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Author(s)	Manhique, Milagre; Kouta, Raed; Barchiesi, Dominique; O'Regan, Brian; Silva, Fábio
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Energy Transition X Energy Inclusion: A Community Energy Concept for Developing Countries

Milagre Manhique
UR LIST3N/Dept. Electrotecnia
UTT/UEM
Troyes, France/Maputo, Mozambique
milagre_alfredo.manhique@utt.fr

Raed Kouta
UR InSyTE
UTBM/UTT
Belfort, France/Troyes, France
raed.kouta@utbm.fr

Dominique Barchiesi
UR GAMMA3
Université de technologie de Troyes
Troyes, France
dominique.barchiesi@utt.fr

Brian O'Regan, *IEEE Member*
International Energy Research Centre (IERC)
Tyndall National Institute, Cork, Ireland
brian.oregan@ierc.ie

Fabio Silva, *IEEE Member*
International Energy Research Centre (IERC)
Tyndall National Institute, Cork, Ireland
fabio.silva@ierc.ie

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***Abstract*—The concept of community energy has gained acceptance and popularity within academic and scientific communities, in addition to public debate forums. Community energy drives socio-economic transformations, as it places the citizen and the community as the main actors in the entire energy value chain, based on the principle of local and autonomous generation of energy by and for the community. In this article, we analyze the socio-economic impact of community energy as a strategy for energy inclusion and participation in the industrial, socio-economic and human development of communities in developing countries, especially those in sub-Saharan Africa. The community energy model discussed is based on the symbiotic interaction between social strata within local communities, the so-called community energy symbiosis. In addition, it was concluded that the concept of community energy is generally advantageous, but should be implemented by adapting it to each context, as regulation and government support vary significantly, especially in developing nations.**

***Index Terms*—Community energy, energy inclusion, energy transition, energy policy**

I. Introduction

The use of fossil fuels (mineral coal, oil and gas) as an energy source has always been identified as the main cause of irreversible environmental and human damage characterized by the emission of greenhouse gases, global warming, climate change, air pollution, degradation of health of plants, animals and humans. In this context, the international community is committed through the Paris Agreement on climate change to limit global warming to 2^0C [3], [4] or even 1.5^0C [4]–[6].

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In the process of transition from energy sources based on fossil fuels to the use of renewable energy sources, the concept of community energy - or Community Self-Consumption (CSC) - gained prominence in academic research [7], with several projects addressing the related new technologies, policies, and paradigms under development across the world [8].

Developing countries are aware of the opportunities offered by new renewable energy sources (such as solar Photovoltaic (PV) panels, wind and/or water-powered energy sources) [9], [10]. However, as relatively new technologies, these Distributed Energy Resources (DERs) – or more specifically, Distributed Renewable Energys (DREs) – still lack adequate regulation policies and standard practices.

As a consequence, regulations on the amount of energy that can be produced by renewable energy sources vary significantly [11], [12]. Those limitations target mostly *"individuals"* producing energy for self-consumption (in a individual and/or collective manner) and can impose stringent limits to the amount of generated energy and the amount of surplus energy that can be commercialised (or donated).

These regulations and policies can impact negatively the community energy by limiting scalability and, consequently, influencing how the energy social tariff could be explored in order to achieve more inclusive results.

This paper is organised as follows: Section II explains the basic concepts of community energy. Section III describes briefly the methodology used for the development of this work. Section IV contextualise the energy landscape and case studies used. Section V describes the socio-economic situation of Mozambique as the case study chosen. Section VI introduces the suggested framework to address the proposed integrated community energy framework and its social aspects. Finally, Section VII discuss and presents the conclusions of this research and also suggest important topics for future research.

II. Community Energy: Definition and Concept

The concept of community energy has been attracting attention and acceptance within the academic and scientific communities, even popularity in public debates. The concept of community energy is defined by [4] as energy installations in which energy is generated by and for the community, for [7] the term refers to local social groups that generate and distribute renewable energy. Similarly, [13] describe the concept as decentralized systems based on renewable energies in which citizens are directly involved in the activities of generation, distribution, supply and trade.

Despite the diversity in the definition of the concept of community energy, there is a shared view also discussed in [13] which consists of placing the citizen and the community at the center as the main actors (consumer empowerment) in the generation, distribution and consumption of energy.

The most notorious example of consumer empowerment is in the figure of the prosumer. Although the term prosumer is not new [14], for the scope of this research, prosumer means a community energy actor that produces and consumes energy. As a matter of fact, the prosumers are at the core of the concept of energy community, guaranteeing decentralised and flexible energy systems, and strengthening the transition to a low-carbon economy. Apropos, prosumers represent a trend that offers a variety of opportunities for all sorts of stakeholders (e.g., policymakers and regulators) [15] and can be the key to make community energy economically viable as the technologies involved with the renewable energy generation becomes more accessible through scalability.

For the context of this research, the community energy advantages can be summarised into two categories, as follows:

1) **Environmental gains:** As the concept of community energy arises in the context of the energy transition, it has the potential to promote, stimulate and accelerate the use of renewable energy sources, reducing greenhouse gas emissions resulting from the use of energy sources based on fossil fuels [4], [16], [17].
2) **Socio-economic gains:** The concept of community energy has a strong component of entrepreneurship. It promotes active and mutually beneficial community participation through the dynamics of the energy value chain, creates jobs, encourages private investment, ensures autonomy and local energy self-sufficiency, reduces the cost of energy, unites the community around common socio-economic goals with reciprocal and mutually advantageous gains [18]. Ultimately, community energy promotes collaborative social transformation leading to successful energy transition, and the economic dynamics arising from the energy value chain, bringing economic benefits to the local community [4].

III. Methodology

The methodology used in this research is a modified Qualitative Comparative Analysis (QCA) [19], [20] shown in Figure 1. The QCA has an analytical approach combining a detailed within-case analysis and a cross-case comparison. As QCA is interactive by definition [19], the case studies selected for this study were submitted to several rounds of within-case analysis and cross-case comparison.

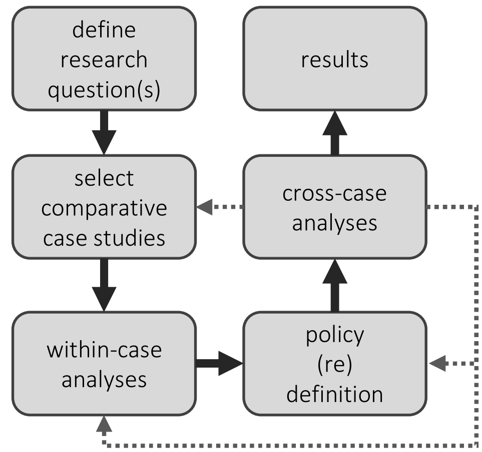

Fig. 1. Modified Qualitative Comparative Analysis (QCA)

Initial results usually demand additional case selection in a cycle that will build up on within-case analyses and broaden the knowledge of the case under scrutiny. Although QCA's results do not necessarily identify causal relations, they identify patterns of association across the set of selected case studies that can reflect an underlying empirical tendency.

So, following the QCA method, the research question was defined as: how community energy and renewable energy sources can promote energy inclusion and improve socio-economic impact in developing countries?

Then, a group of case studies (as a *"reference scenario"*) was selected, containing different countries that already address (at different levels of implementation) the energy transition issue – namely, a subset of the European countries, as show in Figure 3.

Finally, a group of developing countries was selected to contrast the European countries cases by their relatively high inequality and socioeconomic development, and the different levels of policy development in what concerns community energy and DRE.

After several within-case analyses and cross-case comparison rounds, Mozambique was chosen as main case in this research. This choice is due to the fact that Mozambique's socio-economic situation characterises the country as developing country in sub-Saharan Africa, with high prevalence rates of poverty, underdevelopment, with low rates of electrification and access to electricity in general. Also, for the scope of this work, solar PV was selected as the renewable energy source under analysis - as it would be the most abundant resource on Mozambique's renewable energy matrix [21], [22].

Furthermore, Mozambique is one of the poorest countries in the world, with an urgent need to increase electrification and access to electricity (energy inclusion). The socio-economic and electricity access situations in Mozambique fit into the context described in [23]–[25], which states that in 2013 the global rate of people without access to electricity was around 22% of the world's population (approximately 1.6 billion people) of which 99% were from developing regions, four-fifths lived in rural Africa Sub-Saharan and South Asia.

Additionally, [26] states that in 2019 only 57% of the total African population had access to electricity, whereas in the Sub-Saharan African region the access rate was 30% of the total population of the region. In this context, the socio-economic situation of Mozambique is uniquely and exclusively taken as a sample of poor developing countries in need of models for massive access to electricity.

IV. Energy landscape potential

As explained in Section III, Mozambique is the main case study in this paper and, as such, Mozambique had its photovoltaic potential, as shown in Figure 2, compared to the other case studies used in this work - as detailed in Figure 3. To compare the solar energy generation potential of each country, the Direct Normal Irradiation (DNI) and Photovoltaic Power Output (PVOUT) - amongst other variables - of the selected countries (case studies) were tabulated for comparison.

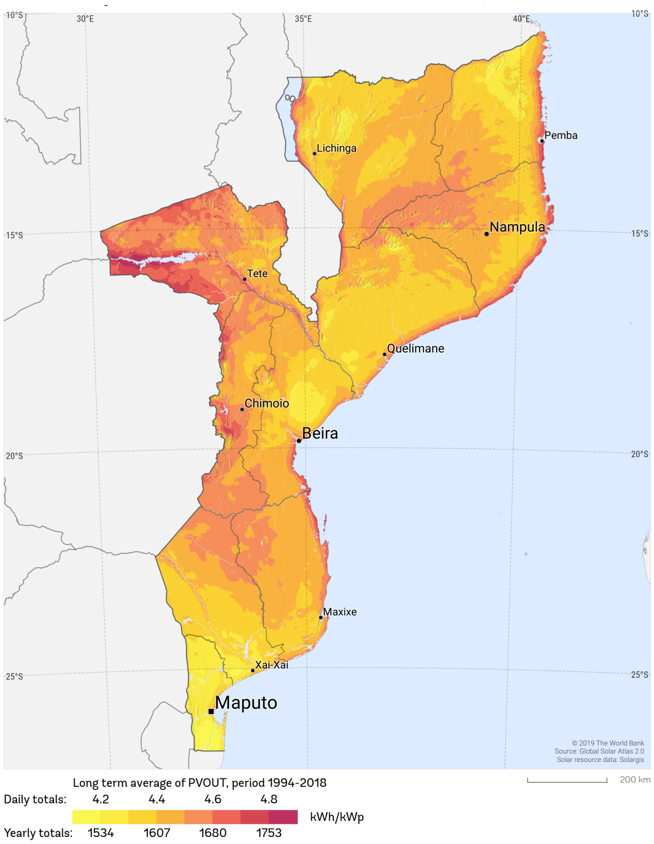

Fig. 2. Photovoltaic Power Potential (Mozambique) [27]

DNI is one of the most important variables when considering solar radiation and corresponds to the amount of solar radiation received per unit area (in our case, kWh/m^2) by a surface held perpendicular to the rays coming from the sun [28]. The PVOUT usually is represented as the *"long-term"* average of potential electricity production from a 1 kW-peak grid-connected solar PV power plant (the rate of power generation at peak performance). Its unit is kilowatt hours per installed kilowatt-peak of the system capacity (kWh/kWp).

The countries in Figure 3 were sorted by the highest levels of DNI. Both Spain and Mozambique occupy the top positions in that table, but offer similar solar energy generation potential. According to the statistical data in [27], although the average of Spain's DNI (5.11kWh/m2) is 9% higher than Mozambique's DNI (4.70kWh/m2), the the average PVOUT for Spain (4.35kWh/kWp) and Mozambique (4.44kWh/kWp) are very similar with Spain's PVOUT roughly 2% higher.

Such differences may be caused by the differences in temperature in both countries (in Spain varying from 4.1°C to 19.4°C, while in Mozambique it varies from 17.9°C to 26.6°C). As it is well known, the higher the temperature, the lower is the power output of PVs. As the temperatures in Mozambique are higher, in the long run its performance can be affected.

In April 2019, Spain approved the decree that regulates CSC technical, economic and administrative aspects. The new regulation defines that power surpluses may be shared not only on the same dwelling, but also with nearby consumers and/or prosumers from other buildings (maximum distance between production and consumption facilities is 500m) – or fed to the grid with a simplified mechanism for compensation in place.

As long as the self-consumed energy comes from renewable sources, co-generation or waste, no charges or taxes of any kind will exist. Also, the new regulation defines the types of self-consumption: without surpluses (no injection of surplus energy in the network allowed) and with surpluses (can inject excess energy into the network).

However, if a generator/aggregator exceeds 100 kW power in surplus generation, it will have to be registered as a facility of electricity and the energy can be sold in the energy market. For facilities producing energy below the 100 kW threshold surplus, new regulations may be developed to facilitate compensation between deficits of self-consumers and surpluses from associated facilities [29], [30].

Mozambique's solar potential is the most abundant, 23 GW – followed by hydro (19 GW), wind (5 GW), biomass (2 GW), and geothermal (0.1 GW). However, from this potential, only 0.6 GW of solar energy is addressed by priority projects [21]. It means that Mozambique still has considerable unexploited solar potential.

The works of [21], [22] state that Mozambique would easily develop 2.7 GW with proper investments - with 599 MW that could be connected to the country's energy grid. However, most of this potential are present only on *Maputo* and *Tete* (some of Mozambique's biggest cities) given the current energy transport grid infrastructure. Investment in solar energy usually targets government institutions (schools, hospitals and administrative functions). With an underdeveloped market and little private sector share, usually users wait for government funded projects - as private projects have cost disadvantages.

	Area	PVOUT		DNI		GHI		DIF		GTI_opta		TEMP		OPTA		ELE	
	km^2	kWh/kWp		kWh/m^2		kWh/m^2		kWh/m^2		kWh/m^2		°C		°		m	
Spain	499564	3.08	4.91	2.70	6.13	3.25	5.45	1.41	2.07	3.69	6.06	4.10	19.40	24	38	3	3718
Mozambique	786380	4.16	4.79	4.05	5.51	4.77	5.87	1.92	2.39	5.22	6.14	17.90	26.60	13	27	3	2436
Portugal	91606	3.11	4.72	2.24	5.78	3.41	5.08	1.42	2.02	3.70	5.81	9.80	17.90	25	35	2	2351
Italy	294140	2.67	4.54	2.30	5.18	2.92	4.93	1.37	1.82	3.18	5.60	-4.00	18.70	29	42	-3	4810
France	547557	2.90	4.38	2.53	5.22	2.97	4.42	1.38	1.71	3.45	5.32	-0.50	16.30	33	41	-10	4810
Switzerland	39516	2.31	4.15	1.82	4.26	2.61	3.87	1.30	1.59	2.77	4.78	-7.60	13.10	34	44	193	4634
Austria	82523	2.25	3.83	1.75	3.69	2.55	3.59	1.36	1.67	2.68	4.40	-4.80	11.30	35	44	115	3798
Romania	230080	2.89	3.71	2.42	3.77	3.01	3.89	1.54	1.74	3.40	4.50	2.20	13.30	33	39	0	2544
Slovenia	20142	2.32	3.70	1.82	3.83	2.65	3.81	1.42	1.69	2.79	4.49	2.30	15.20	34	39	68	2864
Hungary	90530	3.25	3.53	2.99	3.41	3.31	3.64	1.62	1.71	3.88	4.27	8.80	12.00	34	37	76	1014
Slovak Republic	48080	2.62	3.42	2.14	3.29	2.76	3.49	1.47	1.67	3.08	4.12	2.00	11.70	36	40	94	2655
Germany	349360	2.72	3.32	2.32	3.24	2.75	3.34	1.45	1.60	3.21	3.96	5.80	11.40	35	40	-3	2962
Czech Republic	77220	2.78	3.22	2.38	3.00	2.86	3.28	1.52	1.64	3.29	3.86	5.20	10.80	35	38	115	1603
Poland	306190	2.79	3.11	2.50	2.90	2.80	3.13	1.45	1.58	3.30	3.70	6.10	9.90	36	39	-2	2499
Denmark	41990	2.67	3.10	2.40	3.06	2.63	3.02	1.34	1.48	3.14	3.63	8.20	9.60	38	42	-7	171
United Kingdom	241930	1.94	3.08	1.24	2.79	2.10	3.07	1.39	1.63	2.27	3.64	4.70	11.50	35	41	-4	1345
Netherlands	33690	2.73	3.06	2.31	2.78	2.75	3.04	1.53	1.58	3.22	3.62	9.80	11.10	36	39	-6	887
Belgium	30280	2.80	3.05	2.42	2.75	2.85	3.05	1.53	1.59	3.31	3.60	7.90	11.30	35	38	-4	694
Ireland	68890	2.15	2.82	1.39	2.31	2.30	2.82	1.50	1.63	2.51	3.31	6.80	11.10	34	39	-3	1038

Fig. 3. Comparative solar map: Europe (partial) x Mozambique [27]

DIF (Diffuse Horizontal Irradiation); DNI (Direct Normal Irradiation); ELE (Terrain Elevation); GHI (Global Horizontal Irradiation); GTI (Global Tilted Irradiation); GTI opta (Global Tilted Irradiation at Optimum Angle); OPTA (Optimum Tilt of PV Modules); PVOUT (Photovoltaic Power Output); TEMP (Air Temperature)

Although renewable energy is part of Mozambique's government projects [9] as part of its poverty reduction strategy, solar PV energy is underexplored as a renewable energy source in Mozambique – and in Africa in general [31].

However, despite all renewable energy potential, Mozambique's legal system does not have specific legislation for it. Renewable energies are regulated by a general electricity regulation - which establishes the need of a government-issued concession contract (regardless of the generation capacity of any given project) [32] - except for self-consumption production with no third parties participation whatsoever. Additionally, all electricity generated in Mozambique must be sold to *"Electricidade de Moçambique"*, the state-owned power company - which has a negative impact on tariff negotiations.

The Mozambican government seems to be working on a simplified regulation for renewable projects. Some of these initiatives are: an appropriate legal framework for renewables in the existing electricity sector, incentives for implementation based on prices and tariffs, specific tariff scheme for generation below 10 MW, eventual reduction of tax for the first 15 years of a project, and special subsidised funding.

V. Socio-economic situation of Mozambique

Mozambique is a country in sub-Saharan Africa, a member state of the Southern African Development Community (SADC), which is experiencing important social, economic, political and environmental changes resulting from the discovery and exploitation of natural resources, with emphasis on mineral resources that compete as factors for the strength and competitiveness of the economy of Mozambique.

In this context, the Mozambican government authorities have elaborated the national development strategy, whose primary objective is to raise the living conditions of the population through a structural transformation of the economy. By expanding and diversifying the productive base, the aforementioned economic development strategy can be based on a sustainable and inclusive development model, based on industrialization as a strategy for the transformation and dynamization of the economy.

Therefore, the national development strategy for Mozambique projects a prosperous, competitive, sustainable and inclusive country [33]. However, an economic and social development based on industrialization has unavoidably a determining and unavoidable factor, ***electrification and access to electricity.*** According to the declaration of the International Energy Agency cited in [24], access to electricity is a fundamental factor for sustainable human development and, furthermore, providing access to electricity is a precondition for socio-economic development, poverty reduction and the promotion of human well-being [34], [35].

A. Access to electricity in Mozambique

In addition to other development sectors, Mozambique has elected industrialization as one of the main pillars to achieve accelerated economic growth and social development. In this modern era, industrial development is intrinsically dependent on electricity and, in addition, activities to strengthen the economy must be inclusive and participatory.

However, the data on electricity access rates in Mozambique, illustrated in Figure 4, shows that 66% of the population does not have access to electricity and, consequently, excludes this part of the Mozambican society from active participation in industrial and socioeconomic development.

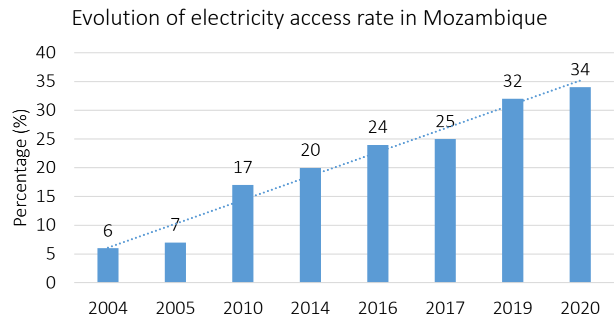

Fig. 4. State of Access to Electricity in Mozambique [35]–[38]

In this context, achieving sustainable human development cannot be realistically addressed with a large part of the population without access to electricity, the task of industrial and socio-economic development in Mozambique is delegated to a minority of the population, the 34% with access to electricity. The lack of access to electricity is a factor of poverty, underdevelopment and social instability and, in the context of the Mozambican reality, ensuring access to electricity is not just a matter of promoting industrial and socio-economic development, but it's mainly an issue of inclusion.

As an illustration, in 2016 the global rate of access to electricity in Mozambique was only 24% of the total Mozambican population (approximately 6.5 million of the population) where rural areas represented only 17% [39]. In this modern era, sustainable human development depends on industrial and socio-economic development, but the key element is access to electricity for all.

In the Mozambican context and in most developing countries, particularly in sub-Saharan African countries the vast majority of the population does not have access to electricity as illustrated in figure 4 the development process is neither inclusive nor participatory, therefore unrealistic. It can be stated that in the context of developing countries, electrification and access to electricity based on the community energy approach is an issue of energy inclusion for poor and disadvantaged communities.

B. Prevalence of poverty in Mozambique

According to [40]–[42], four surveys were carried out in Mozambique to assess the prevalence of poverty in the periods of 1996/7, 2002/3, 2008/9 and 2014/15 as shown in Figure 5.

The 2014/15 survey, the last survey carried out, provides the most up-to-date data [42] the incidence of poverty is severe, the prevalence of poverty is relatively worse in rural areas where the vast majority of the rural population lives as illustrated table I.

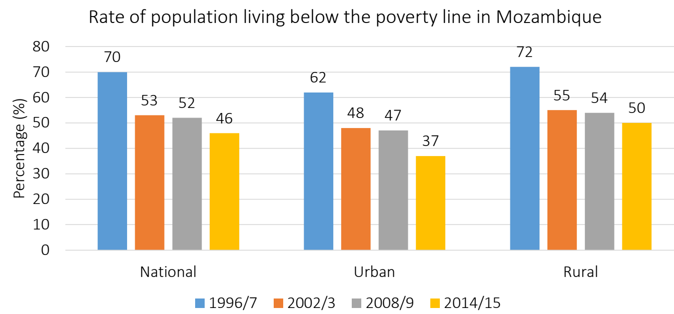

Fig. 5. Assessment of poverty levels in Mozambique [40].

TABLE I
RURAL AND URBAN POPULATION IN MOZAMBIQUE [43].

	Total	Urban	Rural
Population	31 million	10.4 million	20.6 million
%	100	33.4	66.6

C. Community energy in the context of Mozambique

Although the literature does not present a standard definition for the concept of community energy, the diversity of definitions converges in the vision of energy generated by and for the community, in a decentralized approach that places the citizen and the community as the main actors in the entire value chain [7].

As discussed in [8], [44], such implementations usually require high integration of information technology, telecommunications, Internet of Things (IoT) sensors and some level of automation. With that, the community energy can significantly enhance its responsiveness to scenarios with intermittent DER, provide high reliability compliance, reduce the impact on the environment and become compatible with new energy markets standards and good practices.

VI. COMMUNITY ENERGY FRAMEWORK

In the diagram illustrated in Figure 6, we intend to discuss the concept of community energy in the context of developing countries, especially those in sub-Saharan Africa where access to electricity has very low rates.

The debate is based on the fact that the concept of community energy is seen as an energy transition, mainly in developed countries, but this concept may have some additional aspects to be considered in the context of developing countries. It is unrealistic to approach the concept of community energy from the perspective of energy transition for communities in poor countries that have never had access to electricity or clean energy sources whatsoever.

Poverty and underdevelopment in developing countries are factors that hinder massive access to electricity and also to clean energy sources. Thus, this diagram model is intended to discuss community energy from the point of view of *"community energy symbiosis"* based in the relationship of social strata within the community.

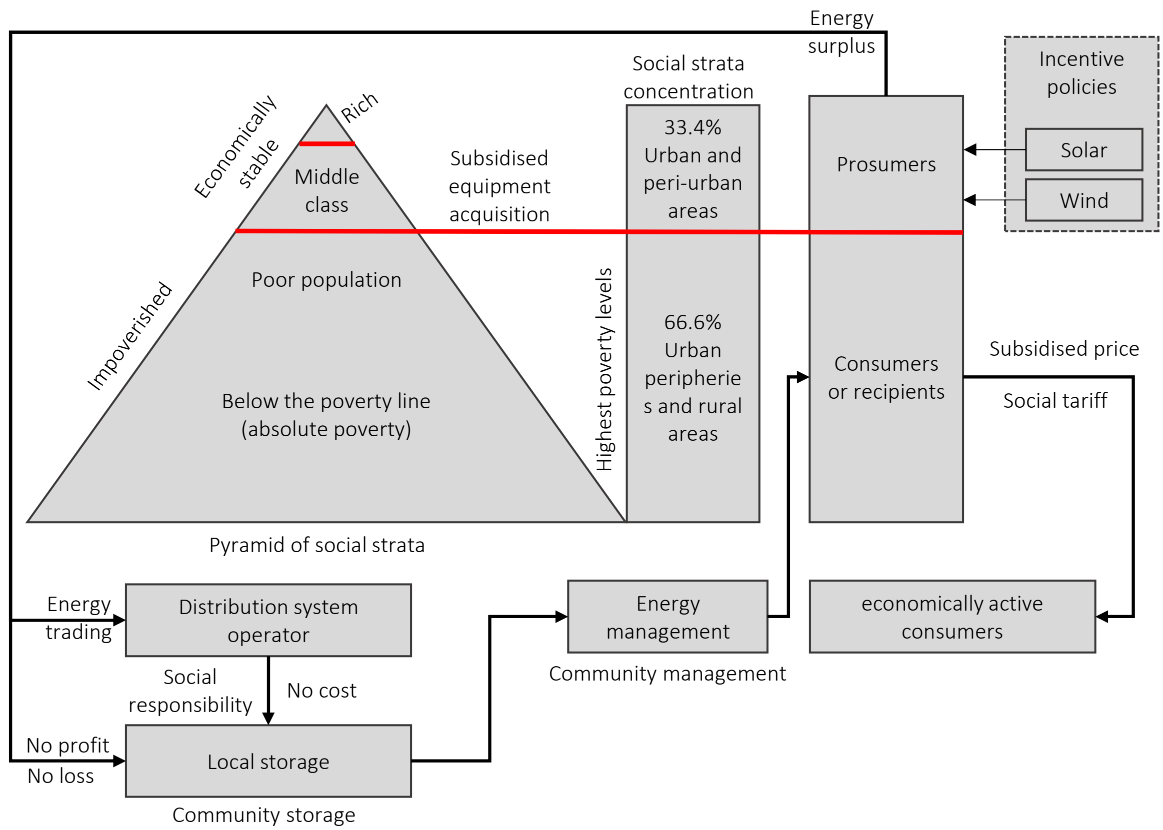

Fig. 6. General framework of an integrated community energy system (social stability through energy inclusion)

By exploring the concept of community energy, which places the citizen and the community at the center of the entire energy value chain (generation, distribution, consumption and services), the diagram describes community energy in the context of developing countries – usually, heavily battered by poverty, underdevelopment, with the vast majority of the population without access to electricity or clean energy sources.

In this article, a community energy symbiosis means a community of energy generation and (self) consumption based on the relationship between economically stable and economically disadvantaged social strata, with reciprocal and mutually advantageous gains, as illustrated in the diagram in Figure 6 described as:

1) **Incentive policy:** Government and authorities should create incentive policies, which encourage economically stable social strata to purchase clean energy generation equipment locally (generation facilities in the residential sector). The objective is that these economically stable social strata supply themselves with the energy they generate, and provide the surplus generation for the economically disadvantaged social classes.
2) **Beneficiaries and consumers:** In this model, the beneficiaries of incentives to purchase and install local generation equipment and later make the surplus generation available, are called energy donors (energy producers or prosumers). Beneficiaries of energy donated by owners of home generation facilities are called energy receivers (energy consumers).
3) **Offer/sale of surplus energy:** When different local points of energy generation within the community generate energy and satisfy their needs, they have the possibility to make their surplus energy available in support of disadvantaged social strata, having two options:
   a) **Sell surplus energy:** The holder of surplus energy can make their energy available for sale. However, as it is an idea of energy inclusion and massification of access to clean energy for the socially disadvantaged strata, the sale should be at the social tariff (reduced or subsidized price). To encourage the availability of the surplus as a contribution to the inclusion of energy in socially disadvantaged strata, the sale of surplus energy at a *"negative price"* is discarded.
   b) **Donate surplus energy:** The holder of surplus energy can make it available as a donation without gain or cost (zero gain and cost). That way, the surplus energy donated contributes to the energy inclusion, allowing more economically disadvantaged people to have access to electricity.

In Mozambique today, all energy generated would be sold to the the state-owned power company. Although most of (or all) the electricity infrastructure - on what concerns distribution and transmission - is owned by the government, the suggested framework demands a more flexible operation scheme. For example, the surplus energy generated should be offered either by the supply company or directly to the local storage.

Local storage is the ready deposit point for distribution to low-income consumers, usually residing in rural areas, without access to clean energy sources. The local storage is of vital importance for those communities or individuals not reached by the standard electricity network. While in urban areas the energy trade (or donation) can happen by means of the available electricity grid, in remote areas this infrastructure is precarious (when it exists at all).

So, the gap between generation, distribution and consumption would ideally be covered by a storage infrastructure [45] - with Lithium-ion batteries as the most common electrochemical storage option [46]. However, the local storage poses a difficult challenge: the high costs of implementation and this would demand subsidy policies and/or a business model (e.g., better surplus trade margins and proper renewable energy tax scheme) that would make it viable for individuals and the private sector to participate in such projects.

When the energy donated or sold (under the terms described previously) is available in the community storage, local community management, such as in [8], will ensure the supply of energy exclusively for economic enterprises that generate income, jobs, and produce goods and services. Emerging technologies, such as Distributed Ledger Technology (DLT) and blockchain implementations, present in such solutions [8] can guarantee generation, consumption, and transaction tracking and validation to support control and proper energy management and distribution. Additionally, Machine Learning (ML) algorithms can help predict the energy generation outcome and proper distribution and consumption policies for the community energy. In such a way, this scheme can promote sustainable industrial, socio-economic and human development, through **energy inclusion** and massive access to electricity and clean energy sources.

VII. CONCLUSION

The concept of Community Energy has multiple advantages in general, and it can be implemented in different contexts, taking into account the singularities and details of a particular context. Addressing access to electricity for developed countries and for developing countries are two different approaches for different realities.

The debate on access to electricity in developed countries is practically extinct, as the rates for access to electricity and other energy sources are extremely high. Several concepts in the field of energy (such as energy transition, community energy and others) arise as a result of the irreversible environmental damage caused by the use of fossil fuels. In developed countries, transition to renewable energies does not aim to solve the problem of access to energy, but rather to reduce their dependence on fossil fuels and the impact caused by these on the environment.

In addition, it is about changing the energy landscape, social transformation, decentralization, citizen and community empowerment, involving them in the entire energy value chain (generation, distribution, consumption and associated services). However, this approach may not be fully applicable in developing countries, where the rate of access to electricity and other energy sources has very low rates, with a large majority of the population seeking access to electricity for the first time.

The diagram illustrated in figure 6 is fundamentally intended to contribute to the debate on taking advantage of the community energy concept, to stimulate massive access to clean energy sources in the context of developing countries, especially those in Sub-Africa -Saharan.

Community energy models should have generic approaches, adjustable to each context and specific reality, especially when it comes to developing countries, where investment in electrification infrastructure, normal use of electricity and access to clean energy sources have a deficit growth rate.

The pace of discussion and implementation of the community energy concept in developed countries may not be in harmony with the reality of developing countries – especially in sub-Saharan Africa. However, taking into account the limited capacity of state and government authorities to invest in electrification and ensuring energy for all, the community energy concept is a perfect solution as it can take into account the socioeconomic characteristics of each country based on the principle that **no model fits all.**

Community energy effectively implemented in developing countries would be an energy inclusion policy mainly for rural and low-income communities, and also a decisive factor of community participation in industrial and socioeconomic development.

Future research in this area will propose an expanded analysis of the proposed community energy framework applied to other African countries' and other developing countries' realities, for the applicability of the proposed framework can be revised and enhanced. And lastly, as a natural expansion of this work, a discussion paper and/or a policy suggestion comprising a viability study and an architectural suggestion to create a scheme where renewable energy generation, in the context of community energy, can become viable by its scalability and the empowerment of its actors (prosumers).

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Acronyms and Abbreviations

CENTS Cooperative ENergy Trading System. 1

CSC Community Self-Consumption. 1, 3

DER Distributed Energy Resource. 1, 5

DIF Diffuse Horizontal Irradiation. 4

DLT Distributed Ledger Technology. 7

DNI Direct Normal Irradiation. 3, 4

DRE Distributed Renewable Energy. 1, 2

DTIF Disruptive Technologies Innovation Fund. 1

ELE Terrain Elevation. 4

GHI Global Horizontal Irradiation. 4

GTI Global Tilted Irradiation. 4

GTI opta Global Tilted Irradiation at Optimum Angle. 4

IoT Internet of Things. 5

ML Machine Learning. 7

OPTA Optimum Tilt of PV Modules. 4

PV Photovoltaic. 1–4

PVOUT Photovoltaic Power Output. 3, 4

QCA Qualitative Comparative Analysis. 2

SADC Southern African Development Community. 4

TEMP Air Temperature. 4