

Strategies to enhance energy availability in Mozambique: A comparison of national electricity market regulations and strategies to encourage grid-integrated distributed renewable energy generation

Estratégias para aumentar a disponibilidade de energia em Moçambique: Uma comparação das regulamentações e estratégias do mercado nacional de eletricidade para incentivar a geração de energia renovável distribuída integrada à rede

Estrategias para mejorar la disponibilidad de energía en Mozambique: Comparación de las normativas del mercado nacional de la electricidad y estrategias para fomentar la generación de energía renovable distribuida integrada en la red

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Abstract

The energy sector in Mozambique faces huge challenges that include low generation capacity and efficiency, affordability, unstable and unreliable energy supplies, low access rates, amongst others. The situation is being worsened by high environmental, social vulnerability and extreme events influenced by climate catastrophes. With the demand of energy consistently on the rise, there is critical need to address policy, investment, market and technical barriers to energy sector development. Mozambican government has made tremendous effort in developing electricity sector regulatory frameworks. However, progress has been uneven across the country. Thus, the aim of the study was to identify potential opportunities to promote the introduction of new distributed generation policies and technologies from renewable sources in Mozambique by analyzing technological and regulatory components of the energy sector in Argentina, Italy and Mexico. Methodologically, the study uses a comprehensive literature review, several national policy frameworks and statistical data from various official sources, with public policy and sectoral performance, as well as organizational and regulatory changes in consideration. Understanding national electricity market regulations and strategies, it will enable to gain a sense of perspective of the major determinants of the sector performance, and both the potential for and constraints on regulatory reform. It was observed that for achieving efficiency in energy provision, fair pricing, equality of access and environmental sustainability, it is important to strengthen the independence of the regulator.

Keywords: Environment; Electricity; Climate change; Renewable energy.

Resumo

O setor de energia em Moçambique enfrenta enormes desafios que incluem baixa capacidade e eficiência de geração, acessibilidade, abastecimento de energia instável e não confiável, baixas taxas de acesso, entre outros. A situação está sendo agravada pela alta vulnerabilidade ambiental, social e eventos extremos influenciados por catástrofes climáticas. Com a demanda de energia em constante aumento, há uma necessidade crítica de abordar as barreiras políticas, de investimento, de mercado e técnicas para o desenvolvimento do setor de energia. O Governo Moçambicano tem feito um enorme esforço no desenvolvimento de quadros regulamentares do setor da eletricidade. No entanto, o progresso tem sido desigual em todo o país. Assim, o objetivo do estudo foi identificar oportunidades para promover a introdução de novas políticas e tecnologias de geração distribuída a partir de fontes renováveis em Moçambique, analisando componentes tecnológicos e regulatórios do setor de energia na Argentina, Itália e México. Metodologicamente, o estudo utiliza uma revisão abrangente da literatura, várias políticas nacionais e dados estatísticos de várias fontes oficiais, considerando políticas públicas e desempenho setorial, bem como mudanças organizacionais e regulatórias. A compreensão das regulamentações e estratégias do mercado nacional de eletricidade permitirá obter uma perspectiva dos principais determinantes do desempenho do setor e tanto o potencial quanto as restrições à reforma regulatória. No presente estudo, observou-se que para alcançar eficiência no fornecimento de energia, preço justo, igualdade de acesso e sustentabilidade ambiental, é importante fortalecer a independência do regulador.

Palavras-chave: Meio ambiente; Eletricidade; Mudanças climáticas; Energia renováveis.

Resumen

El sector de la energía en Mozambique se enfrenta a enormes desafíos que incluyen la baja capacidad de generación y eficiencia, la asequibilidad, la inestabilidad, falta de fiabilidad del suministro de energía, y las bajas tasas de acceso, entre otros. La situación se ve agravada por la elevada vulnerabilidad ambiental y social y los fenómenos extremos influidos por las catástrofes climáticas. La demanda de energía aumenta constantemente, por lo que es necesario abordar las barreras políticas, de inversión, de mercado y técnicas para el desarrollo del sector energético. El gobierno mozambiqueño ha hecho un gran esfuerzo para desarrollar los marcos reguladores del sector eléctrico. Sin embargo, los avances han sido desiguales en distintos sectores del país. El presente trabajo busca identificar posibles oportunidades para promover la introducción de nuevas políticas y tecnologías de generación distribuida a partir de fuentes renovables en Mozambique, analizando los componentes tecnológicos y regulatorios del sector energético en Argentina, Italia y México. Metodológicamente, el estudio utiliza una revisión exhaustiva de la literatura, varios marcos de políticas nacionales y datos estadísticos de varias fuentes oficiales, teniendo en cuenta la política pública y el desempeño sectorial, así como los cambios organizacionales y regulatorios. La comprensión de las regulaciones y estrategias del mercado eléctrico nacional permitirá tener una perspectiva de los principales determinantes del desempeño del sector, así como del potencial y las limitaciones de la reforma regulatoria. Se observó que para lograr la eficiencia en el suministro de energía, la fijación de precios justos, la igualdad de acceso, es importante reforzar la independencia del ente regulador.

Palabras clave: Medio ambiente; Electricidad; Cambio climático; Energías renovables.

1. Introduction

Mozambique is endowed with abundant renewable energy resources, but the country is poor in its capability to exploit and use them. The energy sector in Mozambique faces huge challenges that include low generation capacity and efficiency, unstable and unreliable (often very expensive) energy supplies and low access rates, amongst others (Cristóvão, et al 2021). The situation is being worsened by high environmental, social vulnerability and extreme events influenced by climate catastrophes (Chichango, et al 2021). Additionally, the population projected growth will represent a significant energy and climate challenge for development (Cristóvão, et al 2021). It is well known that countries with low electrification rates, have lower GDP per capita and are less developed. Thus, an increase in energy demand in Mozambique, may put pressure in nature and environment. The situation in Italy, Argentina and Mexico differs considerably.

Constant technological advances in the electricity distribution grid, together with the development of new electricity markets, represent opportunities and challenges for grid planners all over the world (Lubo, 2019). Moreover, at the core of these developments, consumers are being challenged to take part in the energy transition, benefiting from new technologies to reduce their bills and actively participate in the market (European Commission, 2015). On the other hand, governments should ensure access for the most vulnerable populations and find new paths to face this issue. This leads to an indispensable user-grid operator relationship, which must be technically coordinated and regulated under sustainability parameters. In order to

maximize benefits by being interconnected to the system, clear rules and the spread of information are necessary (European Commission, 2015).

The global demand to mitigate environmental impacts of electricity generation, together with the rapid increase in demand in certain regions, significant advances in environmentally friendly technologies such as wind and solar photovoltaic, and the public decision to increase green technologies based on renewable resources have sparked the need to diversify electric infrastructure and must be defined within a clear and effective legal framework (Lubo, 2019).

Globally, renewable energy development needs strong governmental policies. In Mozambique, energy legal framework is composed of a variety of policies, strategies and regulations. The country policy recognizes that adequate access to energy is critical for social and economic development of the country, yet the country faces many challenges in fulfilling global commitment, such as SDG 7 (energy and its universal access) and SDG 13 (Climate change) (Cristóvão, et al 2021). Access to electricity is ranked amongst the lowest in Africa. Moreover, even when energy is available, it is expensive and unreliable. Thus, the purpose of this research is to identify potential opportunities to promote the introduction of new distributed generation policies and technologies from renewable sources in Mozambique by analyzing technological and regulatory components of the energy sector in Argentina, Italy and Mexico.

2. Energy Matrices

Mozambique is often at the bottom of the development tables, has one of the lowest rates of access to clean energy in the world and is among the countries with the largest deficit of clean fuels and technologies as its primary means of cooking, where 80% of the energy used in the country is still in the form of traditional biomass –such as charcoal and firewood– as their primary source of energy for cooking (Cristóvão et al., 2021). Moreover, there is a huge gap between urban and rural areas, where the access to energy through off-grid systems provides electricity to less than the 30% of the population (The World Bank, 2015).

Mozambique's power industry is primarily hydroelectric which represents 97% of total primary energy supply in Mozambique (Uamusse et al., 2020). The majority of the country's power is exported to neighboring South Africa and Zimbabwe via the Southern African Power Pool. Paradoxically, Hidroelétrica Cahora Bassa Mozambique's pre-eminent hydropower generation company exports power to Eskom-South Africa, where energy is transformed and resold to southern Mozambique at a higher rate (Cristóvão et al., 2021). According to the Mozambique's Renewable Energy Atlas, the country has a vast potential in renewables of more than 23 TW and thousands of possible projects, from small solar off-grid projects for rural electrification to the large hydro plants of the Zambezi River. (Gueifão et al. 2014)

The situation in Italy differs considerably. Access to electricity in the European country was reported at 100 % in 2019, and according to the latest IEA statistics, Italy's total primary energy supply (TPES) was substantially based on fossil fuels accounting for 79.3% of TPES, broken down in natural gas (43.2%), oil (32.5%) and coal (3.5%) and RES was 9.9% (IEA, 2019). Roughly 35% of gross national production was originated from renewable sources in 2017: hydropower (35%), solar power (23%), bioenergy (19%), wind power (17%) and geothermal power (6%). Solid biomass was the most used renewable source in heating sector, which was primarily used in the households in the form of firewood and pellets. As for the transport sector, approximately 1.2 million tons of biofuels were released for consumption in 2017, which largely consisted of biodiesel (IEA, 2019).

As well as in Italy, and despite the fact that oil's role in the Mexican economy has reduced over the previous decade, energy production in Mexico is centered in the extraction of fossil resources with a greater role for oil than in any of the other three countries analyzed in this paper. According to data from the Ministry of Energy, 78.92 % of energy output in 2017 came from fossil sources, 15.66% from renewable sources, and 5.42% from clean non-renewable sources. Despite the country's

renewable energy potential and the energy transition law introduced in 2015, no substantial improvements in the energy matrix have been made by 2019 (Villavicencio & Millán, 2020).

As in the above-mentioned countries, Argentina's energy matrix is highly dependent on fossil fuels, mainly oil and gas, accounting for 87% of the total energy supply. The share of fossil fuels in the electricity matrix has been increasing during the last decades, reaching 66% of the total (Porcelli & Martinez, 2018). Currently, most of the electricity available in the Argentine Interconnection System (SADI), with approximately 31.8 GW of installed capacity, comes from large conventional generation plants and, more recently, from some wind farms, being the Wholesale Electricity Market (MEM), up until 2018, the only authorized to dispatch and sell electricity (Perahia, Di Caro e Arbore 2016). The energy demanded according to the annual report of the Wholesale Electricity Market Management Company (CMMESA) in 2020 was 136,815 GWh, of which 63.3 % is of thermal origin; 30.3 % hydraulic; 4.76 % nuclear; 0.44 % wind and solar photovoltaic; and 1.21% imported (export-import balance with neighboring countries) (CMMESA 2021).

This allows us to deduce that countries with greater population access to energy are tied to the use of non-renewable sources that lack sustainability over time and risk problems with energy security, transportation, and affordability, requiring a complex infrastructure to maintain the energy supply. The African country's lack of connectivity reveals both a weakness and vulnerability, as well as a potential to leapfrog dependency on fossil fuels, accelerating the energy transition. The opportunity to have a diversified and decentralized energy matrix promotes the search for options and allows avoiding the disadvantages suffered by more developed countries and improving the efficiency of investments.

3. Chronological Framework of the Creation of Policies and Strategies for the Energy Sector in Mozambique

The policies and strategies of the Mozambican energy sector have their beginning marked by the creation of the electricity law, Law no. 21/97, which aimed at regulating the activities of production, transport, distribution of electricity, as well as its import and exploitation. The same law created the National Electricity Council (CENELEC) to mediate disputes between utilities and consumers (Law 21/97, 1997). Due the need to develop better mechanisms for the exploitation and management of renewable energy resources, the Energy Fund (FUNAE) was established in 1997, marking a turning point in the country's institutionalization of the promotion of renewable energy exploitation. FUNAE began to ensure the spread of access to renewable energies in rural areas where the national electricity system could not be expanded due to various orders (Decree no.24/97, 1997).

The Council of Ministers establishes an energy policy in 1998, which serves as a foundation for the implementation of activities such as infrastructure restoration, new structure construction, and resource development to support cultural and social development. Resolution No.5/98 allows for increased investigation of the country's current energy resources, as well as the optimization of the use of infrastructures left over from the colonial regime, which were of little value after the country's independence in 1975 (Resolution no.5/98, 1998).

Decree no.8/2000 was issued as a result of the growth in the structure of electricity production and transportation, establishing the competencies and procedures for the distribution, control, and extinction of concepts of electricity production, transport, distribution, and commercialization, as well as its production and export (Decree no.8/2000, 2000).

From the need to adopt instruments that would ensure the orientation of the national energy policy, Resolution no. 24/2000 ensures the availability of energy in Mozambique, contributing in this way to the sustainable socio-economic development. Besides regulating the national sector, the instrument contemplates development actions for the benefit of neighboring countries and highlights the national energy contribution to the emerging industrialization in the country's

development matrix (Resolution n° 24/2000, 2000). The demand to regulate the planning, implementation, operation, and maintenance of electricity generation, transmission, distribution, and sale infrastructures, as well as their ownership, procedures, and standards for the operation and management of the national electricity grid, is addressed by Decree No. 42/2005.

Eletricidade de Moçambique (EDM) was given legal responsibility for operating the national electricity transmission and distribution grid, as well as the respective dispatch center, in 2005 by Decree 43/2005. (Decree no.43/2005, 2005). Moreover, Decree no. 48/2007 of the regulation of licenses for electrical installations was approved in response to the need to regulate the license concessions for the establishment and operation of electrical installations, as well as the legal regime in accordance with the electricity law (Decree no. 48/2007, 2007).

The old Resolution no. 24/2000 has been replaced by Resolution no. 10/2009. The focus of this new energy strategy resolution is on continuing and accelerating electrification efforts, with rural electrification as a top priority through the extension of the national energy network and the use of renewable energy, reinforcing the need for greater institutional collaboration between the EDM and the FUNAE. The resolution also called for the use of low-energy light bulbs to promote productive utilization and energy efficiency (Resolution No. 10/2009, 2009). To promote the use and harnessing of renewable energy resources in order to accelerate the use of modern energy, as well as encouraging the creation of favorable platforms for investment in the energy sector, particularly in rural areas, Resolution no. 69/2009 is created approving the policy of development of new and renewable energy.

Decree No. 58/2014, which regulates the establishment of the tariff regime, was enacted in 2014. In addition to fostering the diversity of the energy matrix and the secure supply of electricity, the Decree provides a tariff model for new and renewable energies, allowing the private sector to participate in the generation of electricity from renewable sources (Decree no. 58/2014, 2014).

By Law No. 11/2017, CENELEC, the National Electricity Council, was replaced by ARENA, the Energy Regulatory Authority, which has a stronger responsibility than CENELEC. ARENA is tasked for supervising, overseeing, and sanctioning the energy sector's actions.

In order to guarantee the supply of electricity to the entire Mozambican population by 2030, the government launched National Electrification Strategy (2018-2030) becoming important instrument for the sustainable development of the country, where the connection of the national grid to the communities accessible to the national grid and the implementation of renewable systems to the most isolated and dispersed communities is reserved (National Strategy, 2018).

4. Comparing Institutional Frameworks

Whereas in Mozambique, the national government is responsible for energy issues throughout the country, in Italy the responsibility for energy policy is shared between the Government and the Regions. With Legislative Decree no.112/1998 Regions obtain responsibility for administrative functions relating to renewable sources, electricity, oil and gas not previously reserved for the state or assigned to local authorities. Furthermore, with Constitutional Law no.3/2001, the State retains legislative power in the field of renewable energy sector, while the Regions acquire administrative power (IEA, 2016).

The organization and regulation of the Argentine electricity sector date back to 1960, when Law no.15.336, known as the "Federal Energy Law", was passed. The law conceptualized energy as a "thing" susceptible to be affected by economic transactions and established a legal system for the generation, transport and distribution of electricity. In Argentina, as a Federal State, the national government dictates the norms that regulate the sector concerning the generation, transmission and general aspects of electricity distribution, and the Electricity Regulatory Bodies of each jurisdiction control the concessions and issue the technical and commercial regulations that concessionaires must comply with (Introducción a la generación

distribuida, 2019).

The regulatory framework for introducing renewable energies into the electrical matrix dates back to 1998, when Law no.25.019, "National Regime for Wind and Solar Energy," was created. Subsequently, Law no.26.190, titled "National Promotion Regime for the Use of Renewable Energy Sources for Electrical Energy Production," was enacted in 2006. This law considers all renewable source technologies, including wind, solar, geothermal, tidal, hydro, biomass, landfill gas, sewage treatment plant gas, and biogas, with the exception of the biofuel uses specified in Law no.26.093 (Romero et al., 2019).

In the field of renewable energy in Italy, the Regulatory Authority for Electricity, Gas, and Water, an independent administrative authority charged with ensuring the promotion of competition and efficiency in public utility services while also protecting the interests of users and consumers, has a number of responsibilities, including ensuring fair grid access and allocating support to different consumer groups to address the costs of renewable energy (ARERA, 2021). Since 2005, the Energy Services Operator (GSE) has been the institutional organization in charge of promoting and expanding renewable energy sources through the provision of financial incentives, as well as disseminating the culture of utilizing green energy that is environmentally friendly. The Ministry of Economy and Finance is GSE's sole stakeholder, and it defines its lines of action in collaboration with the Ministry of Economic Development (Di Marco, 2012).

Another government agency is The National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), tasked with conducting technological innovation research and providing advanced services to businesses, government agencies, and citizens in the fields of energy, environment, and sustainable development. Its efforts are concentrated on energy technologies such as renewable energy, energy storage, and smart grids. The Ministry of Economic Development, in partnership with other ministries, is in charge of ENEA's work, which aids the productive system as well as government agencies in making the transition to a circular economy (ENEA, 2016). Terna, an Italian company, owns the national transmission grid. It was founded in 1999 after the power market was deregulated, and it is currently a joint stock organization. It is in charge of 431 transformation and sorting stations, as well as the national high and extra-high-voltage energy system's 63,500 km of lines. It's Europe's most successful independent operator (IEA, 2016).

The Argentinean federal system and the autonomy of the regions in Italy allow for more coherent actions based on the needs of each area, whereas the Mozambican national system can fall into generalization by taking decisions from the capital, Maputo, in the south of the country over remote areas, resulting in a loss of effectiveness and efficiency; however, a system of provincial delegations serves to mitigate this risk. The trend towards renewable energy legislation in all analyzed countries is seen as a positive development.

As may be observed, policy revisions are continuous. For example, in 2013, Mexico passed an energy reform as a result of a deal between the country's major political parties. The main opposition political groupings signed the "Pact for Mexico," promising to enact significant constitutional amendments by 2013 (Avelar, 2013). The Mexican government offered a reform of the energy industry in October 2021 that includes more state participation and pledges price stability, addressing the issue from a new ideological standpoint. The CFE (Federal Electricity Commission), a state-owned company, will recapture 54 percent of the market and reclaim regulatory powers it lost in 2013. The reform is still being debated, and opponents claim that it may pose a threat to the country's environment (Weiss, 2021). This allows us to argue that maintaining consistency and taking the issue seriously requires the establishment of State policies rather than Government policies.

Argentina has advanced in matters of regulations for distributed energy generation, and could be taken as example in developing countries, shedding a light on Mozambique's path. At the end of December 2017, Law no.27.424 was passed, granting the right to users of the distribution company to generate their own energy from renewable sources for self-consumption and, if there is a surplus, to inject it into the electricity grid and receive remuneration for this injection. The body of the law includes the definition of Net Billing as the billing scheme to be applied, the creation of FODIS, a financial

administration trust fund to grant promotional benefits to demand. The program granted loans, incentives, guarantees, capital contributions and the acquisition of other financial instruments, all of them aimed at the implementation of distributed generation systems from renewable sources. It also applies a scheme of tax credit certificates under the electronic voucher modality, which can be applied to the payment of national taxes (Romero et al. 2019).

In addition, the Secretary of the Government of Energy (SGE) is designated as the Authority of Application. At the end of 2018, Resolution no.314 of the SGE was issued. SGE. It creates the RENUGER, which is the National Registry of Users-Generators of renewable energies. It categorizes User-Generators into small (up to 3kW), medium (up to 300 kW) and large (up to 2MW). This resolution establishes the User-Generator Connection Procedure and the basic rules of the contract between the parties. It also establishes that the Distributors must declare monthly the energy injected by all its user-generators to CAMMESA (Romero et al. 2019).

At the beginning of 2019, Provision no.28 of the Under-Secretariat for Renewable Energies and Energy efficiency (SSERYEE) was issued, defining the requirements for electrical protections and requires quality certificates for the equipment to be connected. It also establishes the procedure to follow to carry out the user-generator connection procedure in the Digital Public Access Platform, a tool created specifically for this purpose. Finally, it describes how to register distributors and installers on the platform (Romero et al. 2019).

5. Conclusions

Based on the results obtained from literature review, the following conclusions can be reached:

- Off-grid can be combined with on-grid expansion and help to achieve SDG 7 in a cost and climate-friendly, and timely manner.
- In Mozambique, the net-metering policy can be the opportunity to provide the necessary incentives to promote the development of local distributed energy resources, primarily solar photovoltaic and wind generators.
- Argentina, Mexico and Italy are implementing net-metering and net billing in order to address affordability, reducing electricity costs and, increasing the availability of supply.
- To achieve efficiency in energy provision, fair pricing, equality of access and environmental sustainability, it is important to strengthen the independence of the regulator.

This enables us to propose that in addition to a diversified energy matrix, with incentives for distributed generation and small-scale local production, as well as the development of an adequate microfinance system, it is necessary to maintain coherence and take the issue seriously by establishing State policies instead of Government policies.

As a perspective, the authors propose to carry out the study of public policies on energy and environment in Mozambique, in the context of sub-Saharan Africa.

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