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Feasible pathways for energy transition in Tanzania: shifting unproductive subsidies towards targeted green rents

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Executive summary

Tanzania's energy sector is at a crossroads. After almost two decades punctuated by corruption scandals and increasing financial unsustainability of the country's state-owned public utility the Tanzania Electricity Supply Company (TANESCO), the government needs a new approach to honour its political commitment to affordable energy access. However, despite the ambitious pipeline of new energy generation plans, progress remains slow and several challenges remain. First, the governance and financial sustainability of TANESCO is still very precarious, and the most recent estimates confirm a cumulated debt of over US$600 million. Second, the overall management and maintenance of the energy generation and transmission infrastructure is far from efficient and presents several bottlenecks, with significant impact on energy reliability, power losses and need for government subsidies. Third, the energy technology mix has not diversified at a sustained rate, and this has exposed the overall energy infrastructure to various vulnerabilities. Due to traditional dependence on hydropower, droughts have resulted in extensive power supply shortages and interruptions.

Against this backdrop, this paper identifies feasible pathways for energy transition in Tanzania that allow for an incremental improvement in the financial position of TANESCO and that creates windows of opportunities for targeted substitution of the most cost-ineffective power plants with a combination of on-grid and off-grid renewable technologies. We conduct a political economy analysis of the factors contributing to the existing subsidised regime and highlight how this is highly vulnerable to several forms of corruption. Building on a newly built plant-level dataset that covers 31 energy plants throughout 2008–2017, we conduct an econometric analysis of the subsidy regime administered by TANESCO through its electricity buying decisions across several public- and private-owned plants. In Tanzania, in 2017 alone, at the end of the period considered in our econometric analysis, electricity subsidies amounted to 2.47% of total gross domestic product (GDP).

We find new econometric evidence that TANESCO's buying decisions during this period did not always follow an efficiency buying criteria aimed at reducing costs and need for subsidies. On the contrary, it disproportionally allocated subsidies to a sub-group of power generation plants whose unit generation cost structure is relatively more expensive. The emerging evidence points to the existence of potential political reasons underpinning TANESCO's buying decisions and overall arrangements with specific power generation plants. In some cases, these are due to direct and indirect opportunities for rents capture (for example, the running of industrial diesel plants in remote parts of the country), in others to purchasing power agreements (PPAs) with guaranteed capacity charges.

While the energy sector might need dramatic transformation, in the short-to-medium term an incremental anti-corruption approach would be to consider how to improve the performance of the sector, and in particular TANESCO. To do this, we show that it is critical to take into account differences in performance among power generation plants that are receiving either direct or indirect subsidies. The most feasible pathway that emerges to transform the energy sector is a two-pronged approach focusing on relatively shorter-term

replacement of isolated plants with variable renewable energy (VRE) solutions off-grid or via mini-grids, alongside the unlocking of gas industry negotiations. This strategy would be consistent with the political commitment of the government towards increasing energy access, while retaining control of the public utility. Leveraging existing pressure to deliver affordable energy and expanding access, we show how a targeted approach which focuses on turning increasingly unproductive subsidies towards targeted instruments for scaling up VRE in remote parts of the country could be a viable solution. This is also compatible with a government commitment for centralised energy generation capacity and could offer the population multiple options for energy generation sources.

Acknowledgments

We would like to acknowledge excellent research assistant support from Joshua Bertin.

Acronyms and abbreviations

BRN	Big Results Now programme
CCM	Chama Cha Mapinduzi party
EPP	Emergency Power Plant
ESI	Electricity Supply Industry
EWURA	Energy and Water Utility Regulatory Authority
FYDP	Five-Year Development Plan
GDP	gross domestic product
GW	gigawatt
GWh	gigawatt hours
IPP	independent power producer
IPTL	Independent Power Tanzania Ltd
kWh	kilowatt hours
LNG	liquified natural gas
MEM	Ministry of Energy and Minerals
MW	megawatts
NORAD	Norwegian Agency for Development Cooperation
PPA	purchasing power agreement
PPP	public–private partnership
PSA	Production Sharing Agreement
REA	Rural Energy Agency
REF	Rural Energy Fund
SDGs	Sustainable Development Goals
SPP	small power producer
SSA	sub-Saharan Africa
TANESCO	Tanzania Electricity Supply Company
TPDC	Tanzania Petroleum Development Corporation
TSh	Tanzanian shilling
VRE	variable renewable energy
WDI	World Development Indicators
ZECO	Zanzibar Electricity Corporation

1. Introduction

1.1. The role of energy in development

Energy is the most fundamental enabler of a country's structural transformation. Energy is a primary input to any economic activity and sectors, and a precondition for implementing productivity-enhancement measures, as well as absorption and effective deployment of technologies. Energy use and access are also central to improve social and welfare conditions as well as linking different regions to economic opportunities. A strong correlation between energy and several dimensions and indicators of human and economic development is well established. Lack of energy is therefore a major factor constraining structural transformation and, as part of that, changes in the institutional setting and underlying political settlement in a country. Increasingly, within the Sustainable Development Goals (SDGs) framework and other global initiatives to address the climate crisis, there has been awareness of the fact that energy transition is intrinsically 'political', that is, it involves significant power conflicts, resistances to change and systemic risks (Andreoni and Chang, 2017).

Sub-Saharan African (SSA) countries are among the most electricity deprived in the world. The lack of sufficient electricity generation results in large segments of the population – especially in remote areas – being deprived of reliable and affordable electricity. In urban areas, population growth has introduced new pressure on the existing electricity capacity and infrastructure. Despite some notable progress in some countries since the 1990s, governments have been facing mounting pressure and trade-offs to increase access while keeping electricity affordable through subsidies; to manage stranded electricity generation assets such as coal plants, while investing in scaling-up renewable energy technologies; to leverage domestic investments and manage incumbent interests; and to meet international private investors' conditions for developing electricity generation capacity.

Widespread cases of corruption in the energy sector have been documented and have reinforced a 'good governance' perspective on energy transition. Since the 1990s this has translated in many cases into a push for privatisation reforms across several developing countries (see Lee and Usman (2018) for a review of power sector reforms in developing countries).

While corruption has been used often as a catch-all argument to explain the lack of development in the electricity generation sector across developing countries, it remains unclear why countries with similar governance challenges have recorded very different development outcomes in this sector. In an effort to disentangle this, Gregory and Sovacool (2019) identify and discuss three streams of research and their complementary perspectives: 1) *financial investment governance*, the private investor's perspective, which focuses on the rules and institutions (or lack of) that directly influence the financial investment environment; 2) *political governance*, the political economy perspective, which relates to the negative, indirect investment consequences resulting from the way that governments govern; and 3) *technological governance*, a 'systems' perspective, which encompasses how the standard structure and organisation of the wider electricity delivery system in each country negatively impacts such investment. Based on their analysis of these different perspectives, the authors advance a synthesis approach to governance of the electricity sector and identify 15 'structural factors' responsible for lack of development progress in SSA. Their comprehensive list includes rent-seeking, corruption and patrimonialism as general political economy factors, but also more sector-specific problems related to the uncertain revenue security of the asset or the unearned equity dilution. The extent to which these factors lead to adverse selection in the attraction of long-term committed and capable investors (domestic or foreign) has been documented in other regions also (see, for example, Khan et al. (2020) for the case of Bangladesh).

Lack of sustained development in electricity generation capacity has long been considered one of the major barriers and policy challenges for the structural transformation of Tanzania, despite the country being endowed with natural resources including natural gas, hydro, coal, biomass, geothermal, solar, wind and uranium. Historically, the supply of electricity – mainly generated from hydropower and increasingly from gas – has remained largely unavailable in many rural areas and, when present, frequent shortages are experienced (due to recurrent droughts and climate change) and energy losses (due to the unreliable energy infrastructure). Over the last decade, progress in energy generation and access has been mixed and punctuated by several allegations (and fully documented cases) of corruption (Cooksey, 2017). These mixed results reflect well the ongoing development of Tanzania's political settlement since the first (second-half) and second Kikwete presidency, as well as the first Magufuli presidency (until his passing in March 2021) (Andreoni, 2017; Eberhard et al., 2018; Gray, 2018; Dye, 2021).

1.2. Energy policy in Tanzania

Energy access and electricity-sector development have always been centre stage of the Tanzanian policy debate and government action. In 2011, the lack of adequate and reliable supply of electrical power was identified as one of the key binding constraints to economic growth of the country (Kapika and Eberhard, 2013). In 2012, the Ministry of Energy and Minerals (MEM) – the institution overseeing the power and gas sectors in Tanzania – made projections that per capita electricity consumption in the country would increase five-fold by 2035, and that the overall electricity coverage would go from 14% to 72% (NKRA Energy, 2015). In 2013, the level of electricity consumption in Tanzania was quite low at under 100 kilowatt hours (kWh) per person per year compared to the world average consumption of 2,000 kWh and to 552 kWh per annum in SSA countries. This was attributed to institutional bottlenecks, negligence and corruption of the stakeholders engaged in the power sector (United Republic of Tanzania, 2013).

In 2019, before the COVID-19 pandemic, the Tanzanian Minister for Finance and Planning conducted a Voluntary National Review (VNR) of the country's progress on the Sustainable Development Goals (SDGs), which stated that Tanzania 'espouses the socio-economic transformation of the country to a middle income semi-industrialized country' (United Republic of Tanzania, 2019: iv). The nation has developed the Tanzania Development Vision

2025 (Ministry of Finance and Planning, 2000), to guide policy under the Long-Term Perspective Plan using two different national planning frameworks which aim to incorporate SDG goals within broader government policy. The first is a series of Five-Year Development Plans (FYDP I, II and III), for the 2011/12–2015/16, 2016/17–2020/21 and 2021/22–2025/26 periods respectively (Ministry of Finance and Planning, 2011; 2016; 2021). The second is Zanzibar's Development Vision 2020, referred to as MZUKA III (Revolutionary Government of Zanzibar, 2000).

In FYDP II the very first priority area is aimed at growth and industrialisation, whilst MZUKA III aims to modernise the manufacturing sector and improve access to energy. To support the localisation and implementation of these policy frameworks, the government launched the Big Results Now (BRN) programme, which established several delivery 'labs' that identified priority policy areas, followed by a Performance Management and Delivery Unit to implement policies and monitor progress. The Energy lab identified three National Key Results, to increase generation capacity from 1,010 megawatts (MW) to 2,260 MW; to provide electricity access to 5 million more Tanzanians; and to eliminate reliance on Emergency Power Plants (EPPs) (Eberhard et al., 2018).

Over this last decade, especially after 2015, energy policy in Tanzania has become very ambitious, state-led and focused on mega-projects. The Power System Master Plan of 2016 introduced under Magufuli's presidency targeted a total installed generation capacity of 5,011 MW by 2020 – implying a 256.4% increase compared to March 2018 – 7,000 MW by 2025, and electrification rates of 50% by 2020 and 64% by 2025 (MEM, 2016a). In achieving these ambitious targets, the Tanzanian government's energy policy was based on a state-led energy sector development model centred around state-owned TANESCO.

With the retirement of all EPPs, and the planned end of the two main PPAs with independent power producers (IPPs) and the newly commissioned state-owned energy plants (Kinyerezi-I and Kinyerezi-II), TANESCO's share of total grid installed capacity was expected to reach over 85% by 2020. However, challenges in developing ongoing engagement with the private sector and IPPs project resulted in a series of delays and suspensions during the period 2016–2020.

The development of the liquified natural gas (LNG) industry and related energy plant generation followed a similar pattern. In this latter case, the government pushed for a review of the country's Production Sharing Agreement (PSA) regime, which resulted in the collapse in negotiations between the government and international investors in 2019 (Andreoni and Roberts, 2022). Financing of energy generation capacity investments was envisioned through public–private partnerships (PPPs) and direct government financing, as in the case of the Stiegler's Gorge Dam 2,100 MW project. Even excluding this particular mega-project, the government envisioned an average capacity of projects to be implemented between 2018–2022 in the order of 231.6 MW. This shift towards mega-projects was significant since the envisioned projects exceeded by far the average generation capacity of existing privately and state-owned power plants of 101.7 MW (small power producers (SPPs) excluded).

Electrification has sped up over recent years, and ambitious plans have been confirmed by the Tanzanian government. The most recent figures reported in the budget speech tabled by former Minister for Energy Medard Kalemani in parliament (and corroborated by the 2019/20 Energy Use & Situation Survey II) shows that by March 2021 about 47 million Tanzanians (equivalent to 78.4% of the population) had access to electricity supplied by TANESCO through the national grid and off-grid in isolated power stations. Success in rural electrification seems to be even more significant, with 86% of all villages in Tanzania Mainland electrified, largely through the efforts of the Rural Electrification Agency. Much of the electrification in rural areas has been achieved within the five years since 2015 (only 2,018 villages were connected to electricity in 2015, by April 2021 10,312 villages were connected to electricity). As for total installed power generation capacity in Tanzania, this has reached 1,609.91 MW (TANESCO, 2021). Of this, the national grid comprises 1,573.65 MW and off-grid 36.26 MW, which includes 5 MW from a solar power project (Solawazi) in Kigoma. Electricity from natural gas takes the largest share of installed capacity at 901.32 MW, followed by hydroelectricity at 573.70 MW and 10.50 MW from biomass. TANESCO's own power generation capacity has reached 86.57% while the rest (13.43%) is from IPPs and SPPs (Lamtey, 2021a).

1.3. Sustainability of the energy sector

While some of these results are encouraging, several challenges remain and threaten the sustainability of these development outcomes over time. In particular, the cumulated and running debt position of TANESCO – which is kept afloat by government subsidies – remains an unresolved structural challenge and a concern from the perspective of sustainability and diversification of the energy technology mix.

First, the governance and financial sustainability of TANESCO is still very precarious, with the most recent estimates confirming a cumulated debt of over US$600 m. TANESCO has also cumulated more than US$100 m. in unpaid bills in the case of Songas, the IPP with the best cost performances. Part of this cumulated debt is the result of longstanding corruption cases and several EPP procurement agreements which did not deliver and resulted in exorbitant costs for the state. Examples of corruption documented by Cooksey (2017) can be traced back to some 30 years ago when independent Power Tanzania Ltd (iPTL) and TANESCO signed a PPA to provide electricity as a 'fast-track measure'. The contract was soon shrouded in allegations of corruption, with accusations of not being subject to open tender and over-pricing.

Second, the overall management and maintenance of the energy generation and transmission infrastructure in Tanzania is far from efficient. It presents several bottlenecks, with significant impact on energy reliability, power losses and a need for government subsidies. The most recent data from October 2021 confirm that TANESCO is losing US$7 million a month due to inefficiencies, power losses and other technical and non-technical issues. At the current pace, this loss amounts to almost US$85 million per year, against a total annual revenue of 1.8 trillion Tanzanian shillings (TSh) per year, that is around US$780 m. (Lamtey, 2021b). Alongside corruption cases and inefficiencies over the last decade, TANESCO's running debt performance has been tied to buying overpriced power from private suppliers and selling it at much lower (hence subsidised) prices to customers in view of increasing access. Low collection rates from customers, including other public organisations, increases the financial sustainability challenge (MEM, 2015).

Third, the energy technology mix has not diversified at a sustained rate, and this has exposed Tanzania's overall energy infrastructure to various vulnerabilities. Due to traditional dependence on hydropower, increasingly frequent droughts have resulted in extensive power supply shortages and interruptions. These have had a high economic and social cost in terms of forgone output and incomes. Opportunities for diversification in the gas industry have remained stagnant for almost a decade, although with the new presidency of Samia Hassan Suluhu some momentum was regained in the second half of 2021 (Andreoni and Roberts, 2022). Despite the country's potential and the increasing cost-competitiveness of renewables, diversification in these green technologies have developed slowly in Tanzania. Mega-projects have been given priority, as discussed above, and in some cases the development of renewables at scale has been seen as a potential competitive problem, especially given the limited effective demand for electricity.

1.4. Objective and structure of the paper

Within the context described above, and given the challenges highlighted, this paper aims to identify feasible pathways for energy transition in Tanzania that enable an incremental improvement in TANESCO's financial position and that create windows of opportunity for targeted substitution of the most cost-ineffective power plants with a combination of on-grid and off-grid renewable technologies.

Identification of these opportunities as politically feasible and as viable business propositions relies on three main steps. In section 2 we provide a detailed account of the energy sector and actors in Tanzania. This is followed in section 3 by a political economy analysis of the factors contributing to the existing subsidised regime, highlighting how this is highly vulnerable to different forms of corruption. Building on a newly built plant-level dataset including 31 energy plants for the period 2008–2017, in section 4 we conduct an econometric analysis of the subsidy regime administered by TANESCO through its electricity buying decisions (and hence subsidy allocation) across several publicly and privately owned plants. Each of these plants have different running cost functions according to their initial investment and operational costs. Due to the extensive subsidies awarded to EPPs – and reliance on these plants – accompanied by corruption scandals surrounding their operation, the paper focuses on estimating the extent to which these energy producers were disproportionately subsidised relative to alternative options for electricity provision. In Tanzania, in 2017 alone, total electricity subsidies amounted to 2.47% of total GDP (around US$1.3 billion) (GET.Invest, n.d.). The paper assesses whether the subsidies awarded to different typologies of power producers are proportionate to changes in their generation costs, to investigate whether subsidies were awarded differently among producers. Furthermore, the paper looks at comparing the efficiency – in terms of cost per unit of energy produced – of on- and off-grids power plants. The regression analysis estimates the elasticity between the generation costs/prices paid to producers and the value of subsidy awarded to different generation plants using two alternative subsidy calculations to check the robustness of results. The efficiency analysis considers the benchmark costs related to the energy provision in neighbouring countries to understand the efficiency of energy provision in Tanzania as compared to countries in similar phases of development.

We find new econometric evidence that TANESCO's buying decisions did not always follow an efficiency buying criteria aimed at reducing costs and need for subsidies. On the contrary, it disproportionally allocated subsidies to a sub-group of power generation plants whose unit generation cost structure is relatively more expensive. The emerging evidence points to the existence of potential political reasons underpinning TANESCO's buying decisions and overall arrangements with specific power generation plants. In some cases, these are due to direct and indirect opportunities for rents capture (for example, the running of industrial diesel plants in remote parts of the country), and in others to PPAs with guaranteed capacity charges.

In section 5, before our conclusions, we advance an anti-corruption strategy for energy transition in Tanzania. Existing studies point to the importance of general governance improvements in transparency, and better procurement rules and rule enforcement, all of which are useful but are unlikely to improve the energy sector in the medium-term sufficiently. Establishing a framework and evidence for assessing the effectiveness of subsidy provision can open the way to a targeted and incremental process of replacement of individual cost-ineffective and corruption-vulnerable projects with new power generation projects that relying on other energy generation solutions. In remote parts of the country where the energy transmission infrastructure is less developed and several cost-ineffective power plants are located, renewable energy technologies are already cost competitive and do not represent a competitive threat to the growing centralised on-grid energy sector managed by TANESCO. Significant growth in the productive sector of the Tanzanian economy is crucial for the country to industrialise and for raising per capita income from at least US$3,000 by 2025. Such economic growth will require enormous investment in the power infrastructure and an estimated 764.5 MW of new capacities to be added annually (Peng and Poudineh, 2016).

2. The energy sector in Tanzania: access, supply and governance

The development of the energy sector in Tanzania can be traced back through several decades. However, while the sector faced different stages of expansion (and contraction), to a large extent a number of key structural challenges have remained constant throughout its history.

As long ago as 1992, under the presidency of Hassan Mwinyi (1985–1995), the Tanzanian government launched a national energy policy with the central aim to drive the development of gas-powered electricity generation and reduce Tanzania's dependence on unreliable hydropower and expensive industrial diesel-powered generators. Contrary to plans, Tanzania's reliance on EPPs began – at that time with Independent Power Tanzania Ltd (IPTL), which started operating in 2002. A second round of EPPs was launched in 2006 with the well-known Richmond – later Dowans – project and finally the Symbion project. The 100 MW Richmond/Dowans EPP has been described as the biggest corruption and political scandal in the country's history, which led to the 2008 resignation of Prime Minister Edward Lowassa and the subsequent dissolution of the Cabinet (Cooksey, 2017).

The cost of these corruption scandals reverberated throughout the decade that followed and exacerbated the financial unsustainability of TANESCO (ibid.). Between 2002 and 2017 IPTL continued to run on expensive imported (and price-inflated) diesel – despite the Tanzanian government winning an international arbitration which ruled in its favour and removed the capacity standing charges from the agreement – thus incurring avoidable costs of an estimated US$1 million a month for 15 years. As a result, the unit costs that IPTL charged TANESCO were six times the cost of Songas, the cheapest gas-powered generation plant in Tanzania that had been in operation since 2004. Dowans and Sympion also resulted in major financial losses for TANESCO. Dowans took TANESCO to arbitration at the International Chamber of Commerce and, in 2010, was awarded US$65.8 million (plus interest) for breach of contract for non-payment of capacity charges. In March 2017, Symbion Power, the current owner of the plant, went to the same arbitration body to claim US$561 million from TANESCO for breach of contract.

In the remainder of this section we look at the decade following the first major season of corruption scandals in the energy sector in Tanzania. The focus is on the period from 2008 to 2017, for which an econometric analysis is also developed in section 4. By analysing this entire period, we have a clear picture of the mounting and unfolding structural challenges faced by Tanzania, and in particular the drivers of the financial sustainability crisis faced by TANESCO today.

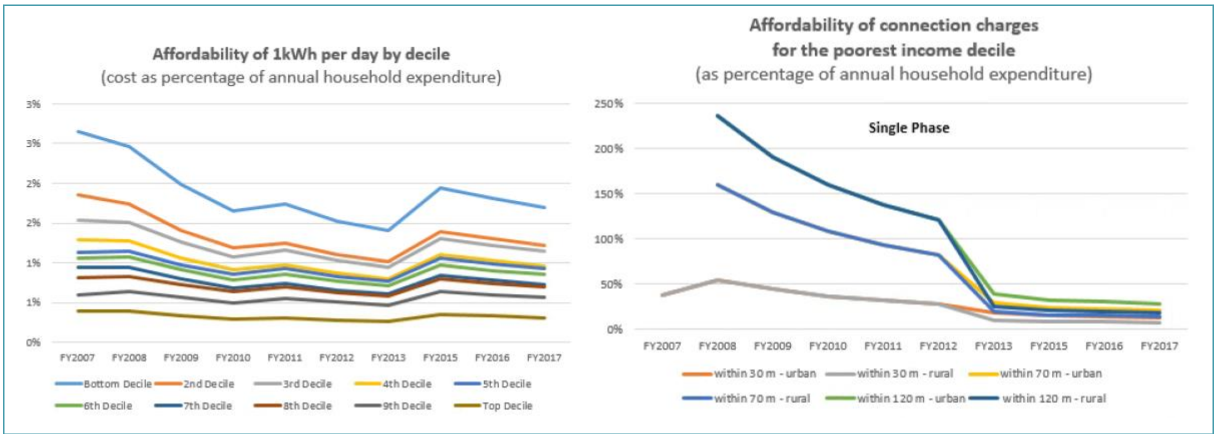
2.1. Energy access, affordability and reliability in Tanzania

Access to electricity rose dramatically in Tanzania in the second half of the decade considered, when the electrification rate increased from 16% of the population in 2012 to 33% in 2016. However, there is a marked difference when looking at the rural context (where electricity access went from 4% to 17%) and the urban one (where access went from 50% to 65%). According to the International Renewable Energy Agency (IRENA, 2020), average electricity access further increased to 37% of the population by 2018.

Recent figures reported by the Tanzanian government suggest that by 2021 the access rate to electricity supplied by TANESCO through the national grid and off-grid in isolated power stations reached 78.4% of the population, but this seems to be an overestimate (IRENA, 2020). Given the widespread distribution of the population and extensive geography of Tanzania, rural villages remain largely disconnected from the grid and off-grid solutions remain limited. In urban areas, in contrast, fast rates of urbanisation present a challenge for the operational performance of the already overstretched grid.

Based on World Bank estimates, Tanzania's connection charges are among the most affordable in Africa and electricity prices have been consistently affordable over the last 10 years (see Figure 1), also in relation to comparators in the region (Figure 2). However, due to the many challenges in increasing capacity, and operating and maintaining the grid infrastructure, the reliability of the energy supply has been poor in Tanzania in comparison to other countries. Data show that 86% of firms experience outages with an average monthly duration of 45 hours, causing significant losses in sales. In the World Bank's Enterprise Survey, 46% of large businesses cite poor electricity service as a major constraint in the investment climate (World Bank, 2018a).

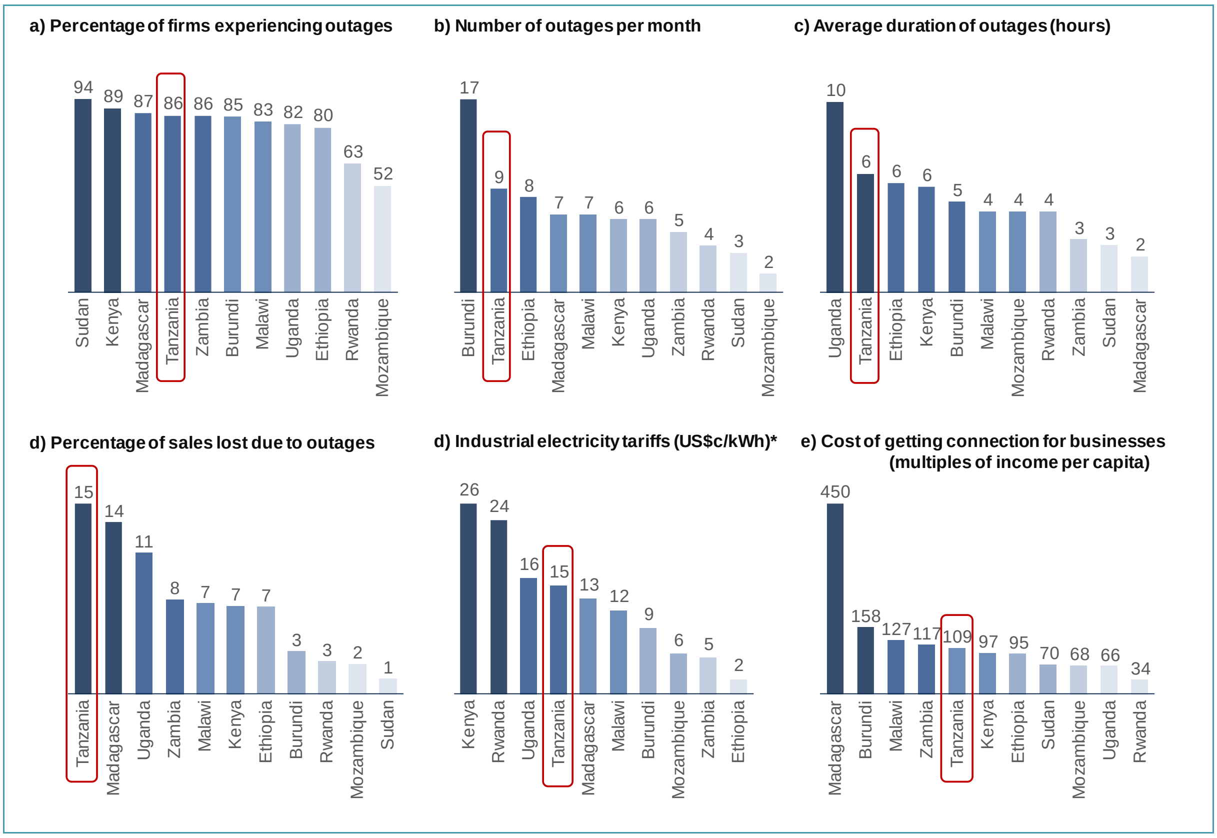
Figure 1. Affordability of electricity and connection charges



Note: Electricity is considered affordable when 1 kWh/day costs below 5% of household expenditure.

Source: The authors, drawing on data from World Bank (2018a).

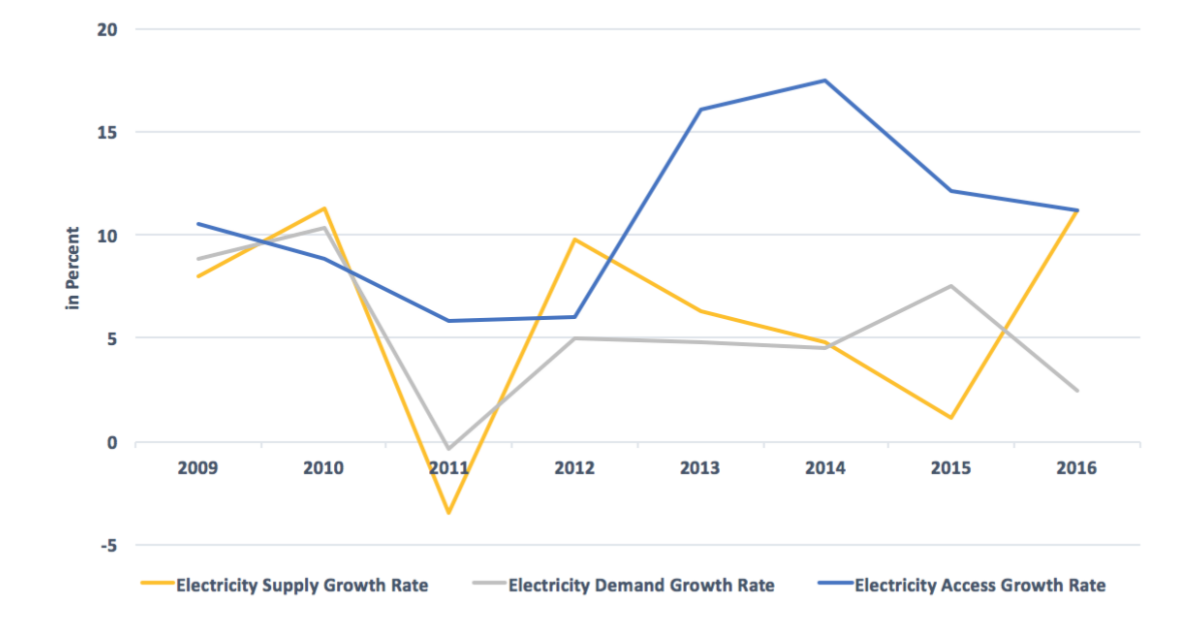
Figure 2. Quality and cost of electricity service in Tanzania in regional comparison, as reported by businesses



Source: The authors, drawing on data from World Bank (2018a).

The growing gap between electricity demand and electricity supply has posed further challenges. From 2008 to 2017, electricity peak demand increased by 67%, while installed capacity expanded by 23% over the same period (Figure 3). This misalignment between power demand and supply has been exacerbated by delays in the completion of several ongoing power generation projects, and further peaks in demand. Even assuming that the government can deliver the majority of mega-projects in the pipeline (see Annex 2), the fact that these demand peaks increase the subsidy burden for TANESCO might result in further deterioration of its financial position. Furthermore, a major challenge in aligning demand and supply is in overcoming inter-temporal coordination issues. This means reducing phases of costly overcapacity (hence capacity charge costs) which might result from poor sequencing of electricity generation expansion. It also means avoiding cases of capacity shortage due to unexpected droughts which might result in expensive EPPs.

Figure 3. Misalignments and gaps between energy supply, demand and access rates in Tanzania



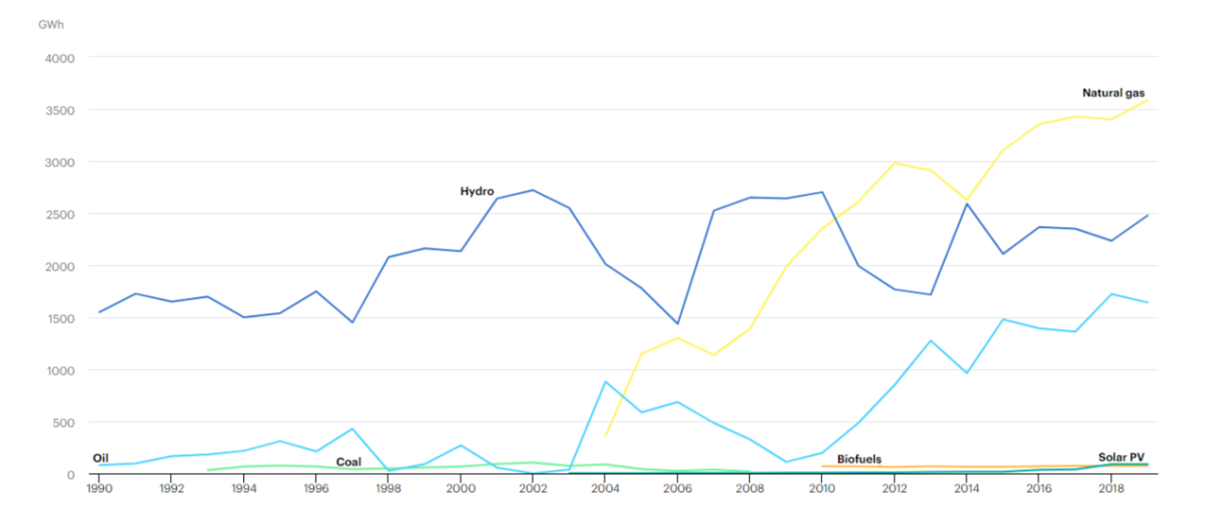
Source: The authors, drawing on World Bank (2018a) and IEA (2019)

2.2. Energy generation in Tanzania: a composite picture

By the end of the decade considered, in 2018, the total installed electricity generation capacity in Tanzania was 1,406 MW (1,324 MW connected to the national grid, and 82 MW connected to isolated grids). This is compared to the peak national demand of 1,051 MW in 2017 (World Bank, 2018b). According to the Tanzanian government (TANESCO, 2021), by 2021 power generation capacity in Tanzania had further expanded to reach 1,609.91 MW (comprising 1,573.65 MW from the national grid and 36.26 MW off-grid).

As shown in Figure 4, the energy technology mix is largely based on natural gas (43%), hydropower (43%) and heavy fuel oil (12%). State-owned TANESCO remains vertically integrated by owning and operating the generation, transmission and distribution of power to the final consumer. TANESCO generates the bulk of the country's electricity (84%), while Songas (an IPP), private SPPs and imports provide additional capacity, at around 12%, 3% and 1%, respectively. The Songas contract is set to lapse by 2024. Hydropower capacity has remained stable over the last decade, but with a significant drought in 2010–2013. Gas-powered plants grew significantly between 2007 and 2012, while their growth rate decelerated and reached a plateau by 2015.

Figure 4. Energy technology mix in Tanzania, 1990–2018



Source: The authors, drawing on IRENA (2020)

Based on the availability of connections to the national grid, the installed power generation capacity in Tanzania can be divided into two main groups (see Figure 5 also):

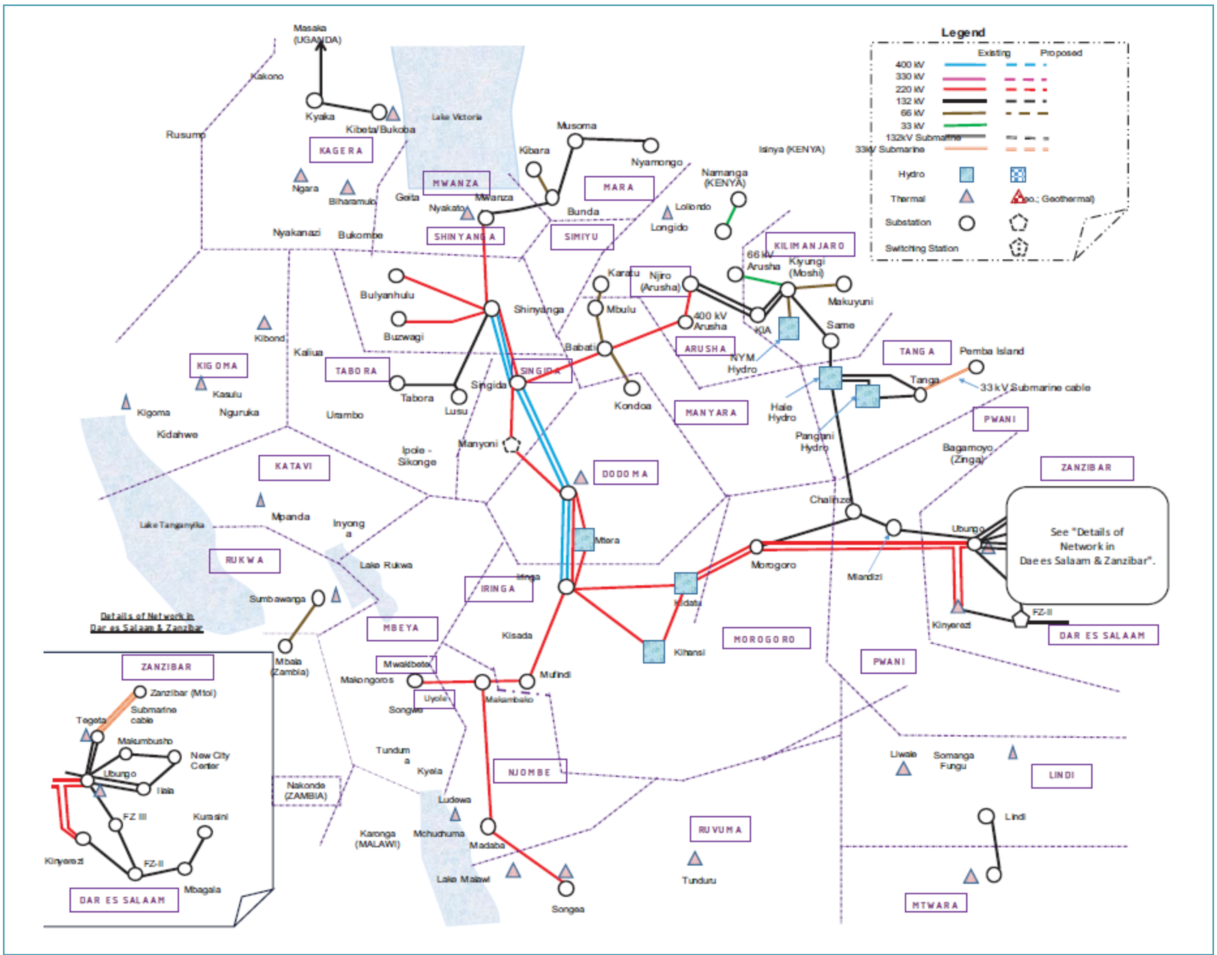
1) On-grid facilities connected to the main grid and connecting major load centres

Of on-grid facilities (Annex 1 provides a detailed list of plants), there were 561 MW of hydropower projects commissioned between 1964 and 2000. These were dominated by the Kidatu Dam (204 MW) and the Kihansi Dam (180 MW). This infrastructure is the legacy of the 'Big Dam Era', during which large hydroelectric dam projects were funded by development aid programmes with sponsors such as the World Bank, the Swedish International Development Cooperation Agency (sida) and the Norwegian Agency for Development Cooperation (NORAD). Currently, these hydroelectric facilities in Tanzania are owned and operated by TANESCO. Increasingly, they suffer from recurrent droughts and cannot be depended upon to generate electricity reliably. Hydropower stations, responsible for about half of the electricity generated in the country, are located in southern Tanzania, while most load centres are in the north.

There are also fossil fuel-fired, on-grid power generation plants built since the 2000s, that have been owned and operated by different companies and that reflect the lifting of TANESCO's monopoly over power generation in 1992. Fossil fuel-fired generation plants owned and operated by IPPs came online in the early 2000s, ten years after the lifting of the monopoly, with IPTL in 2002 and Songas – the joint venture mentioned previously – in 2004. In 2011, TANESCO contracted EPPs, the United States-based company Symbion Power and Glasgow-based Aggreko, to bridge the electricity supply gap caused by droughts and to provide diesel-fired rented capacity. Since 2010, a few SPPs are also active, providing electricity to the grid by burning local biomass feedstock or generating small-scale hydroelectricity.

The Government of Tanzania has actively sought to bring online new power plants for the last two decades, initiating planning and negotiations for over 19 facilities. TANESCO-owned Kinyerezi-I and Kinyerezi-II came online in 2016 and 2018, with ongoing expansion of Kinyerezi-I to add another 185 MW by February 2019. The status of the additional planned power generation facilities is much less clear, having been further disrupted by the COVID-19 pandemic since 2020 and the death of President Magufuli in March 2021 (see Annex 2 for information on the status of planned power plants up to 2017).

Figure 5. Tanzania's national grid system, 2019

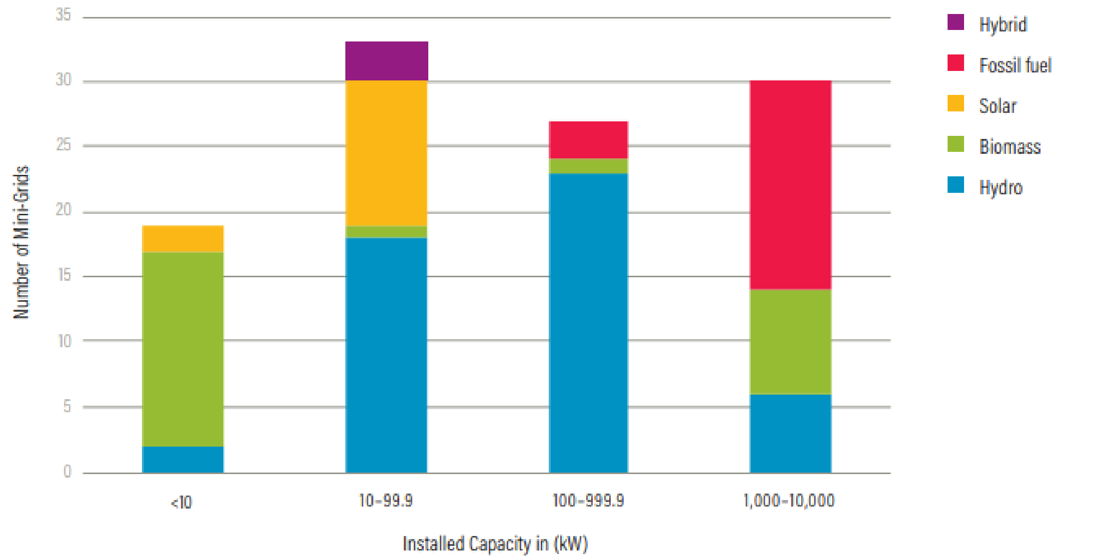


Source: United Republic of Tanzania, 2020

2) *Off-grid facilities connected to isolated mini-grids*

In regions where connection to the national grid is not available, TANESCO owns and operates isolated diesel generator-powered mini-grids (mainly in the Western belt from Bukoba to Songea). The mini-grids located on the Eastern shore, namely in Somangu and Mtwara, are small-scale gas-fired power plants, supplied by natural gas from the Songo Songo and Mnazi Bay projects. Some contracted SPPs also provide electricity to the mini-grids. Since 2008, mini-grid installed capacity doubled to reach 157.7 MW in 2016. Currently, Tanzania has at least 109 mini-grids (private and public plants combined), serving about 184,000 customers (5.8% of total off- and on-grid electricity production as of March 2018).

Figure 6. Distribution of mini-grids in Tanzania by installed capacity and energy source, 2016



Sources: TANESCO 1983; Kjelstrom et. al. 1992; UNIDO 2013; Sarakikya et. al. 2015; and interviews with staff of Kongwa. Leganga, Mawengi, Mwenga, and TANWAT (mini-grids) and the Ministry of Energy and Minerals, the Rural Energy Agency, SESCOM, and TANESCO conducted between February and May 2016.

Source: Odarno et al. (2017).

As shown in Figure 6, however, solar technology has diffused mainly among relatively smaller mini-grids, while hydropower in the form of mini-dams is dominant. Unfortunately, more than half of the mini-grids with relatively higher capacity between 1,000 KW and 10,000 KW rely on fossil fuels for energy generation. These are either isolated diesel generator-powered mini-grids (in some cases owned and operated by TANESCO), or small-scale gas-fired power plants. The unit costs for energy generation are significantly higher in the case of diesel generator-powered mini-grids than the plants operating on gas. Industrial diesel is imported and subjected to several rents-capture opportunities, from sources to port and distribution in the country. It is also the worst polluting source of electricity generation.

2.3. Governance structure of the energy sector in Tanzania

The power and gas sectors in Tanzania are overseen by the Ministry of Energy (formerly known as the Ministry of Energy and Minerals, MEM). Its mandate is to develop energy and mineral resources; it furthermore develops and reviews government policies in the power sector. The Ministry of Energy published the Electricity Supply Industry (ESI) Roadmap for 2014–2025, which aims to support ESI in an ‘environmentally sound and sustainable manner’ that ensures ‘availability of adequate, reliable and affordable electricity supply’ (Ministry of Energy, 2015). The policy reform objectives set out in the ESI Roadmap aim to fuel economic growth with low cost and reliable power, which will rely on two elements, 1) increasing generation and 2) expanding the electricity grid and national electrification rate.

Operational since 2006, the Energy and Water Utility Regulatory Authority (EWURA), an autonomous multi-sectoral regulatory authority, is responsible for the technical and economic regulation of electricity, petroleum, downstream oil and gas, and the water sector in Tanzania (Bauner et al., 2012). EWURA awards permits to entities seeking to undertake licensed activities. It also approves and enforces tariffs and fees for licensees (including the transmission tariff for gas and the retail tariff for electricity). EWURA was established through the Energy and Water Utilities Regulatory Authority Act, Ch. 414 (United Republic of Tanzania, 2001), and its core functions include (among others) licensing, tariff review, and the monitoring of performance and standards with regards to quality, safety, health and the environment (Larsson et al., 2013).

TANESCO – a vertically integrated and fully state-owned utility – is responsible for generation, transmission and distribution of electricity. The company generates, purchases, transmits, distributes and sells electricity to Tanzania Mainland and sells bulk power to the Zanzibar Electricity Corporation (ZECO), which in turn sells it to the public on the islands of Unguja and Pemba. In undertaking its core functions, TANESCO is guided by the National Energy Policy of 2003 (MEM, 2003) and the Electricity Act of 2008 (United Republic of Tanzania, 2008). TANESCO Ltd functions under the regulatory guidance of EWURA. The company operates the grid system in Tanzania Mainland and isolated supply systems in Kagera, Kigoma, Rukwa, Ruvuma, Mtwara and Lindi (Bauner et al., 2012).

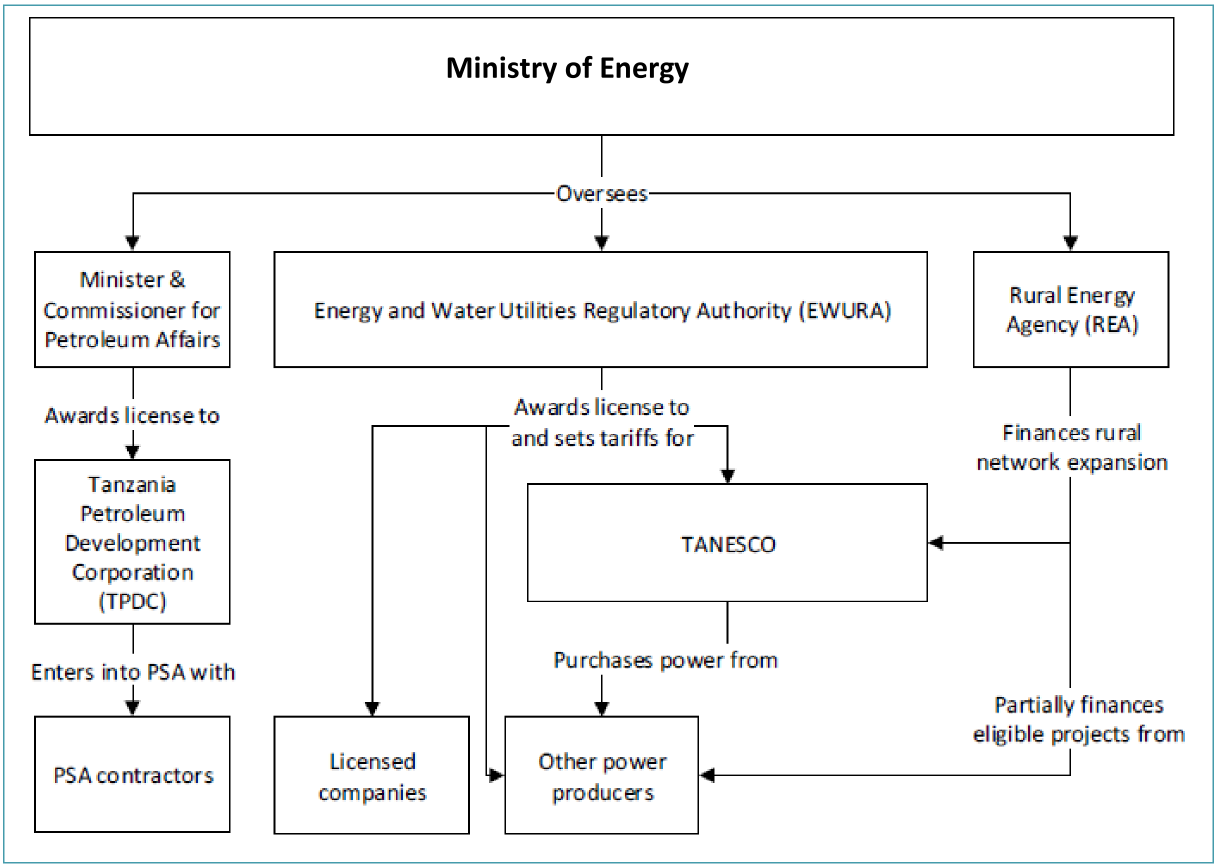
Before 1992, TANESCO had been the sole company responsible for electricity generation, transmission and distribution. However, due to slow development in the sector and the general global trend in the electricity supply industry, the government lifted the monopoly of TANESCO and allowed the involvement of the private sector (through IPPs) in the electricity industry (Vagliasindi and Besant-Jones, 2013; Eberhard et al., 2018). In 2014, the BRN Energy Lab proposed energy sector reforms under which TANESCO would have been split into three different companies to manage power generation, transmission and distribution of electricity separately. The intention was to eliminate any reliance on EPPs, to eventually sell off the generation and distribution companies to the private sector in the long term and to eliminate all subsidies to electricity utilities by 2020 (ADBG, 2015). Today TANESCO still remains the sole licensee for the transmission of energy and the main licensee for distribution activities, even if it purchases electricity generated by a number of IPPs, EPPs and SPPs.

The financial performance and sustainability of TANESCO have remained volatile and precarious over the last decade. The drought-triggered supply shortages of 2011–2013 put significant pressure on TANESCO and forced the use of EPP procurement. By 2018 TANESCO had phased out 300 MW of EPPs and returned to positive operating cash flow. However, the cash flow surplus has remained insufficient to meet its infrastructure investment needs and to clear its cumulated debt positions. Due to the devaluation of the Tanzanian shilling and arrears accumulated through FY2015/16 (after an initial drop in FY2014), the cumulated debt of TANESCO reached around US$312 million in 2017 with a relatively high debt ratio of 73.49%. In 2020 the cumulated debt had doubled to reach around US$600 million.

Figure 7 provides a detailed representation of the governance structure of Tanzania’s energy sector. The Ministry of Energy oversees EWURA and TANESCO, as well as the Minister and Commissioner for Petroleum Affairs which operates via another corporation. The Tanzania

Petroleum Development Corporation (TPDC) participates and engages in the exploration, development, production and distribution of oil and gas and related services; facilitates a fair trading environment; and safeguards the national supply of petroleum products (Larsson et al., 2013). The Ministry of Energy also oversees the Rural Energy Agency (REA), which supports and facilitates improved access to modern energy in rural areas by running training programmes, financing rural grid expansion and partially financing rural energy projects (mostly projects developed by SPPs).

Figure 7. Formal governance structure of the Tanzanian energy sector



Source: Adapted and updated from Peng and Poudineh (2016).

The REA and a Rural Energy Fund (REF) were established in 2008 by the Rural Energy Act (United Republic of Tanzania, 2005: Part V). These organisations were set up as part of wider efforts to achieve SDG 7, guided by the National Energy Policy (MEM, 2015) for directing the sustainable development and utilisation of energy resources. A major project contributing to energy sector development is the Rural Electrification Expansion Project, which is overseen by the Rural Energy Board (REB), the REA and the REF to promote, stimulate and facilitate modern energy services in rural areas. This project is implemented under the National Rural Electrification Programme (NREP) 2013–2022.

Tanzania is recognised globally as a role model in terms of the effective management of mini-grids under the governance of REA and the regulatory framework of EWURA (Tenenbaum et al., 2014; Odarno et al., 2017). The current SPP framework provides technology-specific feed-in tariffs and it streamlines processes, including standardised PPAs and tariff methodology, with standardised forms and process rules, which removes the need for negotiation and regulatory review of tariffs. This significantly reduces transaction and administrative costs. Furthermore, EWURA grants SPPs the right to sell electricity directly to local communities and to set their retail prices freely, which lowers the dependency of mini-grids on payments from TANESCO. Thus, the government has succeeded in establishing a clear set of rules regarding mini-grids that reduce the cost of entry and enable competent firms to profit from their investments.

However, scaling up of SPPs still involves various institutions, some outside the energy sector. Cumbersome steps (13 in total) to obtain clearance for project development create bottlenecks that reduce the benefits from streamlined PPAs and licensing procedures. This significantly slows implementation and dissuades high-quality developers from entering the market. Odarno et al. (2017) found that the small pool of high-quality firms in particular has constrained the effectiveness of competitive procurement to coordinate private and public actions. Many potential producers are small and do not have the resources to participate in such a process.

Non-governmental organisation (NGOs) have also taken part in the development of the sector. The Tanzania Renewable Energy Association (TAREA), formerly known as the Tanzania Solar Energy Association (TASEA), was founded in 2000. The objective of TAREA is to promote the sustainable development of renewable energy. TAREA has been realising its objectives through training, community awareness-raising, policy influence, solar industry and end-user protection, energy efficiency, research, volunteer programmes and consultancy services (Bauner et al., 2012). TAREA has trained solar photovoltaics (PV) technicians on behalf of sida/MEM solar PV projects in the Tanga, Morogoro, Pwani, Mbeya, Kigoma, Rukwa, Mtwara, Dodoma, Ruvuma, Lindi and Tabora regions. It has also trained Vocational Education and Training Authority Trainers in solar PV technologies in the Dodoma, Mbeya, Mtwara, Ruvuma, Kigoma, Tabora, Singida and Rukwa regions. Other NGOs include the Tanzania Traditional Energy Development and Environment Organisation (TaTEDO), Solar Innovations of Tanzania, AMKA Trust, and CARE-Tanzania, to mention a few. There are also a number of universities and training institutions that build the human capacities needed for the energy sector. These include the University of Dar es Salaam, Nelson Mandela African Institution of Science and Technology, Dar es Salaam Institute of Technology, Mbeya Institute of Science and Technology, Arusha Technical College, and the Vocational Education Training Authority (VETA). Research Institutions include, among others, the Tanzania Engineering and Manufacturing Design Organization (TEMDO), Tanzania Industrial Research and Development Organization (TIRDO) and the Centre for Agricultural Mechanization and Rural Technology (CAMARTEC).

3. Governing energy rents allocation: the political economy of the energy sector in Tanzania

Corruption scandals have been a recurring feature of Tanzania's political landscape since the start of the 21st century. Corruption cases have implicated senior politicians, high-ranking government officials, domestic industrialists and multinational companies in a series of illegal activities involving bribes, kickbacks and the theft of public funds. And the energy sector has been at the centre of several of these corruption scandals and allegations.

Most recently, the 'Escrow scandal' erupted in 2014, during the last year of President Kikwete's second term and just before the election of President Magufuli (Andreoni, 2017; Cooksey, 2017; Dye, 2021). In October 2014, the ruling party, Chama Cha Mapinduzi (CCM), found itself embroiled in a corruption scandal involving the alleged illegal payment of US$122 million by senior state officials to businessmen under the guise of energy contracts. In response, 12 donors suspended aid payments to Tanzania pending the resignation of several senior figures who were implicated in the scandal. Donors withheld budget support worth US$500 million and negotiations were put on hold for a US$450 million US government Millennium Challenge Account grant that includes a power generation component.

Such corruption cases have occurred not because of a lack of vertical enforcement efforts, including good governance reforms (Andreoni, 2017; Khan et al., 2019). Specifically, within public finances, since 1998 the implementation of the Public Financial Management Reform Programme has aimed to reduce corruption through greater transparency and accountability. As part of this, a cash budget, limiting payments to cash availability on a monthly basis, and a centralised payment system were introduced. The development of a medium-term expenditure framework and a Public Expenditure Review involving different stakeholders increased transparency; and an expenditure tracking system was introduced to reduce leakages at service delivery level.

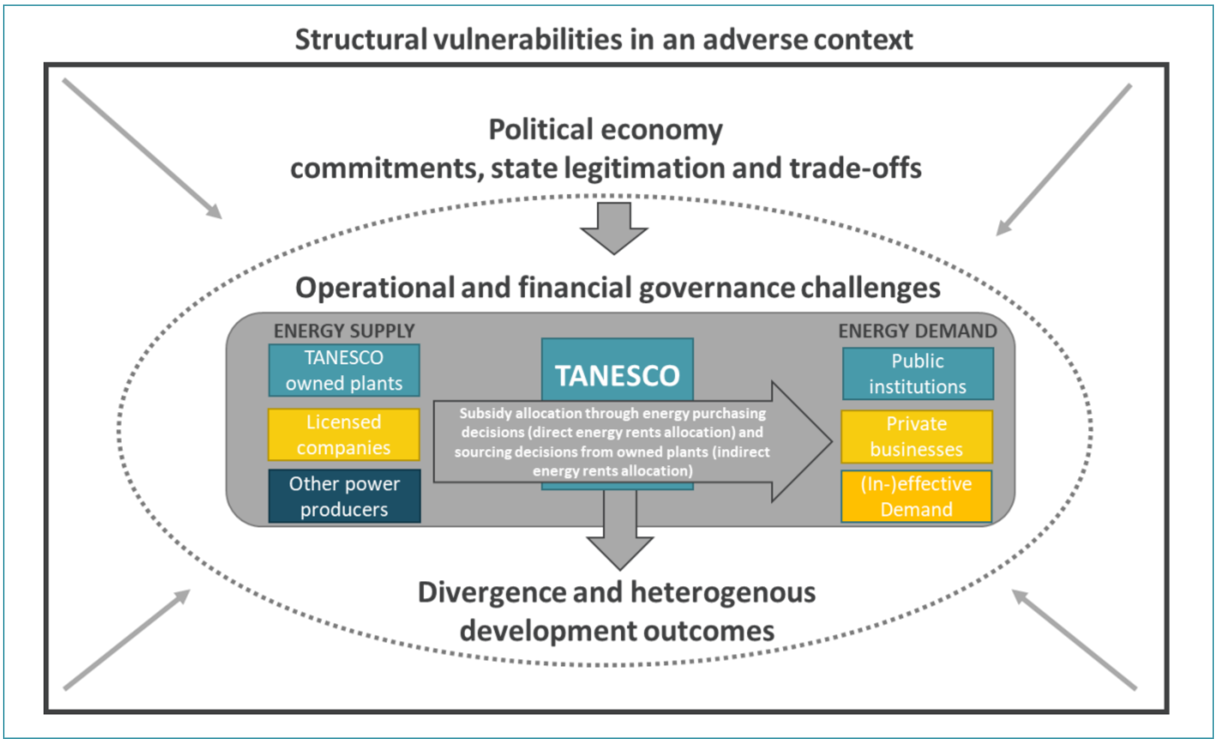
By the mid-2000s, Tanzania had achieved some notable successes in constraining certain forms of bureaucratic corruption within the budgeting system. An example of these good governance principles can be found in the energy sector regulatory framework. The principle of tariff setting in Tanzania, set out in Part II, sub-section 5 of The Electricity Act states that 'The Authority shall, in setting the tariff, apply the following principles: (a) cost of efficient business operation; (b); recovery of a fair return on the investment, provided that such investment has been approved by the Authority, (c) cost covered by tax exemptions, subsidies or grants provided by the Government or donor agencies shall not be reflected in the costs of business operation' (United Republic of Tanzania, 2008).

However, corruption has persisted in Tanzania despite these reforms and regulatory frameworks. Evidence points to the fact that the technical improvements in the budgeting process have done little to address the underlying structural drivers of the corruption phenomenon in the country. The literature and evidence on grand corruption in Tanzania has also failed to disentangle some of the mechanisms through which different forms of corruption influence economic development. The standard rent-seeking framework rests on the assumption that grand corruption ultimately constrains economic development by raising the costs of collective goods and by undermining investor confidence. Yet recent literature has shown that corruption is linked to a range of different economic outcomes and that corruption processes are highly heterogeneous across and within sectors (Khan et al., 2019).

In what follows we unpack a set of interconnected issues that underpin the political economy of the energy sector in Tanzania. In a country affected by several *structural vulnerabilities to corruption* like Tanzania, there is a process of *energy rents allocation* at the core of the political economy of the energy sector that is shaped by political commitments, the need for state (and CCM) legitimation and trade-offs (Figure 8). This process of energy rents allocation is both *direct* and *indirect* in the case of Tanzania. It is direct because TANESCO's purchasing power decisions result in the allocation of subsidies to licensed companies and other producers, each one having different energy production cost structures. It is also indirect as TANESCO sources energy from its own power plants. Given that the selling price of energy is lower than the sourcing of energy, TANESCO indirectly allocates energy rents across its fleet of power plants. For example, by deciding to support more or less cost-effective energy generation plants via sourcing decisions, TANESCO is indirectly re-allocating rents across its own fleet of plants. TANESCO's energy sourcing and purchasing decisions and internal cross-subsidisation is never determined by purely technical efficiency or cost-effective principles. Other factors shape these decisions, and these factors affect the overall financial and operational viability of TANESCO itself. Because of these factors, moreover, we can expect divergence more than convergence in cost structures across plants as well as heterogenous development outcomes.

Figure 8 provides a schematic summary of the political economy of the energy sector in Tanzania, highlighting the channels through which direct and indirect subsidies are adopted.

Figure 8. The political economy of Tanzania's energy sector: direct and indirect energy rents allocation



Source: The authors.

3.1. Structural vulnerability, political economy commitments and trade-offs

As discussed in section 2, the Tanzanian energy sector has several structural vulnerabilities. Some of them are due to its historical energy generation development – reliance on mega hydropower projects, and hence vulnerability to droughts – and repeated cases of corruption which spiralled into crises of confidence in the sector and reliance on EPPs. In many EPP cases, as we have highlighted above, there have been several allegations of corruption in the project evaluation phase, and in selection and negotiation processes (Peng and Poudineh, 2016; Cooksey, 2017). The fact that Tanzania is a vast country with largely outdated and poorly performing energy infrastructure, that it has a rapidly growing and spreading population, and that power generation has been historically a very 'politically charged' issue, puts enormous pressure on government to deliver. This pressure also exposes a key fundamental set of trade-offs, which in some cases take an inter-temporal form.

On the one hand, the Tanzanian government's legitimacy as a service provider (through the state-owned public utility and producer TANESCO) and the CCM's political commitment are strongly dependent on delivering affordable energy and a continuous process of grid expansion in rural areas. Such commitments are fleshed out in several strategies, including the National Electrification Prospectus 2013–2022 (IED, 2014). Powerful factions within CCM and constituencies across the country (especially in rural regions where CCM has a strong hold) have been historically able to organise collective action that prevented reforms in the sector. This was the case in 2005, in the pre-election period (preceding the ten years of Kikwete's presidency; see Andreoni, 2017), when citizens were mobilised to resist several reforms including the privatisation of TANESCO. Underlying this resistance is a fundamental effort to retain subsidised energy tariffs and, in this way, to increase energy access even if the existing effective demand is limited (that is, unable to pay non-subsidised prices) and expansion of the grid is at a high cost. In a context where energy tariffs are set far below full cost-recovery levels (Peng and Poudineh, 2016), the expansion of the energy grid does not simply imply a stock of new capital investment to build the infrastructure; it also implies an increasing stream of subsidies for new consumers. Subsidised tariffs, energy losses through the grid and reliance on expensive EPPs or industrial diesel plants makes it increasingly difficult to keep a political commitment for energy access.

On the other hand, over the last decade, the government has also committed to move the energy sector towards an economically viable and efficient model of service delivery and expansion. The BRN Initiative and the ESI Roadmap 2014–2025 include several strategic reforms aimed at unbundling TANESCO, increasing the participation of the private sector and increasing transparency and accountability. In these strategies, the government has also fleshed out financial commitments aimed at reassuring potential private-sector investors. These reforms are not necessarily incompatible with the political commitment towards affordable energy access for large segments of the population; however, they have become so in the Tanzanian context.

Raising confidence among private-sector investors has proven increasingly challenging. The corruption cases of the late 2000s and first half of the 2010s discussed above have led to increasing state interventionism in the sector since 2015. Under Magufuli, the government proactively shaped TANESCO's decisions and their direct negotiations with the private sector, in some cases taking over the regulatory mandate of EWURA. For example, in 2017, EWURA's decision to raise tariffs was blocked and revoked by the government. Indeed, this was not the first time. In Tanzania, the political commitment to give access to energy despite increasing financial losses and payment arrears sustained by energy producers has dominated the scene and has continued even with the increasing deterioration of TANESCO's financial situation and corruption scandals. Over the years, this has also meant that TANESCO has cumulated outstanding debt positions towards private providers under PPAs spanning from 9 to 12 months. This has been particular true towards Songas, which threatened to withhold its electricity supplies because payment delays from TANESCO were undermining its financial commitment with its gas supplier.

As pointed out in other country cases (see, for example, the case of Bangladesh in Khan et al., 2020), in such adverse contexts, investments in the energy sector tend not to be viable for capable energy generation firms that rely on continuous returns to meet their financial obligations and to cover their upfront capital investment costs in energy generation plants. As a result, in this context, the tendency is to attract either firms with a high risk tolerance (and hence higher cost of financing and higher resulting cost of electricity generation) or firms that bet on political connections to get their money returned (and for that to happen as fast as possible, and with minimum investment effort). The EPP Richmond corruption case (Cooksey, 2017) can be explained within this structurally vulnerable context.

3.2. Financial and operational governance challenges

As already stressed, the political economy of the energy sector results in a challenging financial and operational position for the public utility TANESCO. Over the years, TANESCO has internalised the financial costs associated with corruption cases (and related extremely expensive contracts). Moreover, it has delayed payment of electricity bills by private customers (households and firms) and public institutions, as well as affected by the subsidised tariff policy enforced by the government. Given its financial situation, TANESCO was also prevented from borrowing financial resources in the commercial banking sector. This, combined with limited financial returns (and in fact losses) from buying and supplying electricity, has reduced the internal organisational capabilities of TANESCO.

Limited organisational capabilities in a pivotal institution like TANESCO results in operational inefficiencies. It also increases vulnerability to corruption at all stages and across all core business functions from procurement and negotiation through to contract monitoring and enforcement. The Public Procurement Act details a very specific set of recommendations and regulatory frameworks to secure the integrity of the entire process of tendering, comparison of bidding propositions by private actors, and due diligence on the firms bidding, etc. In many cases, limited organisational capabilities have been overcome by engaging firms in direct negotiations under the pressure of emergency energy shortages. Alongside disjointed monitoring processes and long decision chains, this has made it difficult to reach the levels of efficiency required to address TANESCO's financial crisis.

Financial and operational challenges are therefore intertwined. They help in framing the long track record of legal disputes, allegations of mismanagement of contracts, and limited contract enforcement. The most notable example is the case of the Richmond plant, which remained idle for two years after commissioning and yet TANESCO was charged by the company US$4 million per month throughout the period. Financial and operational challenges also offer significant opportunities for rents capture and explain the divergent patterns among energy plants – It is worth to note how TANESCO operated at the same time plants whose performances were strikingly different and that these differences persisted over time.

To illustrate this point, building on Eberhald et al. (2016), in Table 1 we contrast the performances of the two main IPPs – Songas and IPTL – in 2015. We find that while IPTL was contributing around 11% of total energy production and accounted for 25% of the total costs for TANESCO (with a unit cost of electricity equal to 31 cents per kWh), Songas was generating more than double the electricity of IPTL but was costing TANESCO less than one third that of IPTL (with a unit cost of electricity equal to 0.05 cents per kWh). These differences in tariffs paid to the two IPPs resulted mainly from the fact that IPTL was running its plant using imported industrial diesel, while Songas operated with domestic natural gas. However, striking differences remain, even when accounting for the fixed cost due to investments in building the energy generator plants.

Table 1. Share/cost of capacity and generation, by type of producer in Tanzania, 2015

Entity	2015 Production (US$)	% of Production	Total cost (US$)	% of cost	Running/fuel cost (US$/kWh)	Capacity cost (US$/kWh)	Per unit cost (US$/kWh)
Songas	1,349,195.30	22.52	67,459.77	8.19	0.013	0.037	0.05
IPTL	644,525.70	10.76	199,802.97	25.25	0.22	0.08	0.31

Source: Eberhard et al. (2016)

These differences and unfavourable PPAs signed by TANESCO – which in the case of IPTL spanned 20 years – created a massive financial burden for the company, especially within the political economy context described above. Over the years, these costs meant that TANESCO had to keep allocating disproportionate and paradoxical subsidies towards the most inefficient and expensive IPP plants. Political pressure also meant that remote and inefficient plants owned by TANESCO had to be subsidised, independently from the fact that they were operating at significantly higher costs than others. Shifting these unproductive energy rents towards more productive uses is central to achieving a sustainable financial situation for TANESCO, while continuing to increase energy access. In other words, in light of the strong political commitment for energy access in Tanzania, an anti-corruption strategy for the energy sector needs to start by targeting those unproductive rents that are making TANESCO financially unsustainable and to do this in exchange for retaining the political commitment.

4. A micro econometric analysis of subsidy allocation in the energy sector in Tanzania

Building on a newly built plant-level dataset that includes 31 energy plants for the period 2008–2017, in this section we conduct an econometric analysis of the subsidy regime administered by TANESCO through its electricity buying decisions (and hence subsidy allocation) across several publicly and privately owned plants. Each of these plants have different running cost functions due to their different initial investment and operational costs. We assess econometrically whether the subsidies awarded to different typologies of power producers are proportionate to changes in their generation costs, to investigate whether the subsidies were awarded differently among producers. Furthermore, we compare the efficiency – in terms of cost per unit of energy produced – of on- and off-grid power plants. The regression analysis estimates the elasticity between the generation costs/prices paid to producers and the value of subsidy awarded to different generation plants using two alternative subsidy calculations to check the robustness of results.

4.1. Data and variables

This paper utilises previously unpublished but highly detailed annual and monthly production data, combined with published but unformatted price data from EWURA, and national statistics published by the World Bank through the World Development Indicators (WDI). These datasets were combined to produce a series consisting of 187,051 observations from 2008–2017, of which approximately 15,000 (8%) were imputed. The data were cleaned by applying trend analysis to produce generation data for the year 2016, which was absent from the base dataset (Table 2). Two imputation methods were developed for this: one using a weighted average of monthly units generated for the full 2008–2015 and 2017 time periods, which were applied to each month of 2016; the other using the annual percentage changes from 2015/16 or 2016/17 (depending on data availability) applied to each month of 2016 as a proportion of either the 2015 or 2017 monthly data. The latter approach yielded total unit generation figures which were more accurate compared with the annual figures from our other annual production dataset. This approach produced a data series for the year 2016 which was reflective of the seasonal variation in generation as recently as possible.[1]

[1] Seasonal variations in the production data for 2016 are a combination of seasonal trends from both 2015 and 2017. Note that the seasonal weather patterns differed across all three years and that direct linear relationships exist between sequential annual observations of the imputed variables. The level of production was assumed to be proportionate to the rate of change in unit generation cost across the 2015–2017 years, resulting in an imputed unit generation cost variable for the 2016 year that reflected the differences in production levels and generation costs across different facilities. Whilst this data cleansing is not ideal, we believe that the accuracy of these figures is appropriate for the purposes of this research.

Table 2. Dataset description

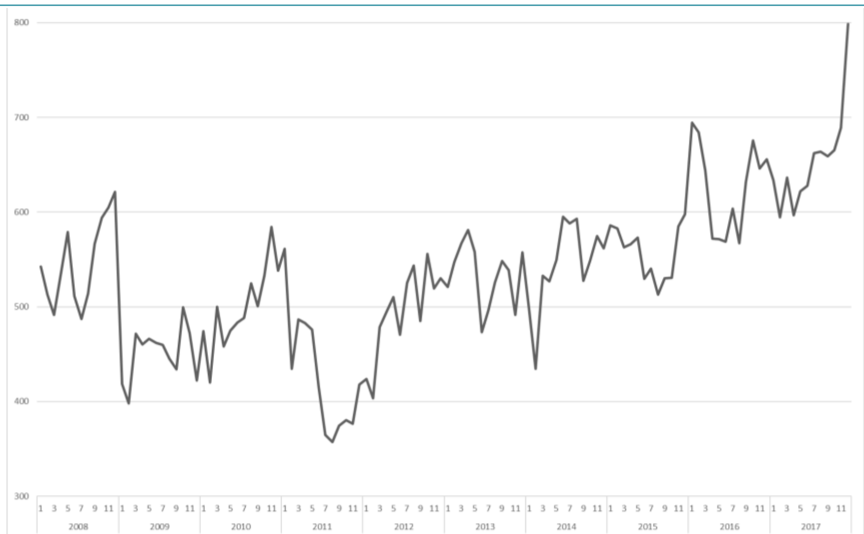
Dataset	Price data	National grid capacity & generation data	Production data	World Development Indicators (WDI)
Description	Extracted from EWURA Tariff Review Applications. Results are published by EWURA as legal documents which detail the prices applied for different categories of consumers under the Approved Tariffs section	The capacity and generation from selected plants, categorised by plant type	Monthly data detailing a selection of variables extracted from each facility	
Time period, interval	2004–2018, updated with each publication	2005–2017, annual	2008–2015 & 2017, monthly, converted also to quarterly and annual figures	2008–2017
Variables	Customer category, unit measure, current tariff, proposed tariff, approved tariff, % change	Capacity in MW (2 decimals), generated electricity in gigawatt hours (GWh) (2 decimals), totals for hydro, thermal and isolated plants, and other facilities	Availability, installed capacity, power station, units generated, units sent out, fuel consumed (litres) and for gas (million British thermal units, mmBTU), lube oil consumption, fuel price (Sh/litre), fuel costs/gas costs, cost per unit generated, SFC, SLC, total lube oil cost, total fuel, summaries for each category of plant	

Source: The authors.

The total electricity generation and the macro-regional distribution of generation in Tanzania is displayed in Figure 9. **Total monthly electricity generation (GWh), 2008–2017**

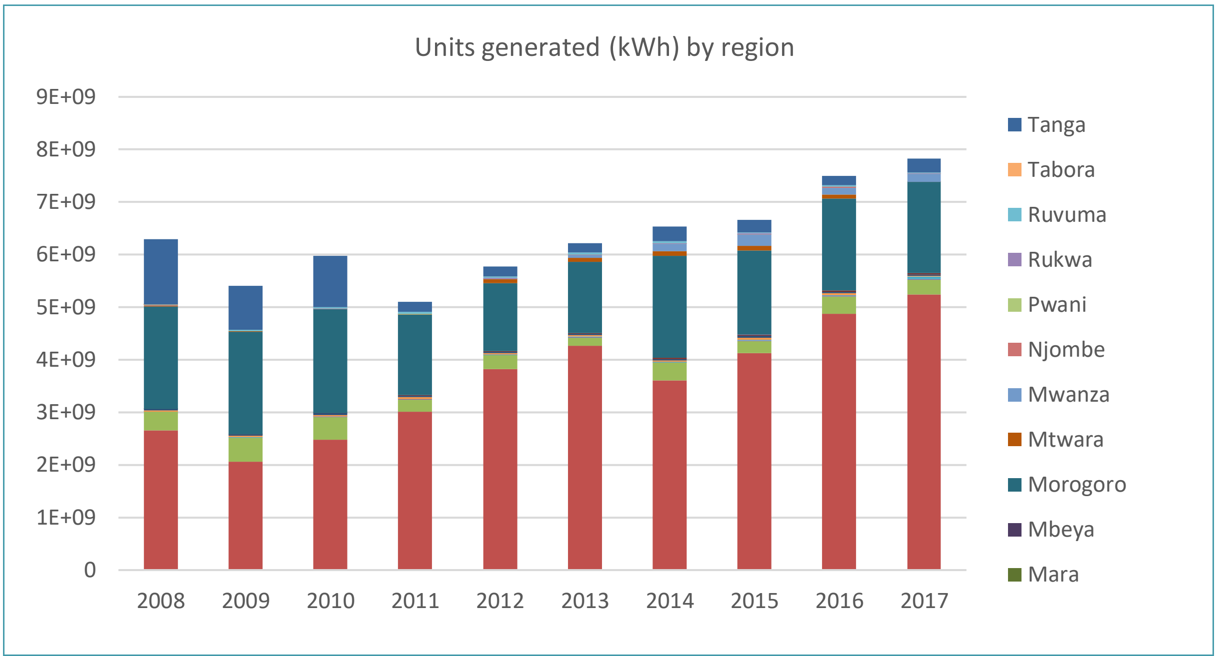
and 10. Electricity generation has been increasing over time in Tanzania, but this has been subject to a degree of volatility arising from recurrent droughts given the reliance on hydropower and heavy concentration of generation to the eastern region of the country.

Figure 9. Total monthly electricity generation (GWh), 2008–2017



Source: The authors based on TANESCO plant-level data.

Figure 10. Macro-regional distribution of electricity generation in Tanzania



Source: The authors based on TANESCO plant-level data.

The EWURA tariff data are split into different customer categories: D1 for Domestic Low Usage, T1 for General Use, T2 for Low Voltage Supply, T3 for High Voltage Supply and T5 for ZECO. However, T1 was split into two tiers in 2017, *a* and *b,* and T5 was abolished to be replaced by two tiers of T3 supply for Medium and High Voltage (T3-MV and T3-HV respectively). To resolve the discontinuity arising from this change within the data set, the average price of T1a and T1b was used as a proxy for the T1 price, and similarly the average of the T3-MV and T3-HV variables was used as a proxy for the entire T3 price. Note that no proxy was employed in 2017 in place of the discontinued T5 category. One of the limitations posed by the averaging of these categorical prices to produce the T(AVG) variable used in the subsidy calculation is that the prices are not weighted by the number of consumers in each category. Unfortunately, such information was unavailable to produce a more accurately weighted average for this research.

To calculate the estimated level of subsidy granted to each facility, two subsidy variables were constructed, denoted P-T(AVG) and P/T(AVG) in the dataset, which are referred to here as the *Net subsidy* and *Ratio subsidy* variables respectively.

The differences between the unit generation cost at each facility and the unit prices paid by the different categories of consumers were first computed, which were then averaged to estimate the net subsidy level for the period. This variable is positive where the producer was paid a higher unit cost than the unit price paid by consumers and negative where consumers were paying more than the producer received per unit. This method of calculation was problematic for the modelling approach adopted as the log conversion of this variable excludes the negative values, reducing the number of observations that could be regressed.

To overcome this limitation and test the validity of the regression results, a second subsidy variable was calculated with lower levels of nominal variability as a ratio between the unit generation cost and an average of the consumer prices. This ratio subsidy variable can only be positive, meaning that all observations are included in the logged form when this is regressed, maximising the observations used in the model. Where the ratio is less than 1, the unit generation cost was lower than the average price paid by consumers, and where this ratio is greater than 1, the unit generation cost was greater than the average price paid by consumers. Note that for both subsidy variables, the calculation method changes for the 2017 year where the consumer categories are adjusted, as different consumer categories are now averaged to form the overall consumer price level. Where our results confirm the hypothesis for both subsidy variables, the results are the most robust.

There are a number of outliers in the base dataset which do not fit with their respective series, for example, at the Mbeya plant, the average unit generation cost ranges between TSh400–700 but for one month in 2009 this spiked to TSh16,456, preceded and followed by a number of months during which this was a four-digit figure. The valuation of such outliers provides an interesting insight into the production shocks in the sector arising from droughts or other supply shortages, as these short-term increases in price potentially represent high transfer payments to the production facilities relative to the generation in each period. However, these outliers also skew the accuracy of our estimation methods, so it is necessary to compare the monthly data with both quarterly and annual figures to assess the differences between short-term fluctuations and longer-term trends. The quarterly data were simply calculated as the average for each variable across the three months of each quarter for four time periods each year. The annual data, similarly, were simply calculated as an average of the 12 months in each year for every variable.

Table 3. Summary statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Installed capacity	22,577.41	46,354.13	0	204,000
Availability	18,249.40	43,014.56	0	200,000
Fuel consumption	442,073.97	2,339,633.76	0	72,699,379
Lube oil used	1,201.34	7,645.70	0	457,973
Units generated	11,113,745.17	25,257,029.34	0	230,077,603.99
Generation cost	477,919,825.21	1,456,190,469.55	0	41,724,664,445
Unit generation cost (P)	3,049.74	14,027.94	0	317,940
Generation cost inflated	476,422,254.25	1,476,712,824.10	0	42,408,947,712
Unit generation cost inflated	476.83	4,859.76	0	323,154.22
Gap of installed capacity to units generated	-8,117,814.38	20,243,491.59	-133,754,616	403,200.03
Subsidy1: P-T(AVG)	2,938.65	13,997.65	-155.78	317,784.22
Subsidy2: P/T(AVG)	16.08	75.52	0	1,448.47

Note: *T(AVG)* is the average of different tariff rates paid by consumers, as per the EWURA publications.

Source: The authors based on EWURA and TANESCO data.

4.2. Subsidies analysis

Graphs of our two subsidy variables reveal the differences between the nominal variability in the two methods of calculation as well as the impact of outliers across these methods and different time intervals. The monthly data in 2017 are of particular interest, because at first glance, it would appear that the level of subsidy rose to a higher level than previously witnessed in October, which is the case nominally. However, comparing this with the ratio calculation of the subsidy, we observe that this was not much higher than the 2011 period. Similarly, observing the annual data, the subsidy level – following an initial sharp rise in 2011 – appears to decline only gradually towards 2017; however, when we observe the subsidy ratio, we see that this actually declines at a slower rate. These examples highlight the importance of the comparison between our two methods of calculation for confirming the validity of our results. This is because the hypothesis is more easily confirmed during periods of high nominal variability, which is compressed when we convert the figure to a ratio, but rapid changes in the nominal calculation reflect price-level changes which do not adjust the ratio as significantly. The following graphs and commentary reveal the extent of these differences, confirming the need for two subsidy measures to check the robustness of our results.

Figure 11. Monthly net subsidy variable (TSh), 2008–2017

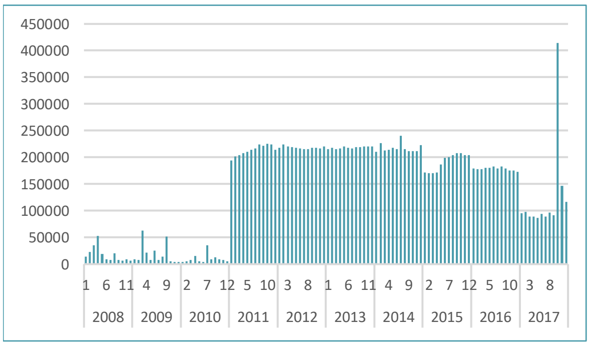
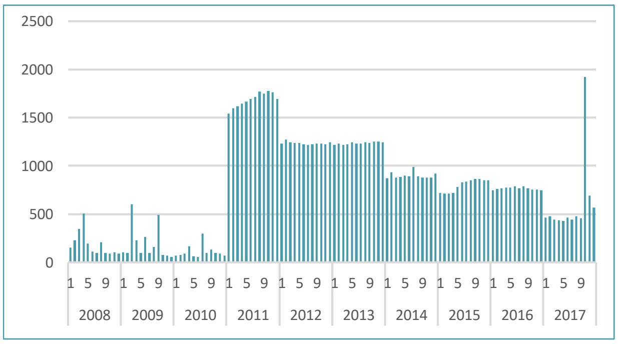


Figure 12. Monthly net subsidy variable (TSh), 2008–2017



Source: The authors based on TANESCO data.

Comparing Figure 11 and **Figure 12**, it becomes apparent why two different estimates of subsidy are needed to test the validity of our results. Note that a spike in the data is present in October 2017 which could constitute a corruption phenomenon in the form of a disproportionate reward for cost increases. In **Figure 12**, this anomalous observation appears to be approximately double the average subsidy level during the preceding 2011–2016 time period. However, when we switch to the ratio subsidy estimation in **Figure 12**, we can see that this observation is only slightly higher than the 2011 average.

As we change the level of observation in the data to a different time interval, such anomalies become obscured as the quarterly and annual averages smooth over such outliers in the data. Figure 13 and Figure 14 show how the quarterly data reverse the implications of the observed outlier in October 2017.

Figure 13. Monthly net subsidy variable (TSh), 2008–2017

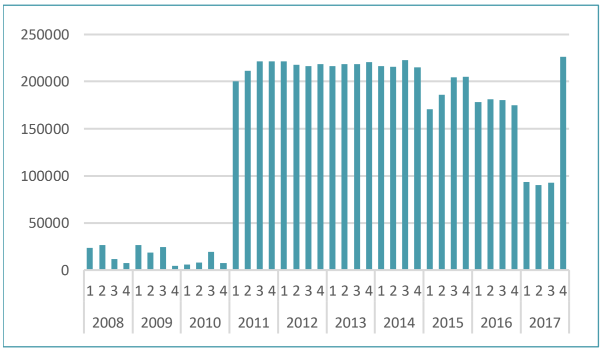
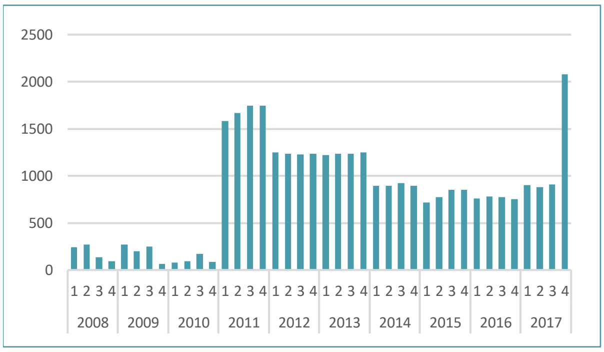


Figure 14. Monthly net subsidy variable (TSh), 2008–2017



Source: The authors based on TANESCO data.

In Figure 13, it now appears that the quarterly subsidy awarded in Q4, covering the October 2017 anomalous observation, is in fact very similar to the average subsidy level from 2011–2016. However, switching to Figure 14 and observing the same anomaly using our ratio variable now reveals two things. Firstly, the rate of decrease in the subsidy from 2011–2016 is much faster than it would appear to be in Figure 11 of the monthly data. Secondly, the Q4 2017 period once again appears anomalous, rising to a much higher level than the 2011–2016 average. Turning to the annual data reveals further changes in the possible interpretation of these results.

Figure 15. Annual net subsidy (TSh), 2008–2017

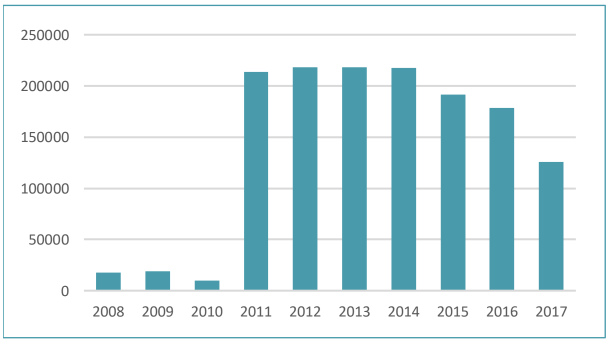
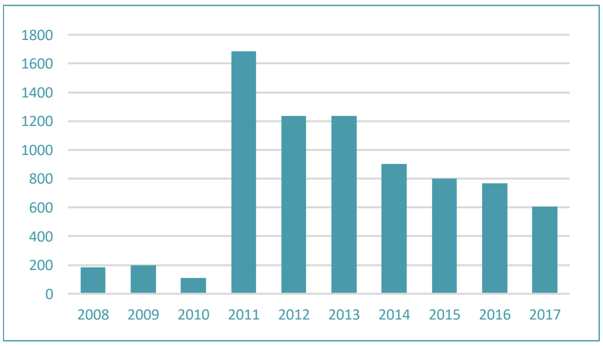


Figure 16. Annual ratio subsidy variable, 2008–2017

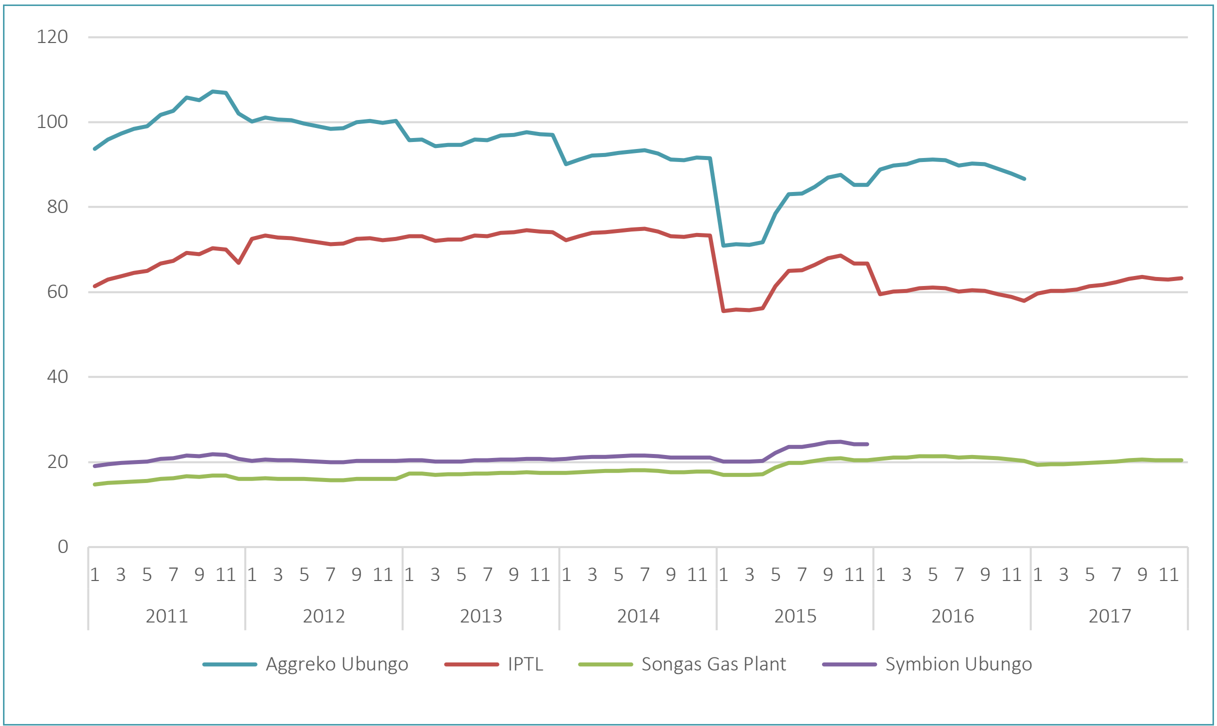


Source: The authors based on TANESCO data.

In Figure 15 and Figure 16, the anomalous observation in October or Q4 of 2017 is completely obscured, changing the observation entirely to show that the total subsidy awarded to generating facilities declined. Once again, the differences in the methods of estimation are revealed by the speed of decline in the total subsidy variable, which is more rapid in **Error! Reference source not found.** using the ratio subsidy variable.

These comparisons highlight the importance of comparing different estimates of the subsidy level because it has been demonstrated that changing the timescale of analysis may be used as a tool to obscure anomalous levels of awarded subsidy in the short term. Policy-makers and government ministers taking advice on the appropriate level of subsidy to award to different facilities, and in total, should be aware of these differences to ensure that one-off subsidy payments that are much higher than the running average cannot be obscured by different forms and timescales of subsidy reporting. Of course, as already identified in the Electricity Act 2008, the three principles of tariff-setting may be employed to justify such anomalous results, hence the need to investigate whether the subsidies awarded are proportionate to the changing cost structures of Tanzania's power plants.

Figure 17. EPP capacity and energy charges (US$/kWh), 2011–2017



Source: The authors based on TANESCO data.

4.3. Econometric model and results

The two subsidy indicators previously described were used as the dependent variables for the model designed to measure how subsidies received by power generating plants responded to changes in a set of independent variables. Among the dependent variables used in the regressions to control the magnitude of the subsidy, the production cost (unit generation cost) variable plays a crucial role. The level of subsidy awarded to each power plant is expected to be proportional to the change in the production cost, and this assumption should apply (on average) to all the different typologies of plants and (within each typology) for all the power plants. The assumption here is that when the subsidy increases disproportionately more than the increase in the production cost, then this will be interpreted as a flag for a potential corruption phenomenon.

The law governing how subsidies are awarded in the power sector in Tanzania is laid out in Part III, Sub-section 5 of the Electricity Act 2008. This covers the cost of efficient business operation, the recovery of a fair return on the investment, provided that such investment has been approved by the Authority and that the cost covered by tax exemptions, subsidies or grants provided by the government or donor agencies shall not be reflected in the cost of business operation. The logic is that when there is a 1% increase in the production costs of a power generating plant, TANESCO could reasonably award an increase of 1% in the subsidy that the given plant is receiving; this would be perceived as a 'fair' premium – or subsidy – to pay. Alternatively, TANESCO could interrupt the purchase of energy coming from that plant – as the purchasing cost of power is now perceived to be too high now – and divert the purchase of power to another power generating plant which operates at a lower cost. This could be a viable possibility as in Tanzania there are several power plants generating less energy than they could potentially generate. The third alternative – which relates to those episodes when TANESCO increases the subsidy by more than 1% – may be considered as corruption-related episodes. In other words, where power generating plants are persistently rewarded disproportionately over time as a consequence of the increase in their production cost –when those costs are not motivated by plant investments – this could potentially raise a corruption flag.

The model aims to assess the main determinants of the subsidy, as indicated in (1):

(1) $Subsidy_{it} = a0 + \beta_{it}$ *(logarithm of unit generation cost)*$_{it}$ + C_{it} *(logarithm of plant related variables)*$_{it}$ + D_{it} *(country level variables)*$_{it}$ + E_{it} *(year dummy)* + G_{it} *(geographical dummy)* + e_i

where the subsidy (independent variable) takes either the form of the net subsidy or subsidy ratio. The variable related to the unit generation cost indicates the logarithm of the cost (expressed in TSh) of producing one kWh of energy. The plant-related variables are the logarithm of the installed capacity – which refers to the amount of energy the plant is capable of generating – and the logarithm of energy production, both measured in kWh. Country-level variables are indicators that relate to the energy market in the country, the number of cell phone subscriptions per 100 people, imports of information and communications technology (ICT) goods, and the energy intensity of industry. These indicators come from the WDI; other WDI indicators have been used in combination and in lieu of the three previously mentioned, with no major differences arising. The subscript *i* relates to the different power generating plants, while the subscript *t* refers to the different time periods; the time under the analysis goes spans 2008 to 2017 and data are intended to be monthly.

Model 1 was run using the first subsidy indicator (results in Table 4 and Table 5) and then using the second subsidy indicator (results in **Error! Reference source not found.** and Table 7); the models were run for all of the power generating plants in a pooled regression and for the different typology of power plants (grid thermal, hydro, isolated, small-scale hydro and EPP). The results in Table 5 and in **Error! Reference source not found.** refer to regression results using sub-sets of the sample.

Overall, regression results suggest that subsidies have been fairly distributed among power generation plants; on average, TANESCO awarded subsidies proportionally to the increase in the production cost, meaning that a 1% increase in the production cost translates into a 1% increase in the subsidy. A more detailed analysis, on the other hand, suggests that there are few typologies of plants which constantly receive higher subsidies, while others are less than fairly rewarded.

The coefficient associated with the logarithm of the unit generation cost that is associated with all of the power generating plants (column (2) in Table 4) indicates that an overall 1% increase in the unit generation costs of all the power generating plants translates into a TSh30 increase in the subsidy; this increase represents a 1% increase over the average value of the subsidy for all the power generating plants throughout 2008–2017 (**Error! Reference source not found.**). Overall, this coefficient indicates that the subsidy system operating in the power sector fairly rewards the plants because an increase in the cost is proportionally compensated by an increase in the subsidy. The same model is estimated at a disaggregated level to see whether subsidies are fairly allocated to the different typologies of plants. Results (columns (3) to (7) in Table 4) indicate that, on average, grid thermal, hydro and small-scale hydro plants are rewarded less when there is an increase in their generation costs; the opposite happens for the isolated plants and for the EPP plants – for which a 1% increase in generation costs translates into a 1.2% and 8.6% increase in the subsidy, respectively.

The results in Table 4 show that, on average, power generating plants are fairly rewarded; however, a more disaggregated analysis suggests that isolated and EPP plants receive proportionally higher subsidies.

Table 4. Ordinary least squares (OLS) regression result

Variable	All power generating plants (2)	Grid thermal plants (3)	Hydropower plants (4)	Isolated plants (5)	Small-scale hydro plants (6)	EPP plants (7)
Logarithm of unit generation cost	3062.14***	1928.00***	21.23***	3,542.45***	114.82***	25,288.61***
	167.52	167.68	1.12	246.14	6.08	1,343.53
Number of obs.	3,476	383	560	1,810	239	418
Adjusted R-Squared	42.29	39.75	84.24	10.66	74.65	82.16
Regression type	OLS	OLS	OLS	OLS	OLS	OLS

Notes: The table only reports the coefficient of the variable 'Logarithm of the unit generation cost'. The other independent variables included in the regressions are the logarithm of the installed capacity and the logarithm of the energy production, which relate to the number of cell phone subscriptions per 100 people, imports of ICT goods, energy intensity of industry, geographical location and dummy year.

Source: Authors' elaboration from the TANESCO dataset.

The analysis is then restricted to different sub-samples to better understand whether higher subsidies are dispensed to specific categories of power generating plants. Column (2) in Table 5 shows the regression coefficient associated with the logarithm of the unit generation cost when the regression only includes those plants for which the subsidy assumes positive values – i.e. those plants for which the difference between the price paid by TANESCO to the plant and the tariff applied by TANESCO to customers is positive. In this specific case, the regression coefficient suggests a very elastic behaviour of the subsidy which increases by 4% when the cost increases by 1%. On the contrary, if we restrict the analysis to only those plants which experience a negative subsidy (column (3) of Table 5), the subsidy behaviour then becomes extremely inelastic – the subsidy still increases but by less than 1%.

The same exercise is repeated for the isolated plants (column (4) and column (5) of Table 5) and the regression coefficients tell us a similar story. In the case of isolated plants, in 95% of the cases under analysis the plants do experience positive subsidies; for those power generating plants the increase in the subsidy is more than proportional to the generation cost. For a total of 90 cases, approximately 5% of the total cases, the subsidies assume a positive but small value; in those circumstances, the plants are rewarded with a minimal subsidy (TSh0.65 in response to a 1% increase in the unit generation cost).

Table 5. OLS regression result

Variable	All power generating plants for which the subsidy is positive (2)	All power generating plants for which the subsidy is negative (3)	Isolated plants for which the subsidy is positive (4)	Isolated plants for which the subsidy is negative (5)
Logarithm of unit generation cost	12,044.65*** 279.44	21.99*** 0.44	5,856.36*** 323.86	65.26*** 1.91
Number of obs.	2,296	1,207	1,720	90
Adjusted R-Squared	68.14	85.62	16,48	98.85
Regression type	OLS	OLS	OLS	OLS

Notes: The table only reports the coefficient of the variable 'Logarithm of the unit generation cost'. The other independent variables included in the regressions are the logarithm of the installed capacity and the logarithm of the energy production, which relate to the number of cell phone subscriptions per 100 people, imports of ICT goods, the energy intensity of industry, geographical location and dummy year.

Source: Authors' elaboration from the TANESCO dataset.

Table 6 and Table 7 show the results for model (1) when we use the second indicator for the subsidy, which is the ratio between the price paid by TANESCO to the plant and the tariff applied by TANESCO to the customers.

The regression coefficients point in the same direction as the previous results; isolated plants and EPP plants (column (5) and (7) of Table 6) are the ones showing, on average, more than proportional increases in subsidy in response to a change in costs (of 1.3% and 4.8%, respectively). The results in Table 6 confirm that higher subsidies – which could potentially hint at corruption-like episodes – are more likely to be found in power generating plants of these two types.

Table 6. OLS regression result

Variable	All power generating plants (2)	Grid thermal plants (3)	Hydropower plants (4)	Isolated plants (5)	Small-scale hydro plants (6)	EPP plants (7)
Logarithm of unit generation cost	18.05*** 1.08	19.20*** 1.93	.12*** 0.01	22.06*** 1.26	.50*** 0.02	106.43*** 6.98
Number of obs.	3,476	383	560	1,810	239	418
Adjusted R-Squared	58.35	38.30	46.97	15.28	79.18	87.04
Regression type	OLS	OLS	OLS	OLS	OLS	OLS

Notes: The table only reports the coefficient of the variable 'Logarithm of the unit generation cost'. The other independent variables included in the regressions are the logarithm of the installed capacity and the logarithm of the energy production, which relate to the number of cell phone subscriptions per 100 people, imports of ICT goods, the energy intensity of industry, geographical location and dummy year.

Source: Authors' elaboration from the TANESCO dataset.

The exercise of restricting the sample to only those plants that show subsidy values higher (lower) than 1 – when the ratio between the price paid by TANESCO to the plant and the tariff applied by TANESCO to customers is higher (lower) than 1 – is repeated and the results are shown in **Error! Reference source not found.**. When the regression is restricted to those power generating plants for which the subsidy assumes a value higher than 1 (column 2 of Table 7), then the regression coefficient suggests a very elastic behaviour of the subsidy. The subsidy is estimated to increase by 2% when the production cost increases by 1%. In contrast, if we restrict the analysis to only those plants with a negative subsidy (column (3) of Table 7) – approximately one-third of total cases – the subsidy behaviour then becomes extremely inelastic, with the subsidy increasing just very marginally.

Columns (4) and (5) of Table 7 relate to only isolated plants with a subsidy value higher or lower than one, respectively. Once again, the results confirm that, for the majority of the isolated plants, subsidies respond in an elastic way to changes in the production cost.

Table 7. OLS regression result

Variable	All power generating plants for which the subsidy is higher than 1 (2)	All power generating plants for which the subsidy is lower than 1 (3)	Isolated plants for which the subsidy is higher than 1 (4)	Isolated plants for which the subsidy is lower than 1 (5)
Logarithm of unit generation cost	32.66*** 2.27	.13*** 0.00	22.33*** 1.78	0.31*** 0.09
Number of obs.	2,149	1,327	1,720	90
Adjusted R-Squared	72.17	90.07	15.28	97.07
Regression type	OLS	OLS	OLS	OLS

Notes: The table only reports the coefficient of the variable 'Logarithm of the unit generation cost'. The other independent variables included in the regressions are the logarithm of the installed capacity and the logarithm of the energy production, which relate to the number of cell phone subscriptions per 100 people, imports of ICT goods, the energy intensity of industry, geographical location and dummy year.

Source: Authors' elaboration from the TANESCO dataset.

5. A feasible reform strategy for the energy sector: towards targeted green rents

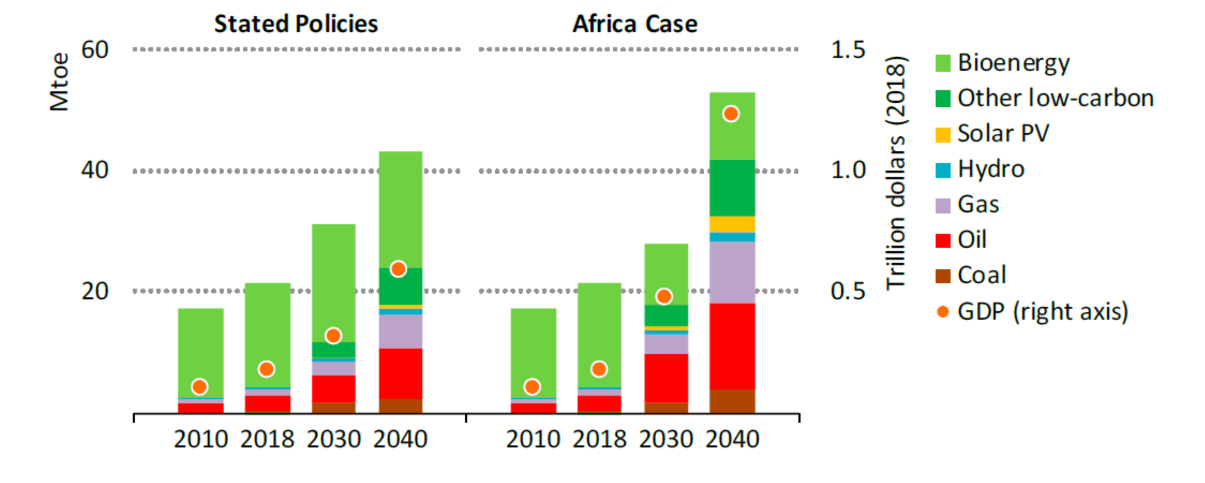
In Tanzania, in 2017 alone, total electricity subsidies accounted for 2.47% of total GDP (around US$1.3 billions) (GET.invest, n.d.). The econometric evidence presented in section 4 highlights how TANESCO's buying decisions have not always followed an efficiency buying criteria aimed at reducing costs and the need for subsidies. On the contrary, during the period under review, it disproportionally allocated subsidies to a sub-group of power generation plants whose unit generation cost structure is relatively more expensive. In some cases, this is due to direct and indirect rents capture opportunities (for example, the running of industrial diesel plants in remote parts of the country), in others to PPAs with guaranteed capacity charges. This subsidy regime has become unsustainable, as TANESCO's mounting debt has clearly demonstrated.

A feasible reform strategy for the energy sector in Tanzania needs to begin with recognition that the political commitment to increasing energy access will remain strong – it is central to state legitimation and CCM's holding power. But that this political commitment is not compatible with the current subsidy allocation regime. Hence, reforms must make TANESCO's subsidy allocation incrementally more sustainable.

More radical privatisation reforms that eliminate subsidies across the board and lead to tariff increases would be difficult to sustain politically and would not necessarily improve the overall financial sustainability of the sector. Indeed, the evidence presented in section 4 points to the fact that reforms must take into account striking differences between energy producers. In those cases, in which energy generating companies are operating efficiently and are selling to TANESCO at competitive prices, maintaining subsidies is compatible with expanding energy access. Removing subsidies across the board without taking these differences into account would make even efficient and competitive energy producers like Songas unviable businesses in Tanzania.

Given the projected increase in the overall energy demand projected by the IEA under different economic growth scenarios (Figure 18), the second condition for a feasible reform strategy is that Tanzania expands its energy generation capacity focusing on the least-cost options available for fulfilling the different roles asked of power generation (baseload, mid-merit, 'peaker' and ancillary services). Tanzania is expected to more than double its energy needs by 2040, and these needs can be met with different energy generation technology mixes. In Figure 18, the Stated Policies Scenario reflects IEA's measured assessment of today's policy frameworks and plans, taking into account the regulatory, institutional, infrastructural and financial circumstances that shape the prospects for implementation (as discussed in sections 2 and 3). The Africa Case in Figure 18 is built on the premise of Agenda 2063, the continent's inclusive and sustainable vision for accelerated economic and industrial development.[2] Under this scenario and in line with the SDGs, the Tanzanian population will benefit from full access to electricity and clean cooking and a significant reduction in premature deaths related to pollution (IEA, 2019).

Figure 18. Tanzania primary energy demand and GDP under two different scenarios



Source: IEA (2019).

To achieve these goals, increasingly the lowest-cost options are wind or solar. The average Levelized Cost of Energy (LCOE)[3] for utility scale solar PV and onshore wind is now often below gas (average LCOEs being US$56/MWh, US$50/MWh and US$71/MWh, respectively, according to IEA 2020 projections) and records for lower electricity pricing from solar and wind projects fall every year (CDC, 2020). At the same time, in Tanzania, the government is increasingly looking at its large gas endowments to scale up its electricity generation capacity. Tanzania has proven natural gas reserves estimated at 57 trillion cubic feet with a total annual production of 110 billion cubic feet. Replacing imported industrial diesel with domestic natural gas could be a major game changer in the country's attempt to increase energy generation capacity and access.

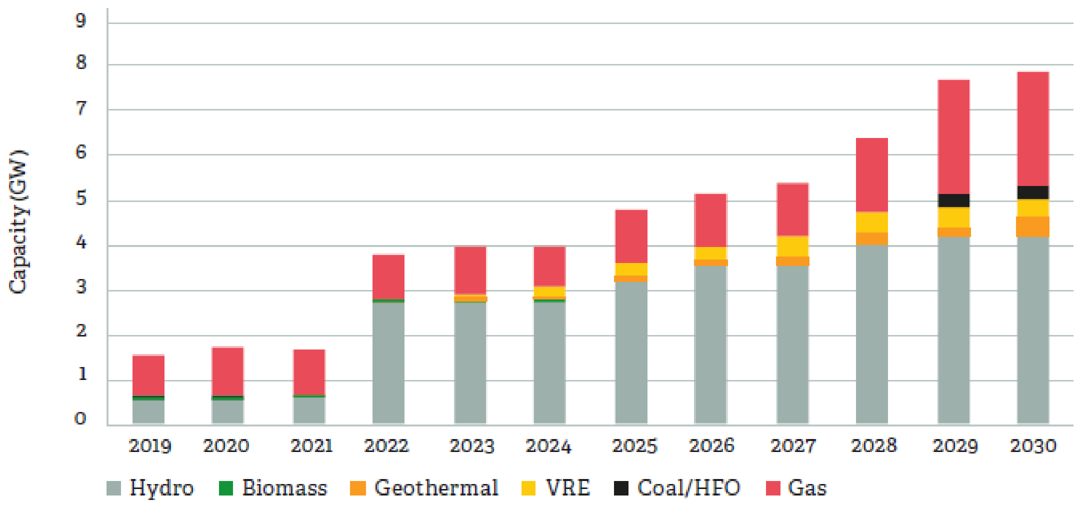
The Power System Master Plan of the Ministry of Energy (MEM, 2016a and 2016b) plans to expand total generation capacity from the current 1.7 GW to 7.8 GW by 2030 (Figure 19). Hydropower's contribution is expected to increase from 0.6 GW to 4.2 GW. Variable Renewable Energy (VRE) in 2020 accounted for only 2.5% of the entire energy mix, despite high potential for solar and wind (Ministry of Finance and Planning, 2020). According to the government plan, VREs are expected to play a relatively minor role to reach less than 0.5 GW by 2030. In combination with gas and hydro, which can provide a steady supply of energy for the grid and major urban and industrial hubs in Tanzania, solar and wind technologies can be extremely viable and cost-competitive (especially in remote parts of the country) in substitution for isolated plants run with industrial diesel. The latter are among the plants

[2] See https://au.int/agenda2063/overview

[3] LCOE calculates present value of the total cost of building and operating a power plant over an assumed lifetime. It includes such things as financing costs, but it does not present a complete picture of the costs associated with different generation choices.

that received disproportional subsidies, despite their high and increasing energy costs. These subsidies could be turned from unproductive rents into productive green rents. Modelling of different electricity production costs in different parts of the country and sectors can be used to inform such a strategy (Moner-Girona et al., 2016; Nerini et al., 2016).

Figure 19. Tanzania 2020–2030 generation mix under the Power System Master Plan



Source: CDC (2020).

Furthermore, off-grid or micro-grid renewable energy solutions, most notably solar energy options, provide a viable alternative source of electricity and an opportunity to continue to improve both access and connectivity for regions facing the risk of disconnection from the grid via transmission infrastructure degradation. Importantly, the implementation of such decentralised alternative infrastructure would require localised offices/expertise, whether under TANESCO or private ventures. This would mean employing local labour to maintain such equipment, thus providing new economic growth and employment opportunities for those dwelling in rural areas. Off-grid or micro-grid solar can accelerate the roll-out of geospatial network expansion plans by establishing forward hubs of supply that delayed transmission infrastructure may later hook into.

This position has also been supported by international donors since 2016. The World Bank Independent Evaluation Group (IEG) report from 2016 states 'deploying a strategy (which may be termed ex ante planned pre-electrification) for efficiently and effectively coordinating the advance of the grid geospatially and in time with off-grid electrification. This is backed by policy to effectively address the issues of retiring off-grid assets when grid service becomes a reality in those locations. This section highlights several country examples that embody the "next generation" of off-grid electrification strategic planning and implementation staging' (World Bank IEG, 2016: 20-21).

Replacing outdated isolated plants with such alternative solar and wind solutions could also bridge the gap towards the medium-term development of further hydropower capacity and of the gas industry in Tanzania. The Magufuli presidency (2015–March 2021) witnessed a long negotiation with international gas companies on the conditions under which Tanzania's gas industry could develop. This led to a review of the country's PSA regime and to the collapse in negotiations between the government and investors in 2019. In March 2021 – with the death of President Magufuli – the negotiation between international investors and the Tanzanian government re-opened. Newly appointed President Samia Suluhu Hassan said during the swearing-in ceremony of the country's permanent secretaries that there was a need to progress the LNG project. Tanzania's LNG in international markets could be worth TSh10 trillion (US$4.3 billion) per year based on today's market prices, with an investment time span of over 30 years. In January 2021, Shell and Equinor also signed a memorandum of understanding for formal collaboration on the LNG project in Lindi.[4]

As of the end of March 2021, the government had invested over TSh5.71 billion (US$2.4 million) for land acquisition in Lindi, and the Energy Minister, Medard Kalemani, announced that negotiations could be completed by October 2021 (the construction of the facility is expected to begin in July 2023 and be completed by June 2028). Despite this dramatic turn of events, investors have jointly stressed that the LNG project cannot develop without (i) a stable and competitive legal and fiscal framework; (ii) an evolving competitive environment, including in neighbouring Mozambique where two LNG projects are underway with opportunities to expand further; and (iii) that LNG can give a massive transformative boost to Tanzania with job creation, unlocking growth in several value chains including production of fertilizers, and advancing the country's energy security and transition.

[4] This is notwithstanding Equinor deciding to write down the book value of its investments by US$982 million in January 2021.

6. Conclusions

Tanzania's energy sector is at a crossroads. After almost two decades punctuated by corruption scandals and increasing financial unsustainability of TANESCO, the government needs a new approach to honour its political commitment to affordable energy access. Despite the ambitious pipeline of new energy generation plans, progress remains slow and the risk of unsustainable subsidies remains high. While the energy sector might need dramatic transformation, in the short-to-medium term an incremental approach would be to consider how to improve the performance of the sector, and in particular TANESCO.

In this paper, we have shown that it is critical to design an approach that takes into account the difference in performance among power generation plants that are receiving either direct or indirect subsidies (IPPs and TANESCO-owned plants respectively). Privatisation of the sector and complete removal of subsidies in the Tanzanian current context is neither feasible nor desirable.

The most feasible pathway towards transforming Tanzania's energy sector involves a two-pronged approach. This should focus on relatively shorter-term replacement of isolated plants with VRE solutions off-grid or via mini-grids, alongside efforts to unlock the gas industry negotiations. We have provided evidence showing that this would be consistent with the political commitment of the government towards increasing energy access, while retaining control of the public utility. Privatisation or unbundling have been often advocated, but these approaches have proven politically unacceptable in the Tanzanian context. Leveraging the existing pressure to deliver affordable energy and expanding access, we have shown how a targeted approach could be viable which focuses on turning increasingly unproductive subsidies towards targeted instruments for scaling up VRE in remote parts of the country. This solution is also compatible with a government commitment for centralised energy generation capacity and could offer the public multiple options for energy generation sources.

Tanzania could implement such a strategy while also leveraging its successful rural electrification programme and governance infrastructure. As shown in section 2, however, off-grid and mini-grid solutions should mainstream VRE over fossil fuel energy sources in order to align with a socially inclusive and environmental agenda. As shown in Figure 6, more than half of Tanzania'a off-grid and mini-grid plants with capacity between 1,000 kW and 10,000 kW are indeed relying on fossil fuels. The use of green subsidies such as feed-in tariff schemes to support the diffusion of a VRE solution is of course an important instrument here.

The introduction of a targeted and incremental approach towards transformation would also depend on significant developments in the organisational capabilities of government institutions and the authorities mandated to regulate and manage the energy sector. TANESCO, EWURA, REA, and increasingly TPDC in the context of the gas industry, need to develop expertise and operational capabilities to support an increasingly complex and diversified energy system. Within the feasible anti-corruption strategy set out in this paper – that is, a strategy compatible with the political commitment and settlement in Tanzania – the establishment of accountability processes and mechanisms could complement a more development-focused governance structure for the energy sector.

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8. Annexes

8.1. Annex 1: Installed power generation capacity

Name	Ownership	Funding	Year installed	Retirement	Fuel	Installed capacity (MW)
			Grid Power Generation			
Hale	TANESCO		1967	2017*	Hydro	21 (produces only 4)
Nyumba ya Mungu	TANESCO		1968	2018*	Hydro	8
Kidatu	TANESCO	WB, SIDA, GoT, CIDA	1975	2025*	Hydro	204
Zuzu diesel	TANESCO		1980	2019	Diesel	7.4
Mtera	TANESCO	IDA, KfW, SIDA, MCC, KFAED, NORAD,GoT	1988	2038*	Hydro	80
Tanwat	SPP/IPP	WB, DFID	1995	2029	Biomass	2
Pangani Falls	TANESCO	SIDA, NORAD, FINNIDA	1995	2045*	Hydro	68
Kihansi	TANESCO	WB	2000	2050*	Hydro	180
Tegeta IPTL	IPP	IPTL	2002	2021 EWURA declined production license renewal in 2017	HFO	103
Songas	IPP	Globeleq, TPDC, TDFL, GoT	2004	2024	NG	185
Tegeta GT	TANESCO	GoT	2009	2028	NG	45
TPC	SPP/IPP	DANIDA, WB	2010	2030	Biomass	17
Ubungo I	TANESCO	GoT	2008	2026	NG	102
Mwenga	SPP/IPP	WB, REA, ACP	2012	2030	Hydro	4
Aggreko Tegeta	Aggreko (EPP)	GoT	2011	2014	Gas Oil	50
Aggreko Ubungo	Aggreko (EPP)	GoT	2011	2014	Gas Oil	50
Symbion Ubungo	Symbion (EPP)	GoT	2011	2016 (still in place but not producing)	NG/Jet	126
Symbion Arusha	Symbion (EPP)	GoT	2012	2014	Diesel	50
Symbion Dodoma	Symbion, (EPP)	GoT	2012	2014	Diesel	55
Ubungo II	TANESCO	GoT	2012	2031	NG	105
Nyakato/Mwanza	TANESCO	N/A	2013	2038	HFO	63
Kinyerezi-I	TANESCO	GoT	2016	2035	NG	150
Kinyerezi II	TANESCO	EPC 15% GoT 85% JBIC (Japan)	2018 (commissioned but not yet operational)	-	NG	240
Yovi	TANESCO	EU	2016	2031	Hydro	0.95
Ikondo	TANESCO	N/A	2015	2035	Hydro	0.6
			Total installed off grid (SPP) capacity, 2016			157.5

Notes: NG= Natural Gas; HFO=Heavy Fuel Oil; *to be rehabilitated; ACP= African, Caribbean and Pacific-European Union; CIDA=Canadian International Development Agency; EU=European Union; FINNIDA=Finnish International Development Agency; Got=Government of Tanzania; IDA=International Development Association; JBIC=Japan Bank for International Cooperation; KFAED=Kuwait Fund for Arab Economic Development; TDFL= Tanzanian Development Finance Co. Ltd; WB=World Bank.

Source: TANESCO; Eberhard et al. (2016); Odarno et al. (2017); World Bank (2018b).

8.2. Annex 2: Power projects in planning and under construction, 2017

Name	Ownership	Funding source	Estimated cost (US$ million)	Expected online date	Status	Fuel	Capacity (MW)
Kinyerezi I-Extension	TANESCO	GoT	185	2019	under construction	Natural Gas	185
Kinyerezi II	TANESCO	GoT	344	2018	Under construction	Natural Gas	240
Kinyerezi III	TANESCO	PPP China Power Investment	401	2020	Financing secured	Natural Gas	600
Kinyerezi IV	TANESCO	PPP Poly Technology Inc. of China	400	2020	Feasibility study under review	Natural Gas	330
(Somanga Fungu) Kilwa Energy	IPP	ETG POWER, United Arab Emirates	365.6	2018	Working on financial closure,ongoing	NG	320
Singida	IPP	National Dev Corporation, TANESCO, Power Pool East Africa Ltd	136	2017	On hold	Wind	50
Wind East Africa	IPP	Aldwych, International Finance Corporation, Six Telecoms	285	2017	On hold	Wind	100
Stiegler's Gorge (also called Rufiji)	TANESCO	85% loan from Sumitomo Mitsui Banking Corporation 15% GoT	344	2021	Planned construction, July 2018	Hydro	2100
Mtwara	TANESCO	PPP JICA (Japan)	-	2021	Feasibility study in progress	NG	300
Ruhudji	TANESCO	PPP/GoT	407.4 + 53.2 for transmission line	2022	Feasibility study from 1998, financing not secured	Hydro	358
Rumakali	-	-	344 + 44.22 for transmission line	2022	Feasibility study from 1998, financing not secured	Hydro	222
Kakono		ADBG has booked in their portfolio to co-finance with Agence Francais de Developpement (AFD)	379.4	2021	Solicitation of financing in progress, feasibility study completed	Hydro	87
Ngaka	TANESCO	PPP National Development Corporation (NDC) and TANCOAL are mobilising funds	-	2019	Feasibility study not yet undertaken, financing not yet secured, evaluation of expression of interest for consultancy service is done	Coal	200
Kiwira	TANESCO	PPP State-owned enterprise STAMICO	430	2019	Procurement of developing partner	Coal	200
Mchuchuma	TANESCO	PPP	645.75	2020	Feasibility study needs to be updated, financing not yet secured	Coal	300

Name	Ownership	Funding source	Estimated cost (US$ million)	Expected online date	Status	Fuel	Capacity (MW)
Ngozi	TANESCO	PPP	821	2021	Feasibility study in progress, search for private sector financing	geothermal	200
Malagarasi	-	ADBG has booked in their portfolio to co-finance with AFD	149.5	2020	Finance not yet secured, feasibility study on progress, solicitation of financing in progress	Hydro	45
Kisaki	-	-	293	2021	Finance not yet secured, project concept submitted	geothermal	50
Luhoi	-	-	266	2021	Financing not yet secured, project concept submitted	geothermal	50
Somanga	-	PPP	Project cost will be confirmed after feasibility study	2018	Financing not yet secured, but WB financed, pre-feasibility study completed	NG	250–350

Source: World Bank (2018b), based on TANESCO.

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