Assessing the Feasibility of Solar Microgrid Social Enterprises as an Appropriate Delivery Model for Achieving SDG7

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Abstract

Delivering SDG7 by providing secure access to modern electricity for over 1 billion people globally demands innovation in technology, policy and delivery models. Microgrids, defined as energy generation and supply systems with maximum capacity of 100kW having capabilities of managing local energy supply, are proving a viable solution for remote rural areas in the global South with no prospect of main grid connection. While steady technological progress in the microgrid sector is being observed, effective planning methodologies and delivery models are key to sustainable microgrid implementation. Social enterprise is a collective term for a range of organisations that trade for a social purpose, and offer a niche innovative energy access delivery model that is neither public nor private sector. This paper proposes an evidence-based analysis methodology for assessing the feasibility of a social enterprise delivery model for the deployment of solar microgrids in a developing country. Steps of the methodology include conducting a site-specific feasibility study; assessing the market potential; and business scale-up scenario modelling. Conclusions and recommendations are given on the opportunity for this novel technical and business solution to address energy poverty and achieve SGD7.

Key words: SDG7, Energy Planning, Delivery Models, Solar Microgrids, Social Enterprise

1. Introduction

“Energy is the golden thread that connects economic growth, social equity and environmental sustainability” [1]; however, secure access to modern electricity is lacking for over 1 billion people in the world. This challenge is highlighted by the United Nations Sustainable Development Goal 7 (SDG7): access to clean, reliable, and affordable energy [2], but the scale of the problem inherently demands innovative and holistic solutions for rural electrification. The International Energy Agency (IEA) predicts minigrids will provide 48% of the additional generation needed to achieve universal electricity access by 2030 [3]. A nanogrid, microgrid or minigrid is a term used to describe a network consisting of a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the main grid [4]. The international market for microgrids powered by solar photovoltaics (PV) is on the rise globally, due in part to decreasing costs of solar PV modules and battery storage, as well as advances in auxiliary technologies for microgrid metering, communications, monitoring and control. Innovations in business models and tariff setting have also opened up commercial opportunities for prospective microgrid investors.

Microgrids have the potential to address SDG 7 by enhancing socio-economic wellbeing through improved quality of life, access to public services, job creation and entrepreneurship opportunities and industrialisation enabled by access to energy [5]. However, accelerating solar microgrid deployment demands more than technical research; effective energy planning methodologies and delivery models are needed for rapid and sustainable microgrid implementation. The concept of the ‘energy delivery model’ has emerged to describe a core set of activities and actors that constitute an energy service required to make energy infrastructure sustainable [6]. It highlights the importance of understanding how to fulfil end-users’ needs and the supporting services required to make the energy infrastructure sustainable. The concept emphasises the importance of wider enabling-environment policies, additional supporting services and socio-cultural factors when designing and delivering energy services for low income communities. Traditionally, energy service delivery models have followed frameworks based on public, private, charity or hybrid models with varying degrees of success. The efficacy and sustainability of these approaches to reduce poverty through energy provision varies between models and has been questioned by stakeholders [7], [8], [9] [10].

Broadly defined as the use of market-based approaches to address social issues, a social enterprise provides a "business" source of revenue for civil society organizations [11]. Recognising the need for innovative alternatives to status quo delivery models, social enterprises have begun to fill in the gap between public and private provision of electricity to address energy poverty. However, to date, social enterprises have yet to be explored as serious instruments of sustainability transitions [12], and little research has been conducted that systematically interrogates the dynamics of the sector, its discourses, representations and practices [13].

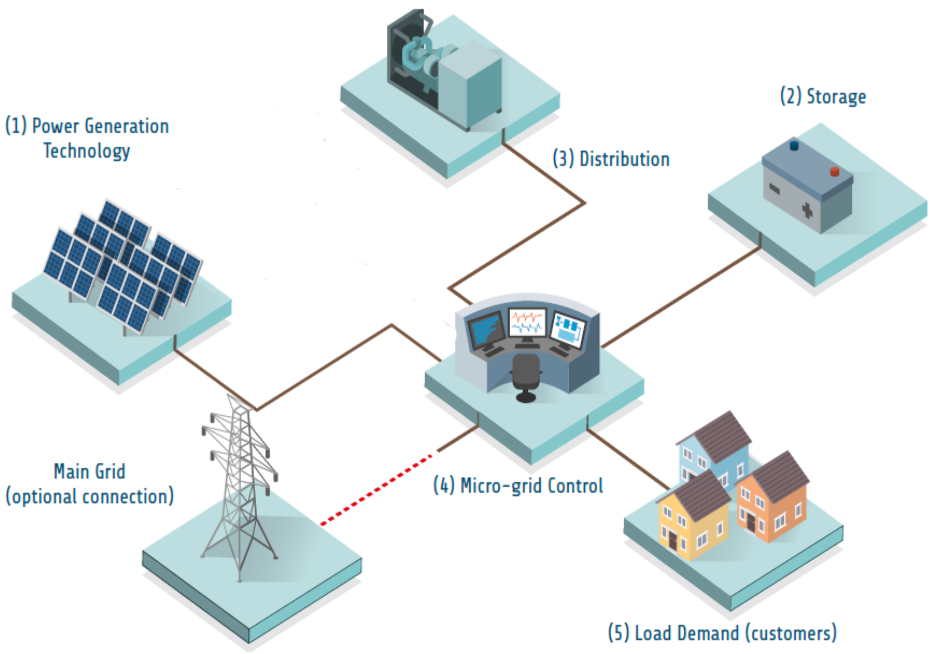
The objective of this paper is to set out the argument for Solar Microgrid Social Enterprises (SMSE) as a conduit for achieving SDG7. Section 2 comprises a literature review of definitions, global trends and advantages of solar microgrids, and introduces the concept of a social enterprise. Section 3 then defines characteristics of an SMSE, an evidence based methodology used to assess their feasibility is outlined in Section 4, before conclusions being drawn in Section 5.

2. Literature review

2.1. Microgrid Definitions and Global Trends

IRENA classifies a microgrid as an energy generation and supply system with maximum capacity of 100 kW having capabilities of managing local energy supply [14], although several definitional exist [15] . As shown in Figure 1, microgrids comprise power generation technology, storage to account for intermittent renewable resources, a distribution grid providing electricity to load demand (customers), and protection and control elements. Microgrids also have the option of interconnecting with other microgrids and connecting to a central grid network.

Figure 1: Micro-grid components Adapted from [5]



According to the IEA, minigrids currently provide electricity to nearly 90 million people and have the potential to serve 212 million people, however to achieve universal electricity access by 2030 the current pace of expansion would have to double [16]. The microgrid market is on the rise globally, mainly due to decreasing costs of renewable energy technologies (specifically solar PV modules) and battery storage [17]. Figure 2 compares solar microgrids to other technologies in terms of tiers of electricity, supply, availability, and indicative use.

Figure 2: Comparing Solar Micrgrids to other technologies [5]

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Minimum Supply	0	3W	50W	200W	800W	2KW
Availability (hours/day)	0	4	4	8	16	24
Indicative Use	N/A	LED light, phone charging	Multiple lights, air circulation (fan), television, Phone charging	Tier 2 + small appliances	Tier 3 + medium appliances, water pumping	Tier 4 + large appliances
Indicative Grid Type	N/A	Stand alone	Stand alone	Pico, Nano (Micro)	Nano, Micro	Mini, National

2.2. Solar Microgrids: Advantages and Challenges

Hazelton [18] conducted a preliminary literature review of the benefits and risks presented to communities by PV hybrid minigrid systems. The paper found that the most commonly identified benefits are reduced cost and provision of improved electrical services (more reliable and higher capacity), with opportunity for rural enterprise, strengthened community and local capacity building also cited. Major risks identified included incorrect system sizing due to load uncertainty, challenges related to community integration, inappropriate business models and risks associated with geographical isolation. Further research is required to identify progress as the technology matures, costs fall and stakeholders learn from previous experience.

Other advantages of microgrids over stand-alone systems include improved reliability and security of supply, economies of scale, improved utilisation factor, load factor, and diversity factor, all leading to reduced cumulative installed capacity, less generation for peak demand compared to that required in a village consisting of highly distributed stand-alone systems, and therefore lower energy cost [5]. Microgrids can contribute to awareness raising and involvement of local communities through development of a common project; allowing the use of higher power electrical appliances and thereby encouraging productive activity. Disadvantages include risk of all customers being disconnected in the event of plant failure, (although reliability issues associated with a microgrid is less than that associated with off-grid stand-alone systems [19]), and more complicated regulatory, organisational and technological organisation than lower power competitors such as solar home systems [20].

2.3. Social Enterprise Definitions

Consensus is growing that human behaviours need to change to a more sustainable paradigm, and alternative frameworks to current public and private sector service provision are being explored as serious instruments of sustainability transition. 'Social enterprise' is a collective term for a range of organisations that trade for a social purpose [21]. Several definitions for a social enterprise exist, including:

- "a business with primarily social objectives whose surpluses are principally reinvested for that purpose in the business or in the community, rather than being driven by the need to maximise profits for shareholders and owners [22]"; and
- "organisations who are independent of the state and provide services, goods and trade for a social purpose and are non-profit-distributing [23]".

Social enterprises exist within the third sector of the economy, aiming to address perceived shortcomings in market or governmental provision of social welfare, and have been acknowledged as a potential driver of social progress [24]. The autonomous nature of the social-economic model applied by such organisations can represent a viable means to reduce state social welfare dependence, and is a proven model for social change [12].

Clear potential exists for social enterprise models to create both social and economic value, while further having an ability to address social and ecological challenges caused by neo-liberal market economies [13]. The innovative business framework is therefore a potential enabler for sustainable development by balancing the three sustainability pillars in social, economic and ecological domains.

Scholarly interest in social enterprise has progressed beyond early focus on definitions and context to investigate management and performance. Within the energy for development sector, delivery model innovation with a social focus has become a key means of embedding energy justice concepts in business models for energy provision [8].

3. Defining Characteristics of a Solar Microgrid Social Enterprise (SMSE)

The purpose of this section is to propose and justify a set of key characteristics for an organisation offering solar microgrids through a social enterprise delivery model such that it supports the delivery of SDG7. The argument presented is based on social enterprise characteristics defined by [25]. With supporting references from literature, these have been adapted and contextualised to consider how SMSEs should define their purpose and strategy.

3.1. Social Purpose

By definition, the primary purpose of a social enterprise is social impact, with commercial activity the means to achieving this. SMSEs should therefore have primary objectives that speak to the social development priorities of the local communities they intend to serve. To enable quantification and tracking of their impact, it is proposed that SMSEs align their social mission within the framework of the SDGs, using methods such as proposed by [26].

Most social enterprises will have more than one objective, with many having goals primarily environmental [27] [28] [29]. Social and environmental challenges are two sides of the same coin, and it is imperative that to maintain a SDG7 contribution SMSE have environmental objectives in their governing documents. Additional to a clear goal of utilising low carbon solar energy in comparison to fossil fuel competitors, SMSEs can go further to monitor, evaluate and reduce their environmental impact. This can be achieved by auditing project carbon emissions (especially from transport), investing in system lifecycle analysis research, and disposing of components such as batteries in a responsible manner.

3.2. Trade Engagement in the Marketplace

The primary revenue source of social enterprises is commercial, relying on market activity from selling goods or services to operate and to scale-up their operations [30]. Many minigrids are examples of one or more organizations that seek to generate revenues by providing a service (electricity) that helps reduce poverty [31]. Other sources of income can include contracts, including service level agreements, usually with the public (or-quasi-public) sector to deliver services [25].

However, due to current legal frameworks and associated lack of feedback on an appropriate and socially accepted tariff structure, minigrid revenue streams are usually quite low and can be insufficient to cover maintenance costs, at least in early stages [32]. Grants and subsidies for initial capital costs can therefore be a key enabler for the successful development of pilot or early stage minigrids [33]. Given the nascent market for microgrids, it is likely the majority of income will come from these donor sources in the short term.

Grant funding can restrict freedom of operations, can foster dependency syndrome [34] and is arguably unsustainable for long-term viability of energy enterprises. SMSEs should therefore accept donor funds for capital or operational costs to pilot microgrids in early stage development, but design a strategy for long-term financial independence through the sale of products and services. Primarily this will be electricity sales, but additional services may include appliance financing, or offering consultancy and technical support to other SMSEs.

3.3. Reinvestment of Profit

Social enterprises target economic sustainability with a wider social mission, reinvesting profits generated to achieve multiple bottom lines [35]. Reinvesting profits ensures operations do not increase personal wealth of those involved and external owners of capital cannot exert control because of their shareholding. Mechanisms can be established to reward workers or customers for efforts in achieving commercial survival and success, however these should not be related to any capital contribution [25].

These restrictions must be clearly defined and adhered to in a SMSE business plan. The business strategy should define a maximum amount of profit which may be used for workforce bonuses and customer benefits, and a minimum amount which should be paid for community benefit. SMSE assets, including accumulated wealth should be held in trust to benefit communities living in energy poverty. Besides the discussion on grants listed above, any capital used by SMSE social enterprise has to be paid for, with debt finance required to be paid with interest as well as regular capital payments, and equity agreements involving deferred payment relating to performance [25].

3.4. Community Engagement and Participation

An emerging trend for communities to take greater responsibility for their own socioeconomic development is evident, and social ventures with a focus on community engagement have the potential to deliver benefits over and above economic outcomes as they closely engage with people with a shared interest in the creation and management of these ventures [21]. Accordingly, participation and empowerment are often forwarded as legitimizing factors for social enterprise [35].

Importantly, for energy focused social enterprises, local people are involved in active dialogue on the future of the energy system for their community, fostering agency, ownership and engagement [36]. New approaches conceptualizing the form of governance for such organisations is essential, centred on ownership, participation and community control [37]; and innovative business models that combine social and community based approaches with entrepreneurship are demonstrating improved sustainability [38] [39] [40].

With such a clear impetus for community engagement and participation in both social enterprises and minigrids more widely, a key aspect of a SMSE strategy should be to recognise the importance of trust, accountability and effective networks in a community, and to invest in developing strong relationships with customers and communities served by the microgrid. Primary goals should be to establish clear communication channels between the SMSE and the community, with mechanisms for bi-directional dialogue to inform change and improve impact and sustainability of the organisation. Options for achieving this include initiating Village Energy Committees, allowing community representatives to engage in democratic processes within the organisation, or exploring options where every customer is a member of the SMSE.

3.5. Organisational Accountability

Accountability in this sense means accounting openly to stakeholders for what the organisation does, primarily to its constituency, or those people whom it affects. Practising accountability requires effective methods of gathering relevant information, consulting stakeholders, reporting on impacts and discussing strategy implications. It also requires the establishment of channels of accountability, the various way through which an organisation engages with its stakeholders and reports on its performance [25].

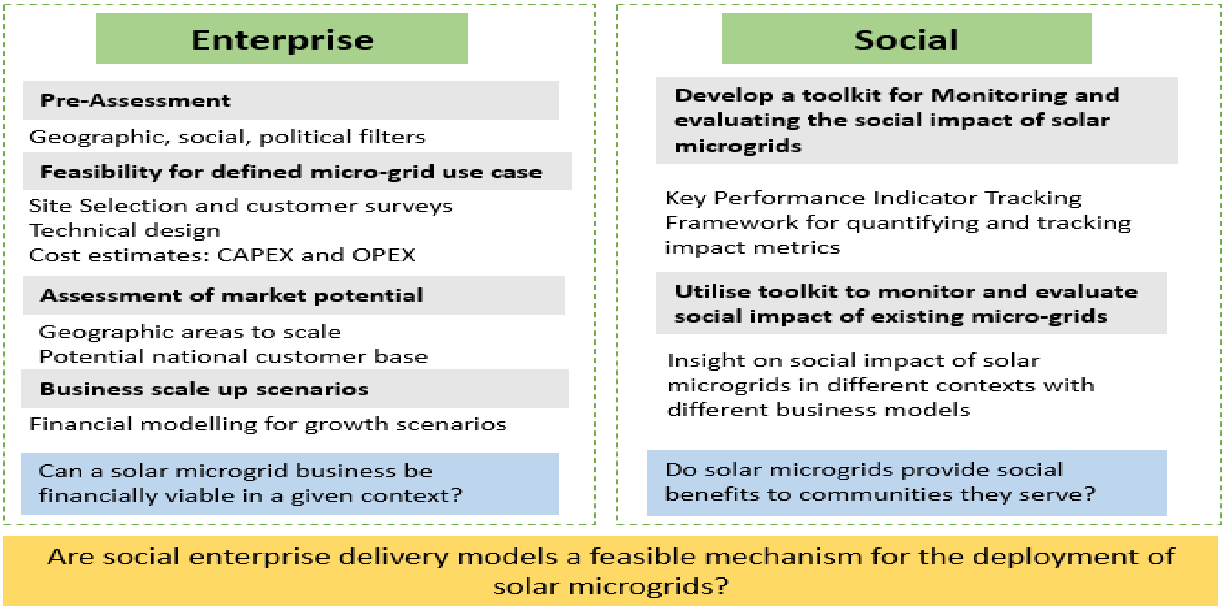
For an SMSE, accountability should involve transparency on the organisational adherence to the above characteristics, with stakeholders to be accountable to including donors, government institutions and other players in the private sector, while the constituency is the rural communities served by the microgrid. SMSEs should therefore invest in clear communication to the communities they serve and the network of organisations within which they operate. Specific attention and resources should be assigned to monitoring, evaluating, and reporting on the social impacts of the organisation, discussed more in Section 4.3.

4. Methodology for Assessing the Feasibility of a Social Enterprise Delivery Model for Solar Microgrid Deployment

4.1. Purpose of the Methodology

While the crucial role of business-based approaches within the international development sector is widely acknowledged by academics and practitioners; clear insight into what constitutes a viable business model in environmental, social and economic terms, remains unresolved [41]. Having outlined defining characteristics of an SMSE, a methodology is needed to establish whether a social enterprise delivery model can be a feasible means of achieving SGD7 through offering secure, reliable and affordable electricity to rural communities in a sustainable manner. This section proposes such a methodology, in two parts: firstly, to determine the financial viability of a SMSE; secondly, to determine and quantify the level of social impact delivered by SMSEs to the communities they serve. A summary of the methodology is shown in Figure 3, while key steps are discussed below.

Figure 3 Methodology summary



4.2. Assessing the Financial Viability of a SMSE

To ensure organisational sustainability over a timeframe sufficient to achieve the desired social purpose, a SMSE must be financially viable (defined here as ‘profitable’, or earning enough income to cover ongoing organisational and project costs with a surplus to re-invest in the organisation). This section of the methodology determines the financial viability of a SMSE at various scales.

4.2.1. Pre-Assessment

A filtering exercise is required to assess whether solar microgrids should be considered as a potential technology for rural electrification in a given geographical location or context. Indicators such as level of grid access, solar resource, population density, and current country-level progress towards SDG7 are considered, and if certain criteria are not met, resources should not be invested to continue the viability assessment.

4.2.2. Feasibility Study for Defined Use Case

A site-specific feasibility study to determine an indicative system design based on realistic user demand is required to output local costs of developing, installing and maintaining a solar microgrid. Use case economic data of CAPEX and OPEX and comparison of indicative tariffs with customer ability and willingness to pay act as indicators of microgrid feasibility. If the business case for one microgrid is deemed profitable, and tariffs affordable, the economic data gained from the use case feasibility assessment can be utilised in subsequent steps of the methodology to assess the market potential and conduct business scale up modelling at a national or regional level for SMSEs.

The proposed method for system design and business planning has been trialed [42]; it builds on industry standards [43] [44] and employs two key elements:

- a qualitative site selection and customer survey exercise, utilising enumerator fieldwork to provide metrics for project feasibility; and
- a quantitative techno-economic modelling, focusing on technical and financial feasibility to inform a viable business model.

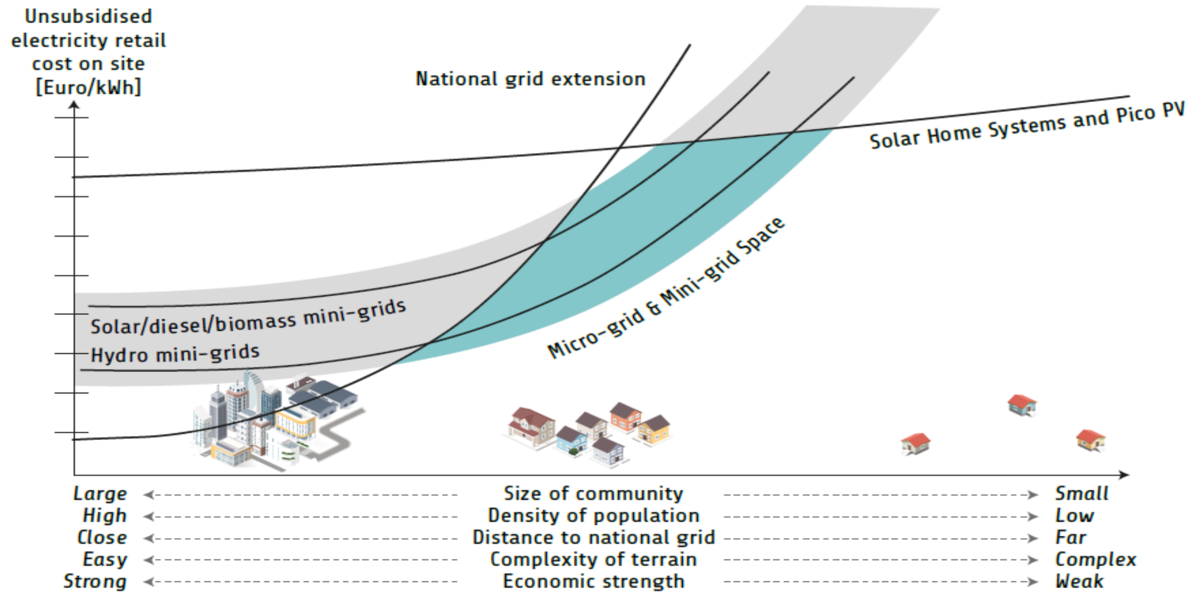
Effective system design and business planning for solar microgrids relies on confidence in expected demand and demand growth of target communities. In areas without an existing electricity supply, load profiles and demand growth suffer high levels of uncertainty [45]. The methodology utilises demand data estimates derived from data captured from customer surveys, national census data, and published demand datasets from microgrids in close geographic proximity.

4.2.3. Assessment of Market Potential

Market assessments are widely seen as being key to the planning stages for off-grid energy provision in the developing world [46]. Acting as a high-level feasibility study, a market assessment indicates the size of the potential consumer base for a technology, along with their distribution within a given region and the necessary considerations of the economic viability of projects at specific locations. Market assessments also map regulatory, political, cultural and socio-economic factors that impact sustainable deployment.

Figure 4 illustrates how parameters related to the geography, density and size of communities also influence the choice of energy access solutions [47]. Such parameters need to be investigated to determine a potential microgrid market size, essential for establishing the business viability of a SMSE.

Figure 4 Micro/Minigrids Space Compared to Alternatives [47]



This part of the methodology assesses the market potential at a national or regional level for SMSEs. The output defines where in a country or region solar microgrids are cost competitive with alternatives, and maps out the regulatory, institutional and economic ecosystem in which implementation will occur. The market assessment quantifies the potential for scaling operations, based on outputs of the use-case feasibility study and is an essential step to evaluate the viability of a SMSE, informing organisational strategy.

4.2.4. Business Modelling for Scale-Up

Based on outputs from the two preceding steps, further modelling investigates business growth scenarios for SMSEs, assessing in detail SMSE financial sustainability by balancing costs of installing and operating microgrids with income from sales of electricity. The financial modelling incorporates economic outputs of the use-case microgrid feasibility assessment, with scenario modelling used to investigate organisational cash flow forecasts through different levels of deployment to fulfil the regional or national market potential.

The ultimate objective is to determine the financial sustainability of the scaled SMSE, but to do so with consideration of the defining characteristics outlined in Section 3. For example, as well as investigating economic implications of the effect of reduced CAPEX through bulk purchasing of materials, the increased costs of monitoring social impact and enhanced community engagement activities must also be factored into the financial modelling.

4.3. Assessing the Social Impact of SMSE

The social enterprise value proposition centers on providing social benefits to communities. Currently there exists a paucity of recorded evidence of the impact microgrid systems have on the general wellbeing or social infrastructure of communities they serve, with reporting generally focused on measuring technical and economic performance of installed systems [48]. It is also recognised that measuring energy access impact needs to go beyond numbers of electricity connections and products sold, to an approach that assesses how effective that energy service is [49]. Following the first methodology pillar to determine financial sustainability, the second therefore centers on forecasting, planning and measuring increased social impact of SMSEs through a Key Performance Indicator (KPI) framework.

KPIs evaluate the success of an organisation or of a particular activity (such as projects, programs, products and other initiatives). Used as part of a Monitoring, Evaluation and Learning strategy, they can form the basis of tracking social impact of a microgrid initiative. KPIs are quantitative or qualitative methods, chosen to assess the scale and rate of progress of an intended social goal [50].

A template KPI framework has been developed [50] that can be used as a monitoring and evaluation tool by SMSE practitioners. A dashboard contains a variety of social impact indicators that practitioners can track, such as increased uptake of productive uses of energy, or impact on gender, education and health. Columns for planned versus actual performance against each indicator at certain milestones allows tracking of the overall microgrid performance. To test the hypothesis of enhanced social impact through a SMSE, the KPI framework must be utilised to gather primary data from an active SMSE with identical indicators gathered from a solar micro grid operation governed by a private or public sector framework for comparison.

5. Conclusion

Solar microgrids have the potential to address multiple SDGs by enhancing socio-economic wellbeing through improved quality of life, access to public services, job creation and entrepreneurship opportunities and industrialisation enabled by access to energy. Their efficacy in achieving the challenge of SDG 7 specifically is largely dependent on the sustainability of the delivery model used to implement them. Private sector initiatives are showing promise to accelerate deployment of the nascent technology, but a purely profit driven approach is unlikely to deliver for the most vulnerable of society, as is the focus of the SDGs. Governments in developing countries are by nature better suited to large infrastructure electrification programs and are generally ill-equipped with the business innovation expertise required for effective and impactful solar microgrid delivery. Social enterprises, with social and environmental goals hard-written into their constitutions, therefore have high potential for delivering solar microgrids with increased social impact and increased sustainability, offering a robust mechanism to achieve SDG 7 in the Global South.

However, understanding the impact solar microgrids operating under a social enterprise framework have on the SDGs is still limited, and this emerging concept needs to be implemented and monitored appropriately to build an evidence base for its value or otherwise. This paper has presented the concept of a Solar Microgrid Social Enterprise, proposed a set of general characteristics that define the social and enterprise aspects with respect to solar microgrids, and has outlined a specific approach for assessing the feasibility (ensuring appropriate implementation) and monitoring impact (building the evidence base). The feasibility methodology includes pre-assessment, feasibility for a defined use-case, assessing market potential, and business modelling for scale up, while the impact evaluation methodology proposes a KPI framework to monitor and track social impact.

Although an argument for enhanced organisational sustainability and increased social impact through SMSE is justified here, data is required to test the hypothesis, proposed through piloting SMSEs and monitoring their performance and impact in comparison with public and private sector microgrid delivery models. The research presented has significance for practitioners and researchers exploring alternative sustainable delivery models for energy service provision in developing countries, however further research is needed to validate the methodology and to draw insight into the potential SMSEs have in contributing to SDG7.

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