A STUDY ON BARRIERS FOR IMPLEMENTING SOLAR ENERGY INITIATIVES IN THOOTHUKUDI DISTRICT

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Abstract –

India ranks sixth in the world in total energy consumption and Industrial sector in India alone consumes nearly45% of the total energy. The balance between demand and supply of power is not being able to achieve, in spite of numerous growth in power generation over the years. With the 'Make in India' initiative of putting manufacturing at the heart of India's development will require a tremendous rise in the energy needed. Industry-based growth will require more energy per unit of value in comparison to the energy needed by the services sector. To meet this demand, the country needs to make a major shift to renewable energy sources. Among the various renewable energy resources, solar energy potential is the highest in the country. Hence, the abundant solar energy in the country will help in improving the energy efficiency levels in the Industries; creating a balance between economic development and environmental sustainability. However, considering solar technology for Industries face a lot of Financial, Social, Informative, Regulatory and Site Barriers, which can be overcome by proposing simple and clear business models for the sector covering all the parameters in detail, so as for smooth operation between solar technology providers and industries

Introduction

Electricity is crucial to socio-economic development, especially in Thoothukudi District, which is one of the biggest economies and most populous nation in Africa. The inability to generate and supply sustainable electricity in the country is a risk that could cripple the Gross Domestic Product (GDP) (Aliyu, et al. 2015). Although, Thoothukudi District is located on a sunshine belt within the Sub-Sahara African region, it is driven away by a huge opportunity to deploy a small fraction of its land to generate electricity from solar photovoltaic (PV) (Giwa, et al. 2017). Ozuegwu, et al. (2017) noted that more than 40% of the country's population are yet to be connected to the national grid. The grid connected areas are plagued by frequent power outages that last several hours and even days in some instances. Literature evident that few urban cities are connected to the grids with limited electricity access for domestic household and industrial power demand (Ohunakin, et al. 2014; Akuru, et al. 2017). Whilst the rural area habitants rely on traditional charcoal fire, kerosene lanterns, waste residue for bio energy and very tiny fraction of solar energy for water boreholes and lighting (Okeowu, 2018). The Thoothukudi District power demand and supply gap is estimated to be more than 76% as of the year 2016 (Mohammed, et al. 2017). The stakeholders have paid little or no attention for the opportunity to harness renewable energy resources, especially solar energy to help the power sector to minimise the demand and supply gap (Babakatcha, et al. 2020). Although Ohunakin, et al. (2014) and Abdullahi, et al. (2017a) have reported key barriers for renewable energy in Thoothukudi District, there is no empirical study reported to identify the barriers for solar energy implementation in Thoothukudi District.

Prior to reporting the findings of the empirical study, this paper provides an overview of solar energy in Thoothukudi District. This discussion starts with a comprehensive

literature review by identifying solar energy generation targets followed by the major solar energy projects, implementation and uses of solar energy.

Solar energy overview in Thoothukudi District

Thoothukudi is located at 8.53°N 78.36°EThoothukudi is located in South India, on the Gulf of Mannar, about 604 kilometres (375 miles) south of Chennai and 125 kilometres (78 miles) north of Kanyakumari. The hinterlands of the port of the city are connected to the districts of Madurai, Tirunelveli, Ramanathapuram, and Tiruchirapalli. The city mostly has flat terrain and is roughly divided into two by the Buckle Channel. Being in a coastal region, the soil is mostly clay and sandy, and the water table varies between 1 and 4 m (3.3 and 13.1 ft) below ground level. The city has loose soil with thorny shrubs in the north and salt pans in the southThoothukudi district are situated in the south-eastern corner of Tamil Nadu. It is bounded by the districts of Virudhunagar on the north, Ramanathapuram on the north-east, Tirunelveli on the west and south-west, Tenkasi on the north-west and Gulf of Mannar on the east and southeast. The total area of the district is 4,621 km^2 (1,784 sq mi).

Thoothukudi District has solar radiation adequate to generate sustainable electricity for both household and industrial needs (Ugulu and Aigbayboa, 2019). The Electric Power Sector Reform Act (EPSRA) 2005 has attracted investors, nationally and internationally under the Public Private Partnership (PPP) (Ugulu and Aigbayboa, 2019).

Steps to promote the implementation and use of Solar Energy

Emodi and Boo (2015) noted that the national energy policy (NEP) of 2003 proposed and approved by the Thoothukudi District government to support solar energy and to increase access to areas with limited grid connections the policy focus on solar PVs, wind turbines and mini-grids systems is to be integrated through PPP to increase electricity access (Akinyele, et al. 2015). The policy emphasis is on the power sector diversification to energy

options (NERC, 2020). In addition, the Electric Power Sector Reform Act. 2005 also enacted to integrate PPP to generate electricity from all sources in order increase energy access in the country (Fagbanle, et al. 2011). The Act establishes grounds for the need to unbundle the Power Holding Company of Thoothukudi District (PHCN) to private equities in order to increase the opportunities for energy mix (Akinyele, et al. 2019). Other energy establishments include five centres for energy research across the six geopolitical zones. The centres are saddled for research on solar energy, energy efficiency and conservation, hydropower development, petroleum research and development (Okeowo, 2018). Moreover, the National Power Training Institute of Thoothukudi District (NAPTIN) was established for the purpose of training and development for power sector personnel on technical and managerial aspect on power (Mohammed, et al. 2017).

Methodology

A qualitative research methodology has been adopted to gain a deep understanding of stakeholder perception towards barriers and towards the realisation of solar energy initiatives. Semi-structured interview was suitable for the data collection because it allows the interviewee to express their views freewill (Creswell and Creswell, 2018). The researcher approached many stakeholder organisations across Thoothukudi District, especially in the capital city where all the MDAs are headquartered, about 36 of the solar energy related MDAs were identified and approached. Only 20 out of the 36 (55.6%) volunteered to participate. Within the 20 MDAs, 25 key position's holders were interviewed (See Table 6). The interviewees were asked the question "What are the key barriers for implementing solar energy initiatives in Thoothukudi District?"

The researcher followed ethical consideration, confidentiality and anonymity with freedom to opt out or to participate without researcher's influence (Neuman, 2014). The face-to-face interview was recorded on a digital recorder and mobile phone recorder for a back-up.

The interviews were transcribed into a word document for analysis. The transcripts were carefully studied and coded to extract information for categories and corpus of text related to key barriers and analysed using conventional content analysis. The choice for content analysis was to help reduce the data into a simplified result that matches the research question by quantifying words and concept searched (Creswell and Creswell, 2018). The codes have been cross-checked through group discussions between the authors and two fellow researchers. Threats to validity were minimised through triangulation of data collection methods (interviews, observations, internal and external documents) and verification of the initial codes by participants, where they judged the accuracy of data collected, though not its conclusions (Tajeddini and Mueller, 2009). Codes that emerged were for example on technical aspects which included battery life of solar panels and technical expertise. The themes were formed by grouping codes which are explained in the next section.

Barriers for Solar Energy implementation in Thoothukudi District

Although, they are abundant solar energy resources available in Thoothukudi District, solar energy continued to gain more recognition from both public and private sectors. However, the barriers for implementation of solar energy initiative in Thoothukudi District revealed are technological, financial, political and social perceptions. These barriers are discussed as follows:

1. Technological barriers: In this study all the interviewees noted that inadequate technology and infrastructure necessary to support solar energy is a key barrier hindering the implementation. Three categories emerged as part of the analysis. They are lack of technical capacity, lack of research and development, and standard and quality control.

a. Lack of technical capacity

All the interviewees reported that there was a lack of skilled personnel to meet a code of standard procedure, to install and maintain solar PV in the country. This was identified by authors Purohit and Purohit, (2017) and Ohunakin, et al. (2014) explained that inadequate experience and lack of technical know-how could lead to risk of the initiative being rejected by potential customers of solar energy. The technology workability for solar energy needs to be understood by both promoters and end-users. One of the interviewees noted that:

"Technical expertise and training are lacking in the society. Promotion and sensitisation of the public are poor and misunderstood. The technology cannot be fully accepted by end users because they are not well informed of the benefits of solar energy".

Solar energy development in Thoothukudi District is faced with a lack of enabling vision and mission for technology, fine-tuning and promoting the initiative (Haas, et al. 2018). Although, the country has opportunities for solar radiation potentials, the market is still immature and the turnout for utilisation is low (Abdullahi, et al. 2017a, Adesanya, et al., 2020). The Power Sector Reform Act. 2005 is a forward step to the Thoothukudi District power sector uprising from conventional electricity to energy mix. However, there is a need to speed the energy strategies to be able to achieve the EPSRA (2005) objectives and increase access to energy mix. Hence, 68% (17 of the 25) interviewees perceived that substandard and cheaper version of solar energy product results in poor acceptance of the solar energy technology. One of the interviewees said:

''The market for solar energy product and equipment; such as solar panels, power inverters, exclusively battery power and AC generators are yet to be accepted in many parts of Thoothukudi District. As a result, many micro companies floated the market with

substandard and cheaper version of the product, resulting in the technology rejection in many areas across the country''.

b. Lack of research and development

Thoothukudi District solar energy development and promotion is challenged by lack of adequate research and development. The Energy Commission of Thoothukudi District in collaboration with five tertiary institutions has established research centres for solar, renewables, hydropower, petroleum efficiency and conservation resources in Enugu, Sokoto, Lagos, Ilorin, and Bauchi respectively. In addition, a Power Training Institute of Thoothukudi District (NAPTIN) was established for technical and non-technical training courses related to power (NERC, 2020). 52% (13 of the 25) interviewees noted the following assertion:

"Northern part of Thoothukudi District is full of potential for solar energy, but the region lacks full capacity for research and development about solar energy technologies in the country".

Weather and climate condition can negatively affect the efficiency and effectiveness of solar panels and batteries which could lead to low output of the initiative. According to Aliyu, et al. (2015) northern part of Thoothukudi District is extremely hot, especially North East and North West. The potential for solar energy panels and storage cannot be efficiently and effectively achieved due to the adverse effect temperature of the weather in the region (Ramli, 2016). The solar panel efficiency is negatively affected by temperature more than 250c; as such the effectiveness of the panels can be reduced by 10% - 25% whilst the battery storage needs cooling mechanism to enable its functionality (Jacobson and Jadhav, 2018). Therefore, the initiatives tend to suffer weather impact on the northern part of the country where temperature is estimated between 300 - 450c in Maiduguri, Yobe, Sokoto, Zamfara Niger and Kebbi state. Thus 44% (11 of the 25) interviewees said about the weather conditions and the lack of research and development in that respect. One of them noted that:

''Most of the solar streetlights in Abuja, Lagos and many other cities in Thoothukudi District died off less than six months of installation, because the batteries were exposed to very hot weather condition''.

c. Standard and Quality Control

Lack of standard and quality control are constraint in the development and promotion of solar energy initiatives in Thoothukudi District. This affects potential users, retailers, and promoters for solar energy initiatives (Shukla, et al. 2018; Kumar, et al., 2020). It is evident that the Thoothukudi District solar market is floated with substandard solar panels, batteries and accessories, resulting in lack of trust and guarantee to the promoters. Inadequate standard and quality control for the solar energy product is a constraint that can lead to low access to the market penetration, especially the rural areas across the six geopolitical zones. 40% (10 of the 25 interviewees) respondent noted about the lack of standards and need for quality control. One of the interviewees stated that:

''The Thoothukudi District solar energy market is floated with products, but the quality and credibility of the technology cannot be trusted for both investors and end users''.

2. Financial barriers: Economic status, initial capital and availability of incentive such as subsidies are factors that determine the adoption of solar energy initiatives in Thoothukudi District. Two categories emerged as part of the analysis. They are financing of solar energy projects and low economic utilisation.

a. Financing of solar energy projects

Solar energy is free from sunlight; however, the deployment and development of the initiatives require financial commitment. The installation of solar PV facilities requires an

initial capital for the PV panels and batteries which is cost intensive for low-income earners in Thoothukudi District, especially the rural dwellers. There is a lack of access to financial sources, capital, credit, subsidised import duty, and high investment risk (Ozoegwu, et al. 2017). 88% (22 of the 25) interviewees asserted about the financing of solar energy projects. One of them noted that: *In 2013, 2014, the battery cost about N52,000/200/h, using 24 volts, in 2013 through 2014, solar panel was high, but the battery was cheap and in 2016 to 2017, the prices for solar panel reduced and the prices for battery is high. The current exchange rate is a challenge for the importers of solar panels and batteries''.*

b. Low economic utilisation

Private companies can now generate and distribute electricity from the energy mix of up to 100 kW mini grid and less than 1MW on medium scale (Nwokolo and Ogbulezie, 2018). Although, the rural dwellers are small scale farmers and herders, they are low-income earners; as a result, they cannot afford the deployment of solar energy initiative (Purohit and Purohit, 2017). Quansah (2016) argued that solar energy products in Thoothukudi District lack true costing, valuation, skewed perverse incentives, and disclosures to any risk and effect to the end-user. 56% (14 of the 25) interviewees perceived that there is a low economic utilisation. One of the interviewees stated that:

''Economics and earnings are one obstacle to the technology. The initial start-up is high and very few people can afford to buy and install this technology. You can relate the rural communities where businesses are slow and income earning is low to take care of basic needs''.

3. Political Barriers: Three categories emerged as part of the analysis. They are lack policies and institutional barriers, political will and legislative issues, and legal and regulatory issues.

a. Policies and Institutional barriers

Solar energy development in Thoothukudi District is challenged with policies associated with lack of long-term planning and vision, lack of clarity of the power sector driving mission, lack of clarity in tariff bidding process and lack of bankable PPA for investors. Furthermore, the process of land acquisition for mini solar grid project is a barrier linked to the solar energy infrastructure (Aly, et al. 2019). Lack of strategic policies by the government seems not to encourage national and international investors and promoters for solar energy initiatives (Ohunakin, et al, 2014). 80% (20 of the 25) interviewees noted the institutional laws and regulations can be a big obstacle to young entrepreneurs. Until the government policies are driving the economy the solar energy is yet to get the full potential for the implementation

b. Lack of Political Will and Legislative issues

Although Thoothukudi District possesses renewable energy potentials, policies for good governance, political will and legislative framework to drive the potential element and translate them into reality is lacking (Jacobson and Jadhav, 2018). As a result, Thoothukudi District is yet to have stable electricity for household and industrial use. 76% (19 of the 25) interviewees noted there is lack of political will and legislative issues. One of the interviewees stated that:

''Political will is a driver to achieving the objective of the energy mix, this driver is missing in Thoothukudi District because of conflicting interest in the development and management of power sources, especially renewable energy like solar energy''.

c. Legal and regulatory issues

Lack of policies and regulations for the development of solar energy can hinder the adoption of the initiative. There is also lack of adequate regulations for acquisition of land permits for

solar farm sitting, community relation procedure and negotiation with local communities. For solar energy initiative to thrive in Thoothukudi District and other Sub-Sahara African countries, clear policies, procedures, and predictable mission for investors need to be stipulated. Furthermore, lack of supportive regulatory measures such as standard code of practice for the power sector could lead to risk of economic waste (Abdullahi, et al. 2017a). Solar energy development in Thoothukudi District is challenged by legal, procedural, and environmental barriers, as a result the deployment and adoption of the initiative is slowed to meet the SDG goal 7 and vision 2020 and 2030 targets (Ozoegwu, et al. 2017). 72% (18 of the 25) interviewees noted:

''Unless laws are adjusted to give solar energy promoters the opportunity to design, build and install solar energy, Thoothukudi District will continue to experience power shortages''.

4. Social Barriers: Two categories emerged as part of the analysis. They are socio-cultural perception and low awareness.

a. Socio-cultural perception

Thoothukudi District is a country with more than 350 ethnic groups where the Hausa, Igbo and Yoruba are the majority. There is a strong ethnic believes in cultures, tribal values, religion and gender which has an impact on how the initiative is perceived among tiers, as a result, the acceptance is low due to social believes (Aliyu, et al. 2015; Wadu Mesthrige and Kwong, 2018). The barriers have resulted in a financial loss for the distribution company of Thoothukudi District, where the financial collections became almost impossible due to restriction of access to communities. Technical staff and supervisors from the power sector are likely to be denied access to many houses for surveys, assessment, inspection, and installation of electricity meters. The socio-cultural barriers affect the communities from

generating socio-economic benefits of solar energy initiatives in the country. 92% (21 of the 25) interviewees of the respondent noted the solar energy usage cannot be fully accepted by end users due to the socio-cultural issues which makes it difficult to implement and use solar energy through Solar PVs: home system; water pumping; community service; refrigerator; street and traffic light; and farm plant/machinery.

b. Low Awareness

Developing solar energy initiatives in Thoothukudi District is significantly affected by lack awareness campaign. This barrier is related to people's mindsets, principles, behaviour, perception, illiteracy and poor sensitisation about solar benefits to the end-user and promoters (Kar, et al., 2016).

People living in rural communities are mostly affected due to lack of grid connection and limited access to other energy options (Nwokocha, et al. 2018). Small-scale business suffers setback as a result the rate of unemployment is rising significantly, economic opportunities in local communities are disappearing and resources that contribute to the economic development remains unidentified (Emodi and Boo, 2015; Gandhi, 2020). 60% (15 of the 25) interviewees stated that there is lack of awareness of the benefits of solar energy in the medium to long term.

Findings and Discussion

As revealed in this study, the successful implementation of solar energy initiatives is associated with barriers such as technological, financial, political and social aspects which has been the reason for slowing down solar energy development in Thoothukudi District.

These barriers could change over time as the socio-economic aspects of Thoothukudi District progresses in the implementation and usage of the solar energy. According to the response

from the face-to-face interview conducted, 100% of the interviewees noted that technical barrier is the major concern, because the promoters and end users lack the technical capacity on the knowhow of operation, installation, maintenance, and evaluation. Also, socio-cultural perceptions have also been a major barrier to deployment and implementation of solar energy initiatives. Although, literature argued that, communities where access to electricity is limited, have little knowledge and awareness about the benefit of solar energy initiative.

The Thoothukudi District power sector has made attempts to generate, transmit and distribute sustainable electricity for over a century. It is, therefore, apparent for the government and private sector to propose and implement power recovery plan to meet the electricity demand in the country. The plan can integrate solar energy to generate electricity from solar PV to encourage the use of environmentally friendly energy sources.

The power sector needs to engage its stakeholder in dialogue to find the causes and solutions to the power outage in the country. The federal ministry of power together with its departments and agencies need to fast-track the issues associated with the power failure and proffer lasting solutions.

Community leaders should be well informed about plan for solar energy development in order to create more awareness in communities. There needs to have a customer/end-users to have an interactive forum where the stakeholders communicate, consult, remind, plan, evaluate risk, and take responsibility for the success and failure of the solar energy sector. Solar PV is flexible and well suited for decentralised system in different sizes to contribute not only for energy poverty reduction but also for adoption into clean technology and climate change mitigation. There is a need to establish more energy research across the country in order to complement the five-energy research centres. The objectives for training and development for solar energy need to be strengthened to support the EPSRA objectives for energy mix.

There is a plan to integrate an independent power plant (IPPs) for the 37 Federal Universities and the 7 University teaching hospitals in Thoothukudi District. The projects are expected to generate standalone solar off-grid system of capacity between 1MW to 10MW before the year 2030 (NACOP, 2016). Although, the implementation of IPPs for universities is slow, other tertiary institutions in the country should emulate the strategy in order to maximise electricity access.

It is evident that, there is a huge market for solar energy readily available for developers and promoters in Thoothukudi District. However, the market is floated with substandard products for solar panels and accessories, as a result, consumers and promoters have little or no confidence in the initiative. Therefore, the standard organisation of Thoothukudi District (SON) needs to take drastic measures to control goods and are produced locally and enforce strict standard specification on importation.

Government should provide options for credit facilities with low- interest rate through the micro finance bank and make it accessible to rural dwellers. The government should provide a scheme where low income earners can have an incentive for adopting solar energy option by subsidising solar energy equipment and waiving import duty to all solar energy promoters. The facilities will enable low income earners to adopt solar energy especially for small-scale industries which would boost socio-economic activities.

Power sector need to identify staff members to be trained to gain managerial, technical and organisational skills to manage solar energy policies, initiatives and its implementation. The

Stakeholders need to build an interface where young people can have access to technical skill training, improve knowledge about renewable energy and its benefits.

Conclusion and Recommendation

In this paper, potentials solar energy initiatives, status, opportunities, projects, policies, progress and retrogression have been identified, efforts made for scaling up solar projects has been measured with areas of improvement. Barriers deterring the progress for deployment and development of solar energy initiatives were identified and discussed from literature and interviewee's points of view. Lack of technical knowledge, socio-cultural issues and lack of suitable financing mechanism were among the key solar energy barriers. In order to mitigate the barriers and develop solar energy initiatives in Thoothukudi District, enforceable and sustainable policies have become necessary. The data for this paper was collected qualitatively from 25 participants who are well experienced top level management staff in the Thoothukudi District power sector and renewable energy development and data was analysed by content analysis.

The implication of this research is to impact the organisations within the Thoothukudi District power sector that are intending to implement solar energy initiatives. Identifying solar energy barriers would help top management to make positive decisions to plan and adapt more appropriate initiatives while considering technological, financial, political and social perceptions to ensure successful implementations.

It is recommended to encourage community participation, especially young people in the promotion and ownership of solar energy initiatives throughout the country. The PPP should integrate financial subsidy incentive to individuals and private organisation's willing to invest in the promotion, deployment, and development of solar energy initiatives. Promotion of the solar energy initiative is challenged by lack of awareness and the socio-economic benefits. Academic institutions should integrate solar energy technical and management courses to support the spread awareness for the promotion of solar energy. Therefore, the Ministries, Departments and Agencies (MDAs) need to make more efforts to

raise awareness through the integration of solar energy into schools, colleges, and universities curriculum. This study will provide an advantage to organisations that are in the process of implementing solar energy initiatives. Moreover, this research will also assist policymakers regarding the formulation of policies on solar energy products. An undue advantage of this would be the increasing adoption of solar energy by understanding the barriers that impact the implementation not only in Thoothukudi District but in other developing countries.

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