Company
TaTEDO-SESO	TaTEDO Sustainable Energy Services Organisation
TBS	Tanzania Bureau of Standards
TEDAP	Tanzania Energy Development and Access Expansion Project
TIC	Tanzania Investment Centre
TPC	Tanganyika Planting Company
TShs	Tanzanian Shilling
URT	United Republic of Tanzania
USc	United States Dollar Cent
USD	United States Dollar
V	Volt
VAT	Value Added Tax
VSPP	Very Small Power Producers
Wh/d	Watt Hours per Day

1 USD = 2,500 TShs. (January 2024)

1.0 BACKGROUND

1.1 Objectives, research questions and paper organisation

Since 2008, Tanzania has been privileged with a comprehensive regulatory framework for small power projects, including mini-grids, which has significantly expedited the deployment of mini-grids across the country (Odarno et al., 2017). Accelerated deployment of mini-grids has supplemented grid extension in the electrification of the country and has stood out as an option for the electrification of remote rural areas located far from the national grid and islands in the country. The primary aim of this research is to establish an evidence-based study regarding the performance of Tanzania's mini-grid regulatory framework concerning sustainability, inclusivity, and governance. The research focuses on two main questions: a) the driving and hindering forces influencing the proliferation and adoption speed of mini-grids in Tanzania, and b) the evaluation of the governance, regulatory, and policy framework for decentralized electricity systems in the country and its level of success.

To address these questions, the paper is organized into sections covering the country's context, policy and regulatory framework, a comprehensive literature review, the methodology employed for on-site mini-grid visits and stakeholder interviews to collect relevant data, data analysis, findings discussion, and concluding remarks.

Additionally, the research extends its scope beyond Tanzania, incorporating a broader perspective by including East and West Africa in certain research questions. Specifically, the paper poses questions related to the drivers and inhibitors of mini-grid proliferation and adoption speed in these regions, considering the roles played by national/international public and private sector entities, as well as civil society actors. It also explores how the geographic allocation of grid or mini-grid projects is determined during the planning stage, the targeting mechanisms for communities, the implications of grid arrival on existing mini-grids, and the factors influencing the implementation of decentralized electricity provision in the case study countries. Furthermore, the research delves into the viability of a private sector-led model of electrification through mini-grids in Sub-Saharan Africa, examining the circumstances under which this model proves successful.

The paper also investigates the governance, regulatory, and policy frameworks for decentralised electricity provision in each case study country, assessing their level of success and variations. Additionally, it explores the nature of financing and ownership of mini-grid systems, considering whether they are privately owned, community-driven, state-supported, or involve public-private partnerships (PPPs).

1.2 Country context

Tanzania is in East Africa between 1.0°S - 11.7°S and 29.2°E – 40.7°E. It is bounded by Kenya and Uganda to the north; Rwanda, Burundi, and the Democratic Republic of Congo to the west; Zambia, Malawi and Mozambique to the south; and the Indian Ocean to the east with Comoros and Seychelles as neighbour countries. The country

stretches about 945,087 km^2 and engulfs significant proportions of the East African great lakes of Victoria, Tanganyika, and Nyasa, as such portions of the country are in the Nile, Congo and Zambezi River basins.

The country's peculiar topography includes Mount Kilimanjaro the highest free-standing mountain in the world and the highest mountain in Africa; the Great African Rift Valley that crosses the country in the middle from the north to the south including the southern highlands and also stretches along the country's western border including Lake Tanganyika and Lake Nyasa. There exists a vast central plateau with sizeable stretches of forests and grassland accommodating several national parks including the world-famous Serengeti National Park. Annually, portions of the country receive rainfall that varies from 550 mm in the central part of the country to 3,690 mm in south western highlands (World Bank, 2023). These locational and topographical features contribute to the country's enormous renewable energy resources. The rift valley is a wind tunnel with the potential for harnessing wind power resources, it is dotted by a number of geothermal sources and varied terrain which exhibit many rivers with substantial hydropower resources for electrification. The central plateau exhibits solar energy radiation intensity of 4-7 kWh/m^2 suitable for small to large scale solar power generation (World Bank, 2023).

According to the August 2022 population census, Tanzania's population was 61.9 million with an annual population growth of 3.06% (URT 2022). The rural population contribution to the total population is about 35% and its distribution is uneven. Population density is high in the Lake Victoria area, Kilimanjaro region, southern highlands, coastal areas and islands of Zanzibar and Pemba. In 2022, the country registered a GDP of about USD 77.06 billion and 2021/22 annual GDP growth rate of 4.7% (BoT, 2023). During 2020, the country was elevated to a low middle-income country economic status (World Bank, 2021).

In terms of country's primary energy consumption, 85.0% of energy is biomass in the form of wood, charcoal, and agricultural residues; petroleum products 9.3%; electricity 4.5%; and coal and renewable energy 1.2% (EWURA 2016). As of 30th June 2022, Tanzania had an installed capacity of 1,740.77 MW of which 1,489.56 MW was owned by TANESCO, 189 MW was IPP (EWURA 2023), Further data compilation by authors indicates that 31.29 MW was traded SPPs, 28.74 MW non-traded SPPs and 2.18 MW was traded VSPPs[1]. Table 1.1 provides an inventory of mini–grids and embedded generators connected to a medium voltage network of 11 and 33 kV. The generation mix for the national grid in terms of installed generating capacity in 2022 was 68.44% natural gas, 31.37% hydro and 0.19% heavy fuel oil. Maximum demand for the national grid in the same year was 1,340.68 MW and annual demand growth stood at 11.63% (EWURA 2023). The total number of electricity customers in the country were 3,864,974 of which 99.4% were served by TANESCO, 0.2% by SPPs that are also distribution network operators and 0.4% by VSPPs networks. During the same year, annual generation and imports totalled 9,150.33 GWh which translates to a consumption per

[1] The provided mini-grid figures exclude mini-grids owned by the national utility.

capita of about 150 kWh, a figure that can be considered as low consumption for middle income countries estimated of 490 kWh PSMPU 2020 (MoE, 2020).

Table 1.1: Summary of mini grids and distributed types, numbers, capacities and number of connections

Mini–Grid Type/Source	Number	Capacity in kW	No. of connections
Mini hydro	57	33,484.9	14,279
Biomass	25	48,886.0	561
Solar	75	7,347.0	82,147
Wind	1	2,400.0	-
Hybrid	4	216.8	781
Diesel & Gas	14	68,332.0	181,951
Total	176	160,666.7	279,719

Source: Authors compilation

1.3 Evolution of regulatory framework

A background to the evolution of the Small Power Project (SPP) framework which incorporates Standardized Power Purchase Agreement (SPPA) and Standardised Power Purchase Tariff / Feed-In Tariffs (SPPT/FIT) policies in Tanzania dates to 2006, when TANWAT signed a negotiated PPA with TANESCO and started selling electricity to the Njombe, Makamabako and Uwemba decentralized network, supplied by diesel and mini hydro integrated system. A TANWAT wood-fired combined heat and power SPP substituted expensive TANESCO diesel generated power. In 2008 the Njombe, Makambako and Uwemba integrated mini-grid was connected to the national grid following the commissioning of the 220/33 kV substation at Makambako. Subsequently, TANESCO and TANWAT engaged in a lengthy and unsuccessful renegotiation for a lowered tariff as such TANESCO suspended power imports from TANWAT as it was considered more expensive than grid supplied power.

Another unsuccessful PPA negotiation experience involved the TPC bagasse fired plant which during 2004 – 2006 undertook retrofit and expansion of their combined heat and power plant which established a surplus capacity of about 9 MW that could be exported to the national grid (Tenenbaum et al. 2014). Similarly, the proposed tariff for the TPC plant to be sold to TANESCO was higher than the national grid average generation costs as such TANESCO denied purchasing TPC electricity.

In 2008, the World Bank via the TEDAP Project developed the Renewable Energy SPP Framework incorporating SPPA and SPPT/FIT for Tanzania. The SPPTs were developed and set by EWURA. TANWAT was the first SPP followed by TPC to sign an SPPA with TANESCO and start selling power to the national grid at the prevailing SPPT. In view of

the above, the SPP Framework was developed to address barriers that discouraged commercial/quasi commercial mini-grid development (Odarno et al. 2017).

The SPPA is non-negotiable and lasts 15-25 years depending on the generation framework. SPPTs are reviewed annually and are capped both upward (price ceiling) and downwards (price floor) making it possible for the SPP developer/sponsor to undertake a feasibility study and business plan to assess if the project is going to be financially viable during the tenure of the SPPA. Following consultations with the distribution network operator (DNO) and obtaining a letter of intent for the development of the SPP, the developer can obtain a provisional generation and distribution license for three years so that they can conduct a feasibility study, environmental and social impact assessment (ESIA) and business plan, solicit financing and build the plant. After the commission of the plant the developer can obtain a final license.

1st generation SPP framework

Adopted in 2008, the 1st generation SPP framework established SPPAs and SPPTs or generation feed-in tariffs for SPPs of capacity 1 – 10 MW who opted to sell to TANESCO grid or their isolated mini-grids. The feed-in tariffs were developed based on avoided costs of TANESCO in the grid or isolated mini-grid. The feed-in tariffs were technology neutral, however they proved unattractive for solar and wind projects which had higher upfront costs. The feed-in tariffs in the TANESCO national grid were lower than in isolated mini-grids. As such, when an SPP supplying a TANESCO-isolated mini-grid was connected to the grid, a lower approved tariff was applied by TANESCO, thereby affecting the financial viability of the mini-grid and increasing financial risks for the developer (EWURA, 2020) Rules.

2nd generation SPP framework

The 2nd generation SPP framework was introduced in 2015 with different feed-in tariffs for the development of hydro, biomass, wind, and solar energy projects of capacity 0.1 MW to 10 MW. To benefit from falling prices of solar and wind, a competitive bidding process was introduced for solar and wind projects of capacity 1-10 MW. As such, solar and wind SPPTs were project site specific. Solar and wind projects of less than 1 MW that opted to sell to a distribution network operator were not subject to competitive bidding. However, their tariff was determined by EWURA, or set at a premium to the biomass tariff for a 0.5 MW plant. The said feed-in tariff was set for 15-25 years and would not change even following the arrival of the national grid. Moreover, the tariff was pegged to the US dollar, thereby maintaining the financial situation of the developer (EWURA 2020). However, TANESCO would continue to face exchange rate financial fluctuation risk. The extent of foreign investment the SPPs attracted in the country could not be assessed. Similarly, the long-term exchange rate fluctuation of the Tanzanian shilling against the US Dollar impact on TANESCO's financial performance could not be evaluated. However, over the years there was less interest for the utility to sign new SPPAs owing to the exchange rate risks and diseconomies of scale the mini-grids introduce to the national grid.

3rd generation SPP framework

The 3rd generation SPP framework was introduced in 2017 with an aim to improve on the mini-grids enabling environment, inclusivity and governance. The framework allows mini-grids at multi locations to acquire a single license (above 1 MW) and registration for mini-grids using the same technology (below 1 MW); defines eligible customers that need their tariffs to be reviewed by EWURA; allows grid-connected mini grids to operate in islanded mode when the main grid power supply is not available; provides additional credibility on the clarity on the calculation of compensation for distribution assets when the main grid is connected to previous isolated mini-grids.

It be noted that the SPP framework engulfs regulations and rules all renewable energy small power generation infrastructure of up to 10 MW including mini-grids and embedded plants that generate and export power to the national grid or decentralised grid operated by TANESCO as well as those directly supply on their distribution networks. As such the SPP framework is also relevant to SPPs and VSPPs mini-grids as generators and distribution network operators (DNO). It appears therefore, there is no specific regulation for mini-grids.

Consumer tariffs for SPPs with own distribution network with a capacity of more than 0.1 MW are computed and approved by the regulator. VSPPs below 0.1 MW with own distribution network are unregulated, hence set their tariffs. However, at the beginning of August 2022, three cross boundary companies owning more than 12 VPPs mini-grids each have started being regulated. These companies are PowerGen, PowerCorner and JUMEME.

Tanzania's energy policy does not promote consumer energy subsidies. Instead allows cross subsidies within energy consumer categories for the national grid and SPPs with more than 1 MW and their own distribution network. SPP regulatory framework is innovative with smart subsidies as capital grants in the form of matching grants of USD 100,000 for undertaking feasibility studies, ESIA and business plans; and performance-based grants of USD 500 for each electricity consumer connection.

Developers are encouraged to register at TIC to benefit from tax and subsidy related aspects. Solar PV and wind equipment are exempted from import duties (NEP 2015; EWURA 2020 Rules). As regards asset recovery, SPPs and VSPPs are supposed to obtain a letter of support from the government to qualify for compensation due to grid arrival.

2.0 METHODOLOGY

The research aimed to investigate the regulatory framework and tariff aspects of electricity mini-grids in Tanzania, focusing on four key research questions. The study covered 17 villages across nine regions, namely Ruvuma, Iringa, Kilimanjaro, Morogoro, Dodoma, Njombe, Kigoma, Pwani, and Tanga where 18 operational and non-operational mini-grids were visited and provided diverse experiences (Table 2.1). To align our methodology with the research questions, a purposive sampling technique was employed to select key stakeholders, including representatives from the Ministry of Energy, EWURA, TANESCO, REA, EU delegation, Swedish Embassy, small

power producers (SPPs), and electricity end-users. The selection aimed to capture a spectrum of perspectives on the regulatory framework. Primary data collection involved in-depth interviews and focus group discussions during site visits to mini-grid operators, households, and small and medium-sized enterprises (SMEs). These methods were chosen for their effectiveness in gathering qualitative insights, as emphasized by Mpeta (2015). The interviews with mini-grid developers sought to uncover their perceptions of the existing regulatory rules and tariff arrangement, challenges faced, and suggestions for improvement.

Additionally, focus group discussions with developers were conducted to explore the viability of their businesses and gather insights into how they envision the evolution of the regulatory framework and policies. Engaging electricity end-users through interviews and focus group discussions aimed to understand their perspectives on inclusive and affordable services, along with their preferences for service delivery. The overarching goal was to identify common ground among diverse stakeholders, creating a sustainable and inclusive mini-grid business supportive of local economic development.

Table 2.1: List of mini-grids visited, locations, types, capacities, connection status and operating status

Mini-grid Type	**Village**	**Region**	**Capacity kW**	**Connection Status**	**Operating status**
Tulila Hydro	Mpepai	Ruvuma	5,000	Grid	Operational
Chipole Hydro	Magagura	Ruvuma	400	Grid	Non-operational
Mwenga Hydro	Itipi	Iringa	4,000	Integrated mini-grid & main grid	Operational
Mwenga Wind Power	Usokami	Iringa	2,400		
Kikuletwa Hydro	Chemka	Kilimanjaro	1,650	Grid	Non-operational
TANWAT Biomass	Kibena Njombe	Njombe	2,500	Grid	Operational
TPC Biomass	Langasani	Kilimanjaro	17,500	Grid	Operational
Kibindu Solar PV & Biomass Gasification hybrid	Kibindu	Coast	30+20	Mini-grid	Operational
TANESCO Diesel	Kigoma	Kigoma	6,250	Integrated mini-grid	Operational
NextGen Solar PV	Kigoma	Kigoma	5,000		
Leganga Solar PV	Leganga	Dodoma	15	Mini-grid	Operational
Ngutoto Solar PV	Ngutoto	Dodoma	15	Mini-grid	Operational
Songambele/Kitaita Solar PV	Songambele/ Kitaita	Morogoro	6 + 10kVA	Mini-grid	Operational

Leshata Solar PV	Leshata	Morogoro	6 + 10kVA	Mini-grid	Operational
Mji Mwema MFP Biodiesel/diesel	Mji Mwema	Kilimanjaro	8.8	Mini-grid	Non-operational
Mpale Solar & Diesel hybrid	Mpale	Tanga	50	Mini-grid	Operational
Mvuha Solar PV	Mvuha	Morogoro	20	Mini-grid	Non-operational
Biro Biomass	Biro	Morogoro	30	Mini-grid	Non-operational
Total capacity			**44,900.8kW**		

Source: Authors' compilation

In addition, the study used a thematic analysis method to analyse collected data. This method was used to generate new concepts and insights derived from data. Furthermore, the method provides a comprehensive and rigorous approach to analyse the qualitative data (Sekaran & Bougie, 2016). The researchers listened to the recorded interviews and read the written data numerous times to understand and translate the content. Afterwards, the researchers extracted and combined text about mini-grids sustainability, inclusiveness, and governance to identify themes which were analysed by using ATLAS.ti data analysis software. The ATLAS.ti software was employed to condense and abstract the themes into codes, which were then categorized and applied to the entire set of collected data. The data was reviewed to ensure that the script's original meaning is maintained. This comprehensive analytical approach enhances the robustness of the study's findings and ensures a detailed understanding of the regulatory framework aspects of electricity mini-grids in Tanzania.

3.0 OVERVIEW CONCEPT ON MINI GRID REGULATORY FRAMEWORK RULES AND TARIFF ASPECT

Tanzania in 2022 had a total installed power capacity of 1,740.77 MW, mainly sourced from hydro, gas, and oil (EWURA, 2023). The country imports all its petroleum fuels, making it vulnerable to global market prices. The Energy and Water Utilities Regulatory Authority (EWURA) monitors fuel prices monthly, incorporating operating costs, tariffs, and marginal profits into world market fuel prices (Ebert et al. 2019; World Bank 2021; UNDP, 2022; International Energy Agency [IEA], 2022). Over the past 20 years, oil prices in Tanzania have been unstable but generally increasing, reaching 1.56 US$/l in 2023. If Tanzania heavily relied on diesel for rural electricity, the generation costs would be relatively high compared to photovoltaic (PV) and hydro sources.

In 1992, the first national energy policy was established which encouraged private sector participation in the energy sector. This policy marked the beginning of private generators being permitted to contribute to the national grid and utility supply, breaking the monopoly previously held by the utility in power generation (Marandu, 2012). In 1999, IPTL 100 MW diesel-fired IPP followed by Songas 40 MW natural gas-fired IPP in 2004 were commissioned to supply the national grid. Subsequently, there has been a shift in focus towards renewable energy sources as indicated in the national policy of 2015 (EWURA, 2016) and the power system master plan 2020 update (MoE, 2020).

Tanzania is actively engaged in exploring the potential advantages of the Clean Development Mechanism (CDM) as outlined in the Kyoto Protocol by the Intergovernmental Panel on Climate Change (IPCC) (Eberhard, 2010). In 2005, the CDM Executive Board clarified that national policies implemented after 2001 would not be factored into baseline calculations (CDM Executive Board, 2005). This means that combining the Clean Development Mechanism with Feed-in Tariffs is feasible without compromising eligibility for participation in the CDM.

This literature review aims to survey the existing body of knowledge concerning the regulatory framework and tariff structures associated with electricity mini-grids in Tanzania. The review sheds light on the evolving policy landscape and the key considerations in ensuring the sustainable growth of this sector.

3.1 The regulatory framework

Tanzania has been recognized as one of the leading countries globally in establishing sustainable business models for renewable energy-based mini-grids (URT 2023a). To expedite electricity access and encourage the growth of small power projects by both local and foreign private investors, the Tanzanian Government enacted the Rural Energy Act in 2005. This legislation led to the creation of the Rural Energy Agency and Rural Energy Fund (REA/REF) tasked with supervising the execution of rural electrification projects (REA, 2014).

EWURA, the Tanzanian energy utility regulatory authority, plays a crucial role in regulating energy pricing and overseeing tariff issues and policies (EWURA, 2016; Gratwick et al., 2016). Originally, when the Rural Energy Board was established, TANESCO held a legal monopoly in electricity generation and supply. However, private sector involvement, as envisioned by the Rural Energy Act, only became possible after the industry was liberalized through the Electricity Act of 2008. Even though TANESCO remained vertically integrated after 2013, the act allowed other industry players licensed by the EWURA to participate in the generation and distribution segments (United States Agency for International Development [USAID], 2014).

In 2009, Tanzania introduced the Standardised Power Purchase Agreement (SPPA) and, in 2010, adopted a standard tariff methodology (EWURA, 2016; EWURA, 2009). The SPPA forms the legal basis for connecting renewable energy generators to both the national grid and isolated mini-grids, enabling the export of excess power (up to

10 MW) to the national grid and decentralised grids (EWURA, 2011; Rickerson et al., 2013; Tenenbaum, 2014). In 2013 there were 21 isolated TANESCO-owned mini-grids and five Zanzibar Electricity Corporation (ZECO)-owned mini-grids, relying on existing diesel generation that SPPs had the potential to replace, either entirely or partially (Bhattacharyya, 2013). The SPP framework also allows independent small power producers (SPPs) to construct new isolated mini-grids to provide electricity to communities without access and directly sell to new customers (EWURA, 2010; Tenenbaum, 2014). In cases of connection to isolated mini-grids, the Tanzanian SPP framework offers a high Feed-in Tariff (FIT) for SPPs selling electricity to TANESCO's existing mini-grids (Moner-Girona et al., 2016).

The duties of the regulatory authority, EWURA, encompass setting the tariff for small power producers (SPPs), overseeing power-purchase and service agreements, issuing licenses, and ensuring the maintenance of floor prices for a duration of 15 years. Up to 2022, EWURA had granted approval for SPPAs of a total capacity of 40.1 MW, involving biomass (15.6 MW), solar (2 MW), and hydropower plants (22.5 MW). Of these, 25.4 MW are already contributing power to the main grid.

Among the 10 approved SPPAs, six are designated for isolated mini-grids, involving one solar project (2 MW), three biomass plants (5.1 MW), and two hydropower projects (totalling 8.5 MW). Additionally, three more projects are in progress, consisting of two hydropower projects (4.1 MW) and one solar project (1 MW). Furthermore, there are 32 other SPP projects in various stages of development and preparation.

Furthermore, the Electricity Act of 2008 which replaced the Electricity Ordnance of 1932 last amendment of 1957 is the basis of the comprehensive SPP regulatory framework of Tanzania of 2008 that was developed with the assistance of the World Bank via the Tanzania Energy Development and Access Expansion Project (TEDAP) (Odarno et al. 2017). Under this act, any activity from generation, transmission, distribution, supply, cross-border trade, financial and physical trading, and electrical installations requires a license. The exemption under section 18, from 2008 under first generation SPP regulatory framework, allowed rural generation activities below 1 MW and off-grid distribution and supply activities below 1 MW to operate without a license. Under the second generation SPP framework established in 2015, the threshold unregulated installed capacity was lowered from 1 MW to 0.1 MW so that many rural generating facilities were inclusive, could qualify to use FIT and be able to sell power to the decentralized grids or national grid popularly referred to as anchor customers.

Essentially, the main elements of the SPP regulatory framework consist of a) institutional framework and market structure of the Tanzanian electricity sector, b) national policies that affect mini-grid development, c) acts, regulations, and rules relevant to mini-grids, d) international and national strategies that support mini-grid development, and e) plans, programmes and projects that support, promote and finance renewable energy mini-grids. Elements a to c are presented below whereas elements d and e are in Appendix E.

Institutional arrangements of the sector

The institutional framework involves a number of key stakeholders that promote, regulate, develop, operate and benefit from mini-grids in Tanzania. These key stakeholders include the Ministry of Energy (MoE), Energy and Water Utilities Regulatory Authority (EWURA), Tanzania Electric Supply Company (TANESCO), Rural Energy Agency (REA), Independent Power Producers (IPPs), SPPs, VSPPs, developers, financiers, development partners, NGOs, CBOs and end use customers see Box 1.

Box 1: SPP framework stakeholders

The Ministry of Energy (MoE) formulates and articulates policies and strategies conducive for stakeholders to promote renewable energy.

The Energy and Water Utilities Regulatory Authority (EWURA) has mandates for technical and economic regulation of electricity, petroleum, natural gas, and water sector utilities. It is a licensing authority, that is mandated to establish as well as monitor standards for goods, services, and supply conditions. The authority is also responsible for the preparation of rules and guidelines for small power producers and distributors on their activities, tariff and fee determinations, accounting, reporting customer services and safety. The authority is also responsible for the establishment, regulation, and approval of tariff rates to be used by service providers as well as monitoring and their review over time. Furthermore, the regulator is responsible for conflict resolution among the trading partners. As such the authority is responsible for monitoring the performance of the mini-grids, their operating efficiency and the quality of supply services to the customers.

Tanzania Electric Supply Company (TANESCO) is a vertically integrated power utility responsible for generation, transmission, distribution, and sales to end use customers on Tanzania Mainland and bulk power sales to Zanzibar and Pemba islands. It is also a power off-taker for independent power producers (IPPs) and small power producers (SPPs) as well as imports from neighbouring countries. IPPs and SPPs supply the TANESCO operated national grid and some of SPPs also supply own isolated grids and those operated by the utility TANESCO

Rural Energy Agency (REA) is an autonomous body under MoE responsible for the promotion, stimulation, facilitation and improvement of modern energy access in the rural Tanzanian Mainland, as well as; facilitation and promotion of efficient production and energy end uses; preparation and reviewing of application procedures, guidelines, selection criteria, terms and conditions for the allocation of grants; financing of approved projects by the Rural Electrification Fund; capacity building and technical assistance to project developers and rural community recipients; and undertaking preparation of bid documents for rural energy projects.

Independent Power Producers (IPPs) are private large power plants of more than 10 MW that bulk supply power to the national grid. In turn, SPPs are private companies, cooperatives or communities that independently generate 100 kW to 10 MW and can sell power to the national grid or decentralized grid owned by TANESCO or via their distribution networks. Very Small Power Producers (VSPPs) are those who generate 15

kW to 100 kW and distribute to their distribution networks. Distribution Network Operators (DNOs) are public, private, cooperatives and communities licensed to distribute and sell power to end use customers.

NGOs and CBOs also support and promote electrification in the country, some of which have developed own renewable propelled mini-grids that distribute power to end use customers. Some of these organisations are only involved in the advocacy of clean energy provision, efficient energy usage and support in electrification.

Development partners, financiers and the government that fund renewable mini-grid projects, assist in the provision of smart subsidies for the rural population to afford electrification connection and end-use energy tariffs.

End use customers or retail electricity customers are the direct beneficiaries of the electricity supplied by the national grid and mini-grids.

Acts, regulations and rules relevant to mini-grids

The Electricity Act of 2008 established the framework to guide the Ministry of Energy and various key stakeholders like EWURA, REA, TANESCO, IPPs, SPPs, VSPPs and end use customers. The Act includes elements that form the SPP framework and Small Power Projects Tariffs. The Act also gives EWURA regulatory responsibilities for licensing, development of rules and regulations, tariff setting and approval processes, monitoring, and enforcement of standards/regulations etc.

The Energy and Water Utilities Regulatory Authority Act of 2001 established the Energy and Water Utilities Regulatory Authority with responsibilities for technical and economic regulation of the energy and water sectors. In September 2008 EWURA approved the Standardised Small Power Purchase Agreements (SPPAs); in June 2009 approved the standardized tariff calculation methodology for the national grid; and in September 2009 approved a standardised tariff methodology and applicable tariff for sale of electricity to mini-grids, as well as the Development of Small Power Project Rules of 2020.

The national utility, IPPs and SPPs are subjected to and must abide to a set of well-defined procedures, rules and standards involving registration, construction, operation and power supply delivery services as set out by laws passed by the country's law-making body and oversight bodies or regulators.

As such since 2015 the national utility along with IPPs and SPPs of capacity more than 100 kW are subjected to heavy handed regulation whereas VSPPs below 100 kW are subjected to light handed regulation e.g. registration, no licensing, and no retail tariff approval by the regulator. However, retail tariff computation by the regulator can occur if more than 30 end use customers complain of unfair rates being charged by VSPPs. VSPPs of capacity below 15 kW registration is not mandatory.

The Rural Energy Act of 2005 established the Rural Energy Fund (REF) and Rural Energy Agency (REA) and its board with the responsibility to promote modern energy access in rural areas, financing rural energy projects and provision of matching and performance grants to rural energy developers including mini grids as well as private

sector promotion. The REF has greatly contributed to the accelerated deployment of renewable mini grids in Tanzania since 2008. The REF with financial support from the government budget, development partners' contributions and various services' levies in the country; funds the rural electrification plans on a competitive approach whereby selected projects for implementation are ranked based on the poverty of resources.

Tanzania Investment Act of 1997 established the Tanzanian Investment Centre to coordinate and promote investments including renewable mini grids.

The Occupation Health and Safety Act of 2003 enforces the health, safety and welfare of workers including mini grid operators and end use customers.

The Environment Management Act of 2004 established the Environment Management Council that enforces the undertaking and approval of environmental and social impact assessments for all energy projects as well as energy producers to operate their infrastructure efficiently with minimum environmental impacts to society.

The Public Private Partnership Act of 2010 introduced the responsibilities and obligations of the parties, financial management and control, penalties, remedies, and dispute resolution. The law established the PPP Coordination Units at TIC and the Ministry of Finance which assist investors including mini-grid investors.

The guiding policies that work in tandem with the above mentioned acts and regulations and their main purpose are given in Table 3.1.

Table 3.1: National policies

National policy	Main purpose
The National Energy Policy of 2015	Provides a conducive business environment for private investments and local participation in the sector, supports global initiatives on the provision of sustainable energy for all, promotion of energy conservation and efficiency, increasing energy access to modern energy and share of renewables in the electricity generation energy mix (MoE 2015).
The National Environment Policy of 2015 revised in 2004	Articulates provision of an environmental framework law and environmental standards as well as promotion of environmentally friendly technologies and diversified energy sources by harnessing renewable energy sources.
The Water Policy of 2002	Articulates putting in place fair procedures for accessing and allocation of water resources to benefit the social and economic activities of the nation.
The National Land Policy of 1997	Promotion, ensuring the land tenure system and optimal land resources allocation without sacrificing the ecological balance of the environment.

The National Forest Policy of 1998	Aims at enhancing forest sector's conservation and management of natural resources to contribute to sustainable development of the country.
The National Investment Promotion Policy of 1996	Promotion of investments in the development of commercial and alternative sources of energy.
The National Gender Policy of 2002	Focuses at establishing poverty eradication strategies with gender equality aspects.

The mentioned selected national policies support or hinder mini-grids investments as briefly outlined below. The National Energy Policy of 2015 promotes renewable energy investments via waiver of duties on solar and wind-based investments. The National Environment Policy of 2015 revised in 2004 enforces mini-grid projects to undertake ESIA and obtain clearance before project financing and construction for sustainable energy development. The Water Policy of 2002 provides for optimal mini-hydro grids' water rights to be granted by the government for sustainable and equitable allocation of water resources among competing end uses of various economic sectors.

The National Forest Policy of 1998 provides for the protection of rivers' catchment forests and water sources for sustainable water resources availability during various seasons of the year and over the years as well as curbing soil erosion that causes silting of mini hydro plants' intakes and reservoirs.

The National Investment Promotion Policy of 1996 facilitated the enactment of a law establishing the Tanzania Investment Centre that provides a single roof support to mini-grid investors for various services like business registration, land and water applications and tax aspects.

The National Gender Policy of 2002 provides for poverty eradication among households and addresses gender balance issues in mini-grids investments and operation and maintenance.

International and national strategies, mini-grid plans, programmes and projects also support energy access in Tanzania and are covered in Appendix E.

3.2 Tariff structures for mini-grids in Tanzania

Many countries employ traditional feed-in tariffs typically based on their approach to the electricity generation costs. This involves determining the incentive level considering the anticipated electricity generation amount and the estimated lifespan of the power plant. Given that the costs of electricity generation differ based on the renewable energy technology, most feed-in tariffs establish specific rate levels for each technology (Klein, 2008). The underlying idea is that distinct technologies necessitate varying levels of support to become financially viable for investment.

Conversely, a flat rate is often seen as a mechanism promoting the adoption and expansion of the most competitive, or lowest-cost, renewable energy technology.

In Tanzania, the current SPP framework is employed to establish a fixed rate for selling electricity to the national utility TANESCO's grid, set at an annual average value of 0.10 US$/kWh. Additionally, a higher rate of 0.25 US$/kWh is allocated for selling electricity to isolated mini-grids. It's crucial to note that these off-feed-in tariff (FIT) levels are below the cost of diesel for generator sets (EWURA 2020).

Two distinct approaches are considered for determining off-FIT values. Firstly, under specific circumstances, setting an off-FIT based on the avoided electricity cost may be sufficient to support new renewable energy projects in off-grid areas. Secondly, in cases where the utility's avoided cost is insufficient, the incentives are calculated based on the electricity generation costs.

Tariff structures for mini-grids in Tanzania are designed with a multifaceted approach. They aim to balance affordability for consumers, cost recovery for operators, and sustainability for the system. The tiered pricing structure, including cross subsidised lifeline tariff e.g. Mwenga integrated system customers, has been introduced to ensure that low-income households have access to electricity at affordable rates. Furthermore, innovative models, such as pay-as-you-go and community-based tariffs, have been explored to cater for diverse consumer needs.

The pricing of electricity from mini-grids in Tanzania is a critical aspect of their sustainability and the affordability of electricity services for end use consumers. A key concern is how to establish tariff structures that strike a balance between attracting private sector investments and ensuring that electricity remains affordable for low-income households. The current tariff structure relies on a cost-reflective based approach, which considers the capital and operational costs of mini-grid systems. Ensuring affordable tariffs while covering the costs of system development and operation remains a central challenge in this context.

In turn, electricity tariffs for VSPPs mini-grids in Tanzania appear to be a controversial issue that has drawn the interest of various stakeholders- development partners, development banks, commercial banks, investors, minigrid operators, the government, the regulator, Rural Energy Agency, the national utility, renewable energy suppliers, politicians etc. The main issues include tariff affordability, fairness, equity and social aspects related to tariffs as they affect the rural population. Therefore, tariff categories, levels and their impact to the various stakeholders need to be cost-reflective to mini-grid operations; must be prepared transparently and be inclusive to all key stakeholders; be fair to the energy suppliers and end users; and be affordable, stable and predictable to end users so as to allow smooth energy sector governance.

From 2015 to 2022, pan territorial or uniform tariffs prepared by the regulator employed by the national utility, and were requested by some of the government leaders to be employed by the SPPs and VSPPs customers in their distribution networks. This surfaced to be the most controversial issue in the sector as regards commercial sustainability of

the diverse size and locations of mini-grids and their operations, inclusiveness to all stakeholders and to the energy sector's governance.

3.3 Tariff setting

EWURA employs the Standardised Tariff Methodology to calculate the electricity prices for grid-connected generators and isolated mini-grids operated by the national utility as stipulated in the Small Power Projects Rules of 2020. The methodology is based on the concept of avoided costs, determining a tariff comparable to the cost of alternative options available to the buyer (EWURA, 2009, 2019). This involves averaging the short-run and long-run marginal costs as determined in the power system master plan.

TANESCO operates several isolated grids powered by oil fuel plants in various locations across Tanzania. The long-run marginal cost of Tanzania's grid power (adjusted for losses) serves as the foundation for calculating the avoided costs in the long term, with the anticipation that all mini-grids will eventually integrate with the main grid. EWURA has initiated a revision of tariffs based on a cost-of-service study report from 2013. The outcome indicates that tariffs for mini-grids are considerably higher than those for main grid generation (Rickerson, 2012; EWURA, 2016). There are several efforts the government employed so as to decrease tariff of mini-grids. Among which, the government through EWURA established 2nd generation SPP framework in 2015 which calculates tariffs based on technology (hydro, biomass, wind, and solar energy projects) and capacity of the mini-grids (0.1 MW to 10 MW) to decrease tariff of mini-grids. Despite these efforts made by the government, tariffs for mini-grids remain to be higher than those for main grid generation (Odarno et al., 2017).

Less discussed is the aspect of whether SPP FIT tariffs are cost reflective to the provision of the services. It appears that FIT computed by the regulator and sold by SPPs to the national grid and decentralised grids operated by TANESCO as an anchor customer tend to be financially sustainable if mini-grids are efficiently operated and maintained. Moner-Girona (2016) also discusses this matter with regard to Tanzania. Pueyo et al. 2016 also discuss the aspect of productive energy usage in improving the financial viability of mini-grids. However, regulated and unregulated VSPPs mini-grid tariffs are very high and prevail in areas where affordability is a major concern making financial sustainability highly questionable. Mottram (2022), reveals that communities experience electricity price injustice when mini-grids treat electricity as economic goods. Whether tariffs for mini-grids can be financially sustainable is further discussed by Zigah et al 2016. Thus, there is a need to further study tariff aspects in Tanzania and provide recommendations that shall contribute to lowering mini-grid tariffs.

3.4 Gaps in the existing literature

While the regulatory framework and tariff structures for mini-grids in Tanzania have evolved positively, the literature highlights several challenges. Inconsistent application of regulations, bureaucratic hurdles in obtaining licenses, and limited involvement of local communities in tariff design remains as a persistent challenge. Additionally, there

is a paucity of literature that adequately addresses the practical aspects of regulatory framework and tariff implementation specifically in the aspects of sustainability, inclusiveness, and governance of mini-grids in Tanzania. Therefore, this study provides an insight into the current state of mini-grid regulation and tariff design in the Tanzanian context.

3.5 Comparative analysis

Drawing comparisons with international experiences, it is evident that Tanzania's regulatory framework and tariff structures align with global best practices. However, case studies from countries like Kenya, which have implemented community-based tariff models effectively, offer valuable lessons for some of Tanzania's community mini-grids that failed due to low revenue collection to sustain operations. Emulating these successes could address some of the existing challenges and promote community engagement in tariff design and decision-making.

This literature review provides an overview of the regulatory framework and tariff aspects of electricity mini-grids in Tanzania. While the existing literature reveals substantial progress and alignment with international best practices, persistent challenges and gaps necessitate further research. By learning from comparative experiences and addressing practical issues, Tanzania can continue to enhance its mini-grid sector, ensuring that it effectively contributes to electrification and community development. The development of electricity mini grids in Tanzania is a promising approach to address energy access challenges in off-grid and remote areas. The regulatory framework for mini-grids in Tanzania has evolved significantly, with notable achievements in creating a conducive environment for private sector involvement.

4.0 EVIDENCE FROM FIELD FINDINGS

The aim of this study was to investigate the regulatory framework and tariff aspects of Tanzania. This was achieved through mini-grids visits conducted as well as stakeholder interviews with managers of EWURA, TANESCO, REA as well as SPPs and VSPPs developers and operators. The collected information was analysed by using ATLAS.ti software and the results were presented as follows.

4.1 Regulatory framework related aspects

This objective aimed to assess the regulatory framework of electricity in Tanzania. Apart from the rules, regulations, standards and other directions documented on the regulator's website, this objective was achieved through conducting interviews with managers of EWURA, TANESCO, REA and SPPs developers. The major finding of the study was that the main impetus of mini-grid regulation has been to set a conducive, transparent and fair environment for various stakeholders involved in the sector to be able to play their roles so that the national objective of enhanced electrification access by renewable mini-grids is achieved for the benefit of the country. As such,

Tanzania's regulatory framework has been revised over time to pave the way for investors and developers to accelerate the deployment of mini grids in the country by addressing key aspects, including approval processes of projects, grid compatibility of the proposed technologies versus existing technologies, grid interconnection requirements and compliance to prevailing national standards for service provision. Table 4.1 provides codes for the thematic analysis of the regulatory framework.

Table 4.1: Codes for the thematic analysis of regulatory framework related aspects

Theme	**Regulatory framework**
Codes	Approval process Grid compatibility Grid interconnection Technical standards

4.1.1 Approval processes

The study found that, planning, development, commissioning to operation and maintenance of a mini-grid involves many steps and clearances by a number of different institutions in the country. The developer must identify a site to develop, the technology to be used and undertake the following steps for various clearances to project realization (see Table 4.2).

Table 4.2: Steps for mini grid development clearances

Step	**Institution**	**Clearances**
1	Tanzania Investment Centre (TIC)	Investment facilitation: project registration, tax registration, land lease aspects, business licensing registration, immigration issues (for foreigners) and labour issues.
2	TIC, MoE, REA, TANESCO and EWURA,	Project identification and promotion; submission of concept note
3	Village/Local government	Land lease or right of occupancy
	Water Basin Office	Water right (hydro projects)
4	TANESCO / MoE	Letter of intent (for SPPs to sell power to TANESCO) / Letter of support for VSPP to qualify for compensation when the grid arrives
5	REA	Feasibility studies, ESIA, Business plan, Financing facilitation

6	NEMC/ Ministry of Environment	Environmental clearance
	EWURA	Provisional license
7	District/Municipal Council	Building permit
8	Distribution network operator	SPPA signed
9	Investor/Developer	Plant construction
10	EWURA	Plant commission, and final license

Source: Authors' compilations

Also, the study revealed that, from project planning to project realization, developers have to work closely and inclusively with various stakeholders at village and district up to the national level so as to successfully develop and commission the projects. Investors and developers complained of projects delays due to the many steps and many institutions they work with, resulting into delays to occur. Often delays occur in institutions outside the energy sector e.g. it takes more than 90 days to submit and obtain environmental clearance. The TIC is supposed to be a one-stop-centre for investors by facilitating them in obtaining various project clearances. Owing to a lack of coordination among various institutions, delays in project development or the selection of the wrong technology have occurred in renewable mini –grids projects (Odarno *et al.,* 2017). Furthermore, lack of coordination among donors and government institutions, in particular access to central databases, fewer projects have been funded or limited funding has been committed by donors. Following obtaining a letter of intent from TANESCO, a developer is granted a provisional license for three years for project studies, clearances, financing, construction, to commission before securing a final license. The duration has sometimes been surpassed, causing the regulator to cancel the projects or advise the signed parties to opt for alternative and out of existing regulations' mediation.

Based on the insights discussed, it was revealed that.

> *"In project development, collaboration with stakeholders from local to national levels is vital. Bureaucratic hurdles and inter-institutional complexities often lead to delays, especially in obtaining environmental clearances. The TIC aims to simplify processes, yet in renewable mini-grids, disjointed efforts cause hiccups. Discord among donors and government institutions limits funding. The three-year provisional license can tighten, leading to regulatory cancellations or alternative mediation."* Interview with EWURA Manager 2022

4.1.2 Grid compatibility

Furthermore, the study has observed that, small power projects that sell power to the grid/isolated grids owned by TANESCO must be compatible with existing and operating grid system to be connected to it as per SPP rules of 2020 (EWURA 2020). In

the case of a VSPP establishing its own distribution network, or a developer wanting to undertake services as a distribution network operator, the infrastructure needs to be commissioned as grid compatible. In the case of a VSPP, they must obtain a letter of support from the MoE so as to qualify for infrastructure compensation when the grid extends to their network.

Several regulatory tools have been put in place: The Electricity (Grid and Distribution Codes) Rules, 2017, GN 451; The Electricity (Generation, Transmission and Distribution) Activities Rules, 2019 GN 462; The Electricity (Standardised Small Power Projects Tariff Order) Order 2019, GN 464; The Electric (Supply Service) Rules 2019.

Observations from visited sites indicate operational problems in integrated mini-grid switching due to wrong CT ratio settings at the initial days of interconnection. This happens due to lack of experience by the operators in running such systems. Also, problems of synchronisation and associated costs to SPPs when the national grid is not stable as they have to purchase expensive power from the national grid many times.

Also, this is revealed by TANESCO manager, who stated that.

> *"In setting up small power projects, it's crucial to match them with the existing grid system, as per the 2020 SPP rules. If a project creates its own distribution network, it needs to make sure it works well with the grid. There are rules and tools, like the 2017 Electricity (Grid and Distribution Codes) Rules, to guide this. Mistakes in the initial setup, like wrong CT ratio settings, can cause issues, especially for mini-grids. So, getting it right from the start is important."* Interview with TANESCO Manager 2022.

4.1.3 Grid interconnection

Moreover, mini grid visits revealed that; SPPs being developed for sale to the national grid, or isolated grids owned by the national utility along SPPA, strive to select the right technology, size, and undertake component matching to allow interconnection with the grid or synchronization for optimum levels of power exchange and quality of supply services. As such, the interconnection point, equipment requirements, and expected operating conditions are agreed upon by both parties and signed as part of the SPPA with detailed drawings and appropriate specifications appended to the SPPA. This is according to the SPPA The Electricity (Development of Small Power Projects) Rules 2020 GN 491. Observations from all visited operating SPP mini grids connected to the grid and isolated mini-grids operated by TANESCO comply with connectivity conditions as set out in the grid code rules.

Furthermore, it was found that.

> *"In creating small power projects for the national grid or local grids, it's crucial to choose the right technology and match components for smooth interconnection. The Standardised Power Purchase Agreement 2020 and Electricity (Development of Small Power Projects) Rules 2020 (GN 491) stress the importance of clear agreements on equipment, operating conditions, and detailed specifications."* Interview with TANESCO Manager 2022.

In addition, mini grids visits revealed that, mini grids connected to the grid and isolated mini grids operated by TANESCO seem to smoothly operate. The TANWAT mini-grid efficiently supplied TANESCO's Njombe, Makambako and Uwemba mini-grids during 2006 to 2008 and then the national grid from 2010 to 2019 when the plant failed, and services resumed since 2022 following the refurbishment of the plant. TPC mini-grid in Kilimanjaro region, has been efficiently supplying the national grid since September 2010 to date. Tulila supplied the Songea, Mbinga and Tunduru mini grid from 2015 to 2018 and the national grid since 2018. Mwenga hydro and later Mwenga hydro and wind integrated mini-grid system has been efficiently supplying the national grid since 2012.

This is evidenced by one of the respondents who indicated that.

> *"Most observed SPP mini grids, both connected to the grid and isolated ones by TANESCO, operate smoothly. Notably, TANWAT served TANESCO's grids efficiently from 2006 to 2019, resuming in 2022 after refurbishment. TPC has been supplying the national grid since 2010, Tulila since 2015, and Mwenga hydro and wind since 2012."* Interview with TANESCO Manager 2022.

4.1.4 Technical standards

The study also found that, apart from listed rules and regulations mentioned in 4.1.3, relevant standards include TZS 1373:2011 – Power Quality – Quality of supply; TZS 1374: 2011 Power Quality – Quality of service and reliability; and TZS 1375:2011 Electromagnetic compatibility (EMC) – Limits for voltage change, voltage fluctuations and flickers in low voltage supply system for equipment with rated current of < 16A per phase and not subject to conditional connection and other standards governing limits for harmonic current emission.

Also, mini-grids visits showed that a number of VSPPs that are non-registered and non-regulated adopt the lowest approved standards (for example use of 25 mm^2) in their distribution infrastructure, and when the grid is extended into their premises, they must construct new infrastructure higher standard of 50 mm^2 or even higher, and therefore cannot compensate existing infrastructure. As an example, a mini-grid in the coastal area used nonstandard wooden poles in terms of pole diameter for its distribution network.

4.2 Tariff related aspects

Economic power sector regulation involves tariff derivation, setting standards for quality of supply, and entry and exit conditions for providing services (Tenenbaum et al 2014). Tariffs related aspects are separately dealt with in this section. Apart from documents available on the EWURA and other energy institutions in Tanzania websites, the objective to assess tariff related aspects of electricity in Tanzania was achieved through conducting interviews with EWURA managers, TANESCO managers, REA managers and SPPs developers. The major finding of the study was that electricity tariff-related aspects appear a sensitive or rather controversial issue in

Tanzania, as there are diverse viewpoints which are challenging to reconcile. To understand the problem, one needs to review the tariff setting methodology being applied in the computation of tariffs, prevailing tariff types and levels being used by different business models, comparison of the mini grid and national grid tariffs and whether cost recovery is achieved from the said various tariffs to guarantee electricity sector governance. Moreover, whether tariff levels being applied match with quality of power supply services requirements of various types of customers.

Table 4.3: Codes for the thematic analysis of tariff related aspects

Theme	**Tariff**
Codes	Tariff setting Tariff levels Mini-grid and national grid tariff comparison Cost recovery

4.2.1 Tariff setting

The study found that, tariff setting methodology is guided by the "Electricity Development of Small Power Projects Rules 2020" (EWURA 2020). A small power project operator supplying power to the grid or isolated grid operated by the national utility shall charge a tariff approved by the regulator and computed based on avoided cost principles for SPPA signed before 1st August 2015, the tariffs of which shall be revised annually, or technology-specific principles for SPPA signed after 1st August 2015. The latter approach requires that the tariff is calculated to be cost-reflective with a margin for profit. It should be noted that before 1st August 2015, the tariffs were technology neutral and were different during dry and wet seasons. Furthermore, avoided costs for the main grid were lower than those in isolated mini-grids (see Tables 4,4 to 4.6).

Table 4.4: Tariffs for main grid connection under the first generation SPP framework (avoided cost)

Description		Approved Tariff w.e.f. 1st May 2019 (TShs/kWh)
Standardised Small Power Purchase Tariff		203.11
Seasonally Adjusted Standardised SPPT Payable in	Dry Season	243.73
	Wet Season	182.80

Source: EWURA

Table 4.5: Tariffs for mini-grid before and after grid connection under first generation spp framework (avoided cost)

	Before Year 2018 Grid Connection (TShs/kWh)	After Year 2018 Grid Connection (TShs/kWh)
Standardised Small Power Purchase Tariff	480	180

Source: TaTEDO-SESO Field Data

Moreover, the study revealed that tariffs for the second generation were technology and size based – hydro, biomass, solar, wind etc and cover the following: (a) operating costs; (b) depreciation on capital, whether supplied by the Small Power Producer or Small Power Distributor or others; (c) interest expenses; (d) reserves to deal with emergency repairs and replacements; and (e) taxes, and a reasonable return on equity that reflects the risks faced by the Small Power Producer or Small Power Distributor. The trend of SPP tariffs is in Appendix B.

Table 4.6: Tariffs for SPPs selling electricity to the grid based on specific technology under second generation (w.e.f. 21st June 2019)

Capacity (MW)	Mini hydro	Wind	Solar	Biomass	Bagasse
	USc/kWh	USc/kWh	USc/kWh	USc/kWh	USc/kWh
0.1-0.5	10.65	10.82	10.54	10.15	10.71
0.51-1.00	9.90	9.95	9.84	9.34	9.09
1.01-5.00	8.95	9.42	9.24	8.64	8.56
5.01-10.00	7.83	8.88	8.34	7.60	7.55

Source: EWURA

This is evidenced by one of the respondents who revealed that.

> *"The tariff for small power projects connecting to the grid or a national utility's isolated grid is determined by the 'Electricity Development of Small Power Projects Rules 2020' (EWURA 2020). Projects signed before August 1, 2015, follow avoided cost principles with annual revisions, while those after use technology-specific principles, ensuring cost reflectivity with a profit margin. Notably, tariffs were technology-neutral before August 1, 2015, and varied between dry and wet seasons. Additionally, avoided costs for the main grid were lower than those for isolated mini-grids."* Interview with EWURA Manager 2022.

In addition, the results showed that, previously VSPPs were unregulated, as such they set their own tariffs without the approval of the regulator (see Appendix C). Tariffs were

most often set to cover their costs of providing services including a margin for profit. Normally the tariff was presented to the consumers prior to the beginning of business operations so that the consumers were aware and could voice their concerns. An extension of the problem is that the services provided by most of the VSPPs does not last 24 hrs 7 days a week making it rather cumbersome in establishing tariffs for customers billed using load limiters. Energy services are purchased using cellular phones, card tokens, etc., but these systems are not well understood by some of the customers. This concern was raised by many household consumers interviewed during the VSPP mini-grid visits. In part, the cost of regulating the multitude of VSPPs located in distant and remote locations serving a few customers whose major load is lighting is a major challenge expressed by the regulator.

Furthermore, some VSPP have complex billing systems e.g. flat rate billing per day using load limiters, whether power has been consumed or not. Such billing systems do not encourage energy efficiency and demand-side management of the energy services by the customer. Energy services are purchased using cellular phones, card tokens etc., but these systems are not well understood by some of the customers.

Also, we were informed that from 2015 to 2022, all VSPPs were directed by the government to charge the same subsidised pan territorial retail tariff charged by TANESCO of Tshs. 100 per unit. Many VSPP investors stopped providing their services and the development of new projects, as the pan territorial retail tariff was not financially sustainable for their businesses. The pan territorial retail tariff was waived in 2022 and now VSPP can set their own tariffs, if they serve less than 30 customers and there are no customer complaints registered with the regulator.

On 1st August 2022, the regulator instituted via Government Notice a VSPP tariff of TShs 1,600 per unit for the following solar based mini grid service providers: PowerCorner, PowerGen and JUMEME. Tariff derivation for other renewable energy VSPP is ongoing. Many VSPP investors request that the government subsidise the services so that VSPP investors can make a profit by selling at the pan territorial tariffs that apply to the national utility. PowerCorner owns 12 mini-grids with a total installed capacity of 310.1 kW; PowerGen 20 mini grids, 438.9 kW; and JUMEME 21 mini grids, 1,141kW. Retail tariff derivation for other renewable energy VSPP is ongoing. Despite solar and wind equipment being exempted from various duties, many solar based VSPP investors request that the government subsidise their services so that they can make a profit by selling at the pan territorial retail tariffs that apply to the national utility. So far subsidies in the form of matching grants are provided by REF to SPP developers who have received a letter of intent from TANESCO to undertake feasibility studies, environmental and social impact assessment, and business plans. Also, SPPs obtain performance grants for each customer they connect. It appears however, that VSPPs developers do not benefit from both types of subsidies enjoyed by SPPs that could make tariff setting mechanism inclusive to VSPPs as well.

Additionally, this is evidenced by another respondent who stated that.

> "… *Very Small Power Projects (VSPPs) set their own tariffs without regulatory approval, often covering costs and adding profit margins. Some used flat-rate*

billing, hindering energy efficiency. From 2015 to 2022, all VSPPs were mandated to charge a subsidized tariff, leading to service disruptions. In 2022, VSPPs can set tariffs, but challenges remain, with calls for government subsidies and concerns about regulatory complexities for small, remote projects. Unlike Small Power Projects (SPPs), VSPPs currently lack certain subsidies, impacting their ability to compete in tariff setting." Interview with Ministry of Energy Manager 2022.

4.2.2 Tariff levels within and across mini-grid locations

The results found that, Tanzania has two types of tariffs, connection charges and energy charges. Infrastructure connection charges depend on the distance of the customer from the point of connection; the type of connection whether single phase or three phase power supply; and the power or voltage level of connection – low voltage 230-400V, medium voltage 11-33 kV or high voltage 132- 400kV. Connection charges differ among service providers and incentives provided by energy service providers also contribute to differences.

Energy charges tariffs are costs associated with energy consumption services provision following connection to the service provider infrastructure. Energy charges tariff types include a) uniform block tariff whereby the tariff is the same for each unit consumed despite consumption level, b) ascending block tariff whereby it is cheaper for small consumption levels and increases with consumption, and c) descending block tariffs whereby the tariff reduces with consumption.

Tariff types and levels differ with the business model employed: community, private, faith based and public. Also, tariff levels depend on if the project is subsidised, or some of the infrastructure components are exempted from duty or taxes, or a combination of these. Examples are given below.

This is evidenced by one of the respondents who indicated that:

> *"In Tanzania, we have two types of tariffs: connection charges and power service tariffs. Connection charges vary based on customer distance, connection type (single or three-phase), and power or voltage level (low, medium, or high). Differences among service providers and incentives contribute to variations. Power tariffs, associated with energy consumption, come in three types: uniform block, ascending block (cheaper for small consumption), and descending block (reduces with consumption). Tariff levels vary with business models (community, private, faith-based, public) and subsidies or tax exemptions for infrastructure components.*" Interview with Ministry of Energy Manager 2022

Also, the results indicated that, SPPT are standardised based on generation technology and size of the SPP plant since they all sell to the national utility. SPPs selling to own mini-grids differ depending on the business model being employed. Community owned and operated mini-grids set their own tariffs which is approved during the annual meetings and are inclusive via customers' participation and

endorsement. Private business model SPPs selling to customers in own mini-grids must submit a tariff application to the regulator who reviews it and may require the developer/operator to present his application for a public hearing whereby intended/connected customers offer their views and then the regulator authorises the tariff that is cost reflective to the services to be provided. In the case of the faith-based organisations (FBO) business model, the electrical infrastructure is sometimes donated, and power services are provided as a charity service with a tariff that is often very low and not cost reflective. In that regard, FBO owned mini-grids tend to be financially not sustainable. In turn public owned SPPs like TANESCO business model, must submit a tariff application to the regulator for review and be subjected to a public hearing before approval via government gazette notice.

From 2008 to 2015 VSPP tariffs were unregulated whereby they set their own tariffs which they presented to their intended customers during project development. As such customers who wanted their services faced connection and retail energy services tariffs presented to them. VSPPs with more than 30 customers retail tariff was reviewed by the regulator if they filed a complaint to the regulator regarding tariff level injustice or poor power supply quality services. Then the regulator could intervene to remedy the situation. As of August 2022, regulation of VSPPs tariffs started with mini grids owned by PowerCorner, PowerGen and JUMEME companies.

VSPP retail tariffs are also affected by the type of billing, metering, and bill payment model in practice. If billing is based on credit meters which are read once a month, then the bills are computed based on the unit energy cost and energy units consumed. This type of practice is not preferred by project developers, as it creates debt from some of rural customers who fail to repay and end up being disconnected. Instead, load limiters or pre-payment energy meters are preferred, as these technologies avoid this issue. However, load limiters do not incentivize the consumer to undertake energy efficiency in consumption as a demand-side management. Also, some of the VSPP customers with load limiters pay every day for their connection, whether the power supply provided is used or not. This type of metering practice should be avoided in rural areas as it contributes to making the tariffs to be high and many customers fail to comprehend. Pre-payment energy metering seems most suitable to both developers and energy end-users. The payment arrangement/model most preferred by VSSPs is pay-as-you-go, whereby units are pre-purchased online, and customers are connected and disconnected online when the units are consumed, or payment days are over, whatever form of arrangement used. The pay-as-you-go payment arrangement at least guarantees enough revenue for the service provider and appears to pave the way for the financial sustainability of VSPPs if efficiently operated and maintained. What remains as a burning governance issue, however, is the high tariffs that are charged by VSPPs to rural customers that cannot be afforded by the majority of rural people. Notwithstanding the existence of robust and streamlined SPP framework and tariff setting mechanism in Tanzania, equity and fairness of high tariffs charged by VSPPs remain challenging to the government and the regulator that much work is needed to be done so as the rural poor with

affordability inclusivity problems are aligned to addressing the broader mini-grid sector governance aspects.

In addition, the study found that:

> *"The billing, metering, and payment model significantly impact Very Small Power Project (VSPP) tariffs. Credit meters, read monthly, risk bad debts from rural customers. Load limiters, though avoiding bad debts, lack energy efficiency incentives. Pay-as-you-go, with pre-purchased units, is preferred for both developers and users, ensuring revenue and financial sustainability. However, the challenge remains in addressing high tariffs for rural customers, demanding a delicate balance between financial viability and affordability, requiring further governance considerations in the mini-grid sector."* Interview with EWURA Manager 2022.

4.2.3 Mini-grid vs national grid tariff comparison

The results revealed that, customer connection charge tariffs are supposed to fully cover the cost of extending electrical infrastructure to the new customer. In the case of the national grid and mini-grids supplied by TANESCO, approved connection tariffs differ between urban areas and rural areas (see Appendix A). SPPs that sell directly to the national grid and to own distribution networks have customer connection charges. In turn, all SPPs have own distribution networks and have different connection charges (see Appendix B). SPPs offer lowered connection fees as an incentive to connect as many customers as possible. Equally, several solar based VSPPs visited charge TShs 50,000 to connect including house wiring (actual cost is much higher), which is subsidised by the service provider as an incentive to connect as many customers as to establish a threshold of customers for his network. TANESCO grid and mini grid rural customers pay a connection charge of TShs 27,000 (being only VAT) as an incentive to connect but costs exclude house wiring.

Energy charges are set to be cost reflective to energy service providers. As such energy charges tariff purely depends on economies of scale and the efficiency of operating the energy system. Therefore, grid energy generation tariffs tend to be lower than mini-grid SPP generation tariffs, SPP generation tariffs are lower than VSPP generation tariffs.

Also, the results found that, main grid retail tariffs have three components: service charge in Tshs/month, maximum demand charge in Tshs/kVA and energy charge in Tshs/kWh. The service charge covers billing costs, the maximum demand charge is a fee on maximum demand registered in kVA each month or 75% of the average maximum demand in kVA in the last three months registered by the end use customer, and energy charge reflects the cost of operation and maintenance of the energy services by the end use customer (see Appendix B and C)

Additionally, it was revealed that, SPPT tariffs are generation energy tariffs for kWh exported to the grid or decentralised grid. They do not include the maximum demand charge or capacity charges in kVA often charged by IPPs when they trade with

TANESCO, since SPPs trade at medium and low voltage and their contracted capacities cannot be guaranteed at all times of their operations i.e. they are not dispatchable. Furthermore, SPPs with own distribution network have retail customer energy charges in kWh. In turn, VSPP retail energy charges tariffs are also in terms of energy for each kWh consumed. Owing to their small market, high capital costs, and low utilization factors of the infrastructure, they tend to be very high compared to national grid tariffs and feed-in tariffs charged by SPPs when they sell power to TANESCO.

Therefore, grid versus mini grid tariff differences exit. Examples of regulated VSPP end use customer tariffs are in the tune of Tshs 1600/kWh, unregulated VSPPs are in the tune of Tshs 2000-4000 Tshs/kWh. SPPs selling to TANESCO under SPPTs are about Tshs 180-480/kWh (for 1st generation SPPs) and USc 7.55 - 10.82/kWh or Tshs 189-270/kWh (for 2nd generation SPPs). It be noted that SPPT for SPPs registered under the first generation framework based on avoided costs the tariff plunged from Tshs 480/kWh to Tshs 180/kWh upon grid extension to the mini-grid. In turn, national grid retail energy charges tariffs are in the tune of Tshs 100 –292/kWh if you exclude monthly service charge and maximum demand charge for large customers. It be noted that D1 subsidised energy charge tariff sold to TANESCO end use customers at 100 Tshs/kWh is a lifeline tariff that is cross subsidised by tariff T1 retail customers. In view of the above, huge tariff level difference exist between subsidised D1 tariff for main grid customers in comparison to VSPP regulated and unregulated tariffs in mini-grids. The tariff level difference is rather modest between the national grid and SPP supplied customers.

Moreover, it was evidenced by one of the respondents who revealed that:

> *"Connection charges cover electrical infrastructure costs, varying by location. Energy charges reflect efficiency, with grid tariffs lower than mini-grids, and SPP tariffs lower than VSPPs. Main grid tariffs include service, demand, and energy charges. VSPP tariffs are notably higher due to small markets and high capital costs. National grid tariffs range from Tshs 100-292/kWh, differing significantly from VSPP tariffs."* Interview with EWURA Manager 2022

End use customer aspects

The results found that, main grid customers expect to obtain 24 hours, 7 days a week energy services. Small and large residential customers are connected by single phase two wire and three phase four wire low-voltage connections respectively. Productive energy consumers – workshops, grain mills, oil press mills, carpentry workshops and SMEs connect depending on their power needs. Mini grids operated by SPPs also tend to comply with such services. Moreover, main grid and SPP served customers have customer service charters with service providers that is approved and monitored by the regulator regarding power supply quality service standards. VSPPs service operators do not have such customer service provision charters with their customers making it rather a shortcoming to their services to customers.

Furthermore, it was found that, most of the solar VSPPs are small in installed capacity and as such cannot provide three phase power supply to relatively large customers involved in productive energy uses – carpentry works, grain milling, oil press mills and

the like. Some VSPPs tend to limit such large customers to undertake their services during low peak periods of the day and disconnect from the services during the peak periods. Another challenge expressed was that there are not readily available large capacity rated single phase motors that they can use in some of the villages that provide single phase power supply. As such some of them were forced to revert to the use of diesel and petrol-fuelled prime movers. During the study, we visited three VSPP mini-grids that had been encroached by the national grid. Productive use customers immediately switched from prime movers to electricity driven motors for their services due to lower operating costs and better service provision. However, owing to the long distances of the medium voltage supply lines to some of the villages connected to the grid, one to two days in a week power supply service was not provided due to preventive and non-preventive maintenance being done during such days. As such the large productive use customers had to switch back to prime movers during those days or stop their services.

Moreover, the results indicated that in the case of SMEs e.g. barber shops, salons, shops, food and drinks kiosks services providers did connect to both the national grid when providing services and reverted to the mini-grids when the national grid was out. What happened was that the national grid and mini grid services co-existed. In the case of most of the lighting customers, they remained only connected to the national grid and hence used other sources like candles, wick lamps or battery charged lamps. These aspects are discussed to show the extent of impact beyond tariff level comparison between the national grid and mini-grids. The third SPP generation framework has provisions following the national grid extension to the mini grid, the mini-grid infrastructure can be compensated. Experience from the three villages national grid and mini grid co-exists were not compensated since the mini-grids had no letter of support from MoE. One cross boundary solar-based VSPP operator confirmed that 10 of his mini-grids had been encroached by the grid, has not been compensated and were still co-existing with the national grid.

This is evidenced by one of the respondents who indicated that;

> *"Main grid customers enjoy 24/7 energy services, with residential customers connected via single or three-phase low voltage. Productive consumers connect based on power needs. Main grid and SPP customers have service charters monitored by the regulator, but VSPPs lack such provisions, affecting customer satisfaction. Some solar VSPPs face challenges serving large customers with three-phase power, leading to limitations on usage during peak periods. In instances where national grid and mini grid services coexist, SMEs switch between them based on availability. The compensation for mini-grid infrastructure is available in the SPP framework, but experience shows challenges in cases where coexistence with the national grid is not supported by the Ministry of Energy."* Interview with Energy user 2022.

4.2.4 Cost recovery

The study found that, cost recovery is key to the financial sustainability of mini-grids, and contributes to electricity sector governance on the part of service developers and providers and energy service end users. Cost recovery is achieved if revenues from sales of energy and various services rendered by the utility cover the costs of service, including generation, transmission, distribution, administration costs, depreciation and costs of various utilities consumed. Cost recovery is augmented if there is a profit margin.

Also, the study indicated that, during the past years, the national utility has been complaining that the approved retail customer tariff is not cost reflective. In the last two years, however, TANESCO has been collecting annual operating revenue more than annual operating costs, but when considering the outstanding debt from previous years, has not been making a profit. Moreover, the average SPPT or feed-in tariffs charged by SPPs selling to TANESCO is higher than the average selling price of TANESCO. This implies the tariff is not attractive to TANESCO. SPPs selling power to TANESCO grid or decentralised grid via FiT whereby TANESCO is an anchor customer, or via other anchor customers like large productive users tend to be financially viable if efficiently operated and managed.

In turn, when the VSPPs were required by the government during 2015-2020 to sell their power using the subsidized pan-territorial tariff being used by TANESCO of Tshs 100 per kWh, against the existing tariffs of Tshs 2,000 – 4,000 per kWh, there was no cost recovery. As such some of the VSPPs stopped provision of their services, and developers stopped developing new mini grids. From 2022, the previous tariffs employed by VSPP were once more allowed. Furthermore, VSPPs sell power in rural areas where affordability is a challenge, they operate at low utilisation factors and the availability of anchor customers is rare. As such VSPP business models and financial sustainability appears questionable.

High tariffs charged by VSPPs in rural areas do not meet the aspirations of the government on social and equity considerations. So, they are not considered as a long-term solution for electrification of those areas. As such there is a need for subsidy provision to VSPPs so that they can sell power at affordable rates and as enjoyed by customers in the national grid.

This is evidenced by the response of one of the respondents who stated that;

> *"Cost recovery is crucial for mini-grid sustainability, involving revenue covering all service costs and ensuring a profit margin. TANESCO faces challenges with non-cost reflective tariffs and accumulated debt. Higher SPPTs from SPPs are unattractive to TANESCO. VSPPs struggled with a subsidized tariff, impacting services. Subsidies are essential for VSPPs to offer affordable rates, aligning with electrification goals."* Interview with TANESCO Manager 2022.

5.0CONCLUSIONS AND RECOMMENDATIONS

5.1 Concluding remarks

The study concluded that, Tanzania is fortunate to have a comprehensive and innovative SPP framework that addresses most of the key players and actors of the mini-grid development and operation challenges which if well observed can significantly contribute to accelerated deployment of mini grids in the country and hence speed up electrification of the rural areas. Furthermore, the Tanzanian SPP framework has migrated from first generation technology neutral tariff to second generation technology specific and size-based tariffs pegged to the US Dollar to the third SPP generation framework whereby integrated mini-grid operation is allowed and compensation for infrastructure can be provided to the mini-grid following grid extension to the mini-grid, though compensation has not happened to-date. Moreover, the framework is inclusive of most of the mini-grid players' interests, and accommodates standards and regulations that can contribute to the technical, environmental, and financial sustainability of mini-grids though is a challenge to the regulator to monitor and observe standard service provision in a multitude of VSPPs widely dispersed in the rural areas of Tanzania. The framework has sound rules and regulations that aim at making mini-grids and the rest of the electricity sector governance possible.

Concerning tariff aspects, the study concluded that tariff aspects are indeed controversial owing to divergent interests, limited resources to monitor and regulate tariffs in rural areas where the cost of provision of energy services is high, overall high risks in the sector, and the high tariffs being charged by e.g. VSPPs because of this. Equity and social aspects from high tariffs charged by e.g. VSPPs is a major concern of the government, and the regulator as main grid low-income retail customers are subjected to subsidised tariffs whereas their counterparts in VSPPs mini-grids face very high tariffs. This kind of energy service injustice is a concern in the country's mini-grids and electricity sector governance. It be noted that Tanzania is among a few African countries that has enjoyed political and economic stability for a long time. From 2015 to 2020 there were government's interventions to impose subsidised lifeline tariff prevailing in the national grid to as well prevail in VSPP mini grids which resulted in many VSPPs to halt service provision and developers stopping development of new projects as well as development partners to withheld financing mini grids. Since 2022 VSPPs have been allowed to charge cost-reflective tariffs and the regulator has provided a tariff for three mini grid operators with many VSPP mini-grids though the tariff is 16 times the subsidised tariff in the main grid. Similar efforts are ongoing to establish tariffs for all the VSPPs providing service to more than 30 customers.

Some of the key responses to the main research questions in the study include the following:

The study concluded that business models that have succeeded in delivering technical and financial sustainability for mini grids are SPPs with SPPAs with TANESCO

an anchor customer with hydro and biomass based SPPs; and wind and solar based SPPs in integrated mini-grid systems. Owing to diseconomies of scale, end use customer's affordability problems and metering challenges, VSPP models are not sustainable. Also, women and children have benefited from improved lighting, cooking, saloon and drinks kiosk SMEs, and improved schools and health services. Developers, technology suppliers, laborer's, communities in general benefit from the mini-grid supply chain.

Furthermore, key mini-grid drivers include the right energy technologies, policies, regulatory framework, innovative financing arrangements, effective business models and smart subsidies. Hinders of mini-grids are political interventions, high cost of regulation for VSPP below 100kW, lack of knowledge by community leaders and end use customers on tariffs and metering aspects, social equity issues involving well to do national grid customers are highly subsidised against poor customers in rural areas whose retail prices are 16 to 40 times. Lastly, Tanzania's comprehensive SPPs regularity frameworks are key to accelerated deployment of mini-grids in the country and can be adapted in other Sub-Saharan African countries.

The study concluded that the following regulatory and tariff-based challenges can be addressed;

Starting with the Government, the challenge is provision of coherent policy guidelines that ensure social equity as a component of electrification whose intervention can be ensured by improved existing regulations. Owing to multitude of SPPs in the country, it is expensive to monitor their performance and hence maintain quality of supply services by the regulator, the intervention is by undertaking monitoring to address quality of supply, operational efficiency, and tariff matters. Prevailing pan territorial tariffs of the national utility appear not cost reflective and regulated SPPs investors face difficulties to enter into SPPA with the utility as FIT appears higher than their average selling price, that can be addressed by the regulator to undertake a cost-of-service study. Not a single VSPP mini-grid has been compensated following national grid encroachment that is possible by maintaining the national standards and steps in project development.

End use customers have no approved customer care service charters for VSPPs in their locations that can be addressed by the establishment of a standardized VSPP service charter. Metering, billing, and payment arrangements via web-based platforms are complex and could be replaced with simple models. VSPPs retail tariffs are very high and controversial which for equity and social aspects could be addressed by the adoption of pan-territorial uniform tariffs in the national grid via subsidisation.

5.2 Recommendations for further research

Future research in this domain should focus on addressing the identified challenges and gaps. Studies that explore the practical implementation of tariff structures, assess their impact on community development, and provide actionable policy recommendations can contribute significantly to the field. Additionally, an in-depth

analysis of the socio-economic and environmental impacts of mini-grids, within the Tanzanian context, is essential for a holistic understanding of the sector.

However, the challenges of regulatory implementation and tariff structuring remain, and further research and policy development are needed to ensure the sustainability and scalability of mini grid systems. The impact of electricity mini-grids on energy access in Tanzania is evident, but more comprehensive studies are required to assess their long-term socio-economic and environmental implications, ultimately guiding the development of more effective and inclusive policies in this sector.

However, there is a need for more rigorous research to assess the long-term sustainability and scalability of these mini grid systems, as well as their impact on poverty alleviation, job creation, and social development in Tanzania.

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APPENDICES

APPENDIX A: TANESCO End Use Customer Tariff 1st April 2016 to 2024

Customer Category	Component	Unit	Approved Tariff
D1	Service charge	TShs/month	0
	Energy charge (O-75 kWh)	TShs/kWh	100
	Energy charge (above 75 kWh)	TShs/kWh	350
T1	Service charge	TTShs/month	0
	Energy charge	TShs/kWh	292
	Maximum Demand charge	TShs/kVA/month	0
T2	Service charge	TShs/month	14,233
	Energy charge	TShs/kWh	195
	Maximum Demand charge	TShs/kVA/month	15,004
T3-MV	Service charge	TShs/month	16,769
	Energy charge	TShs/kWh	157
	Maximum Demand charge	TShs/kVA/month	13,200
T3-HV	Service charge	TShs/month	0
	Energy charge	TShs/kWh	152
	Maximum Demand charge	TShs/kVA/month	16,550
Key:			
D1: Low usage (lifeline tariff) for domestic customers who on average consume less than 75 kWh per month. Any unit exceeding 75 kWh is charged a high rate of TShs 350 per kWh. Under this category, power is supplied at a low voltage single phase (230V).			
T1: General usage tariff for customers including residential, small commercial and light industrial use, public lighting, and billboards. Power is supplied at low voltage single phase (230V) as well as three phases (400V). Lifeline (D1) tariff is cross-subsidized by T1.			
T2: Applicable to general use customers where power is metered at 400V, average consumption is more than 7,500 kWh per meter reading period and demand does not exceed 500kVA per meter reading period.			
T3-MV: Applicable to customers connected to medium voltage.			
T3-HV: Applicable to customers connected to high voltage including ZECO, Bulyanhulu Gold Mine and Twiga Cement Factory.			

NB: a) Pre-paid energy metering for D1, T1 and T2 tariff categories; credit energy metering for T2, T3-MV and T3-HV with kVA maximum demand metering.

b) T2, T3MV and T3HV consumers who stop consumption or consume less demand in kVA will be charged on average 75% of the previous three months' maximum kVA recorded. Energy charges in kWh will be charged as indicated. After three months, the demand charge will be according to the prevailing reading.

c) End use customer connection charges, excludes VAT 18%, REA 3%, and EWURA 1%.

i) **Single phase charges**

Service Line	Approved connection charges (TShs)	
	Urban rate (VAT exclusive)	Rural rate (VAT exclusive)
Within 30 meters	272,000	27,000
Within 70 meters (one pole)	436,964	27,000
Within 120 meters (two poles)	590,398	27,000

Source: TANESCO

NB:

a) Beginning 1st July 2021 service line connections charge in the urban and rural areas is uniform and is TShs. 27,000 as directed by the Minister of Energy.

b) Beginning 5th January 2022 connection charge of TShs 27,000 continue to apply only in all rural areas and urban areas reverted to previously EWURA approved connection charges.

ii) **Three phase charges, excludes VAT 18%**

Service Line	Meter Type	Approved connection charges (TShs)	
		Urban rate (VAT exclusive)	Rural rate (VAT exclusive)
Underground wire connection		Actual cost + 10%	Actual cost + 10%
Within 30 meters (Cable 16 mm^2)	Pre-paid	772,893	772,893
Within 30 meters (Cable 16 mm^2)	AMR		
Within 30 meters (Cable 35 mm^2)	Pre-paid		
Within 30 meters (Cable 35 mm^2)	AMR		
Within 70 meters (one pole)	Pre-paid	1,058,801	1,058,801

Within 70 meters (one pole)	AMR		
Within 120 meters (two poles)	Pre-paid	1,389,115	1,389,115
Within 120 meters (two poles)	AMR		

Source: TANESCO

Appendix B: Trend of SPP Feed-In Tariff (2009 – 2020) sold to TANESCO

a) Trend of avoided cost SPP feed-in tariff 2009 - 2019 (main grid)				
Year	**Wet season Dec - July (TShs/kWh)**	**Dry season Aug - Nov (TShs/kWh)**	**Standardized Tariff (TShs/kWh)**	**Percentage Change**
2009	86.5	115.33	96.11	Base Year
2010	99.27	132.36	110.3	15%
2011	109.02	145.36	121.13	10%
2012	137.29	183.05	152.54	26%
2013	157.4	209.87	174.89	15%
2014	177.58	236.78	197.31	12.82%
2015	171.85	229.13	190.94	-3.23%
2016	171.42	228.58	190.46	-0.25%
2017	182.80	243.73	203.11	6.64%
2018	182.80	243.73	203.11	0.00%
2019	182.80	243.73	203.11	0.00%
2020	182.80	243.73	203.11	0.00%

b) Trend of avoided cost SPP feed-in tariff 2009 - 2019 (isolated mini-grid)			
Year	**Tariff (TShs/kWh)**	**Percentage change**	**Effective Date**
2009	334.84	Base Year	1/1/2009
2010	368.87	10.16%	1/1/2010
2011	380.22	3.07%	1/5/2011
2012	480.50	27.00%	1/5/2012
2013	490.50	2.08%	1/9/2013
2014	482.64	-1.60%	1/7/2014
2015	493.97	2.34%	1/4/2015
2016	477.16	-3.40%	1/4/2016
2017	499.25	4.84%	1/4/2017
2018	499.25	0.00%	NA
2019	Nil	Nil	NA

Source: EWURA

NB: The last avoided cost tariff adjustment was done in 2017.

c) End use customer tariffs for SPP hydro and wind integrated mini-grid connected to national grid

Table 1: End Use Customer Energy Charge Tariff 2012 to January 2022, February 2022 To-Date

Tariff Category	Component	2012-Jan 2022	February 2022 to-date
		TShs/kWh	TShs/kWh
D1< 50 kWh	Domestic Low Usage	60.00	100.00
D1> 50 kWh	Domestic High Usage	273.04	273.00
T1-1 phase	General Usage	234.04	292.00
T1-3 phase	General Usage	234.04	292.00

NB: The tariff is exclusive of VAT 18%, REA 3% and EWURA 1%

Source: TaTEDO-SESO, Field Data

Table 2: End Use Customer Connection Charges 2012 To-Date

Tariff Category	Oct 2012-Nov 2018		Dec 2018-Jan 2022		After Feb 2022	
	Application fee TShs	Connection fee TShs	Application fee TShs	Connection fee TShs	Application fee TShs	Connection fee TShs
D1	5,000	150,000	5,000	150,000	0	27,000
T1-1phase	5,000	150,000	5,000	25,000	5,000	25,000
T1-3phase	5,000	380,000	5,000	380,000	5,000	150,000

NB: The tariff is exclusive of VAT 18%; upon connection each customer is provided with 50 kWh. Pre-paid kWh metering and PAYGO revenue collection system employed.

Source: TaTEDO-SESO, Field data

APPENDIX C: NON-REGULATED VSPPs

Company A: End Use Customer Solar Based Mini Grid Tariffs

	Consumption kWh	Tariff 2017-31/7/2022 TShs / month	Tariff w.e.f. 1/8/2022 TShs/kWh
Households	5	5,000	1,600
Enterprises	10	10,000	

Source: TaTEDO-SESO, Field Data

NB: Connection charges is TShs 50,000, house wiring is inclusive, and load limiter credit metering employed.

Company B: End Use Customer Solar Based Mini Grid Tariffs

Consumption (kWh)	TShs	Allowed loads
5	500	1 charger socket, 1 radio, bulb
10	1,000	1 charger, 1 radio, bulbs, 1 TV
20	2,000	1 charger, 1 TV, bulbs, 1 single phase welding machine

Source: TaTEDO-SESO, Field Data

NB: Connection charges is TShs 50,000, house wiring is inclusive; new tariff smart energy metering PAYGO payment system.

Company C: End Use Customer Solar and Biomass Gasification Mini Grid

		Before Govt directive	During Govt directive	After Govt directive lifted (by village Govt intervention)	
	Consumption	TShs / month	TShs/ month	Tariff TShs/month	Service charge TShs/month
Households	275 Wh/d	11,000	1,000	1,000	10,000
	550 Wh/d	20,000	2,000	1,000	19,000
Enterprises	1,100 Wh/d	32,000	3,000	1,000	31,000
	1, 650 Wh/d	44,000	4,000	1,000	41,000

Source: TaTEDO-SESO, Field Data

NB: Connection charge is TShs 50,000 and customer is provided with 1 lamp holder, 1 LED bulb, 1 switch socket, 1 light switch, 1 main switch, 5m earth wire, 1 pipe conduit, 1 earth rod, 5m of 1.5 mm^2 cable and free house wiring. Pre-payment load limiter metering PAYGO payment system used.

APPENDIX D: IMPACT OF LIFELINE TARIFF GOVERNMENT INTERVENTION ON SOLAR VSPP REVENUE PERFORMANCE

	Generation kWh/day	No. of Customers	Revenue TShs (million/month)
Before Govt intervention	70-80	256	2.0
During Govt intervention	70-80	256	0.2-0.3
After Govt intervention reversed	70-80	256	2.0

Source: TaTEDO-SESO, Field Data

APPENDIX E

International strategies

The Sustainable Energy for All (SEforAll) agenda of 2010 which Tanzania has ratified, supports universal modern energy access by 2030 and Tanzania has also ratified the Paris Declaration which supports the development of low carbon economy and reduced greenhouse generation projects/technologies e.g. renewable mini grids to enhance Nationally Determined Contributions.

National strategies

The Tanzania Development Vision 2025 developed in late 1990's aspires to attain high quality livelihood; peace, stability, and unity; good governance; a well-educated and learning society; and a strong and competitive economy. Tanzania attained a low middle-income economic status in 2020 ahead of earlier projections for the year 2025. The national Strategy for Economic Growth and Reduction of Poverty, adopted in 2005, focuses on raising incomes, improvement of quality of life and social livelihoods of the poor. Deployment of mini-grids in rural areas will enhance economic growth via productive energy usage that can be contributed by renewable mini-grids.

The Electricity Supply Industry Reform Strategy and Road Map 2014-2025, issued in 2014 supports diversification of energy generation including renewable energy mini-grids and sets the road map to unbundle the vertically integrated national utility.

Mini–grid plans, programmes, and projects

The Scaling up Renewable Energy Programme (SREP) Investment Plan (2013) aims at the promotion of large-scale renewable energy development and diversification from fossil fuelled energy sources.

The Renewable Energy for Rural Electrification (RERE) is a pilot program for SREP on small power projects with three programs: a risk mitigation facility, a credit line facility and a transaction advisory facility with a significant impact on mini grids development.

The United Republic of Tanzania National Electrification Programme Prospectus (2013-2022) with electrification strategy to connect 5,500 settlements by grid sub transmission and 6,000 settlements by off-grid electrification including mini grids.

The World Bank funded TEDAP Project (2008-2015) helped REA and TANESCO expand generation, transmission, and distribution infrastructure; MoE and EWURA established the SPP framework, availed funds to be used by investors as matching and performance grants as well as a credit line facility to support the construction of minigrids.

Tanzania's SE4All Action Agenda 2030 with targets and key performance indicators to be attained via investment prospectus.

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