The Electricity Journal 34 (2021) 106921

Contents lists available at ScienceDirect

The Electricity Journal

journal homepage: www.elsevier.com/locate/tej

A community based approach to universal energy access

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ARTICLE INFO

Keywords:
Energy access
Energy poverty
Economic calculation
Ecoblock
Community ownership
Private ownership

ABSTRACT

In this paper we present an alternative approach to addressing the problem of energy poverty. The private and community ownership in electricity factors of production, economic calculation, and the incentive for innovation through the price mechanism are discussed. A brief analysis on how this new approach can be used to address energy access problems in energy poor communities is done. Cases studies of the Nigerian off-grid mini-grid industry and the Ecoblock pilot project in California in the United States are discussed.

1. Introduction

The relationship between energy services and economic development has been well documented (Alstone et al., 2015). That is when people have access to modern energy services like electricity, cooking gas and liquified petroleum gas (LPG) they generally have better life outcomes (European Commission, 2013; Ping, 2008; Wang et al., 2016). In this paper we focus on electricity. Fig. 1 shows the relationship electricity indicators and human development indicators (Alstone et al., 2015)

For over 840 million people, access to electricity in the quantity and quality that would lead to better measurements of HDI is not a reality (IEA et al., 2019). These people have low electrification rates and most of them live in sub-Saharan Africa (SSA) where the electrification rate is 47 % (The World Bank Nigeria Electrification Project (P161885), 2021). As Fig.1 shows SSA countries do poorly on Human Development Indices (HDIs) than their counterparts in other parts of the world (Alstone et al., 2015). Hence efforts to increase electrification rates in SSA have been on the rise in the last couple of decades (Zerriffi, 2010).

In 2015, the United Nations adopted a set of 17 goals aimed at bringing about a shared prosperity to its member countries around the world by 2030 (United Nations and General Assembly, 2015). In total, these comprise the UN sustainable development goals (SDGs). Among the SDGs, 7 and13 have unique relationship. 7 is to ensure that affordable clean energy and 13 is climate action. This is because the electricity industry is a major contributor to climate change. For example, about 40 % or global CO_2 emissions are from the generation of electricity through fossil fuels (United Nations, 2009). In 2018 the electricity industry was the second largest emitter of greenhouse gases (GHG) in the United States (United States Environmental Protection Agency (EPA), 2018).

Over the past 30 years bringing about electrification was done through state-controlled vertically integrated utilities, especially in India and China. This led to both countries becoming some of the largest emitters of GHG in the world (Janssens-Maenhout et al., 2017).

Global SDG stakeholders have embarked on a plan to achieve SDG 7 at the same time bring about climate action. The use of renewable energy (RE) distributed energy resource (DERs) based technologies have been identified as the appropriate route to bring about SDG 7 and 13 – a kind of killing two birds with one stone strategy (Zerriffi and Wilson, 2010; Levin and Thomas, 2016).

Energy access is approached as something that the energy poor of the world do not have and should be given. This paradigm of addressing the problem looks at it as an issue of technical unavailability. Fig. 2 outlines the current paradigm for addressing energy poverty.

In this paper we offer an alternative to this “technical unavailability” paradigm by discussing a new paradigm introduced by one of the authors to addressing this problem (Kemabonta, 2021). Then we use this model to address issues around the 5–10 years electrification or renewable energy master plans that have become common in many SSA countries. We specifically address issues on the nature of how these plans are developed. In many cases these plans have so many mandatory specific rules that they stifle competition which inevitably shunts much needed innovation and discovery to provide the energy services that would lead to better HDI measurements. Finally, we discuss examples of

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https://doi.org/10.1016/j.tej.2021.106921

Available online 13 February 2021

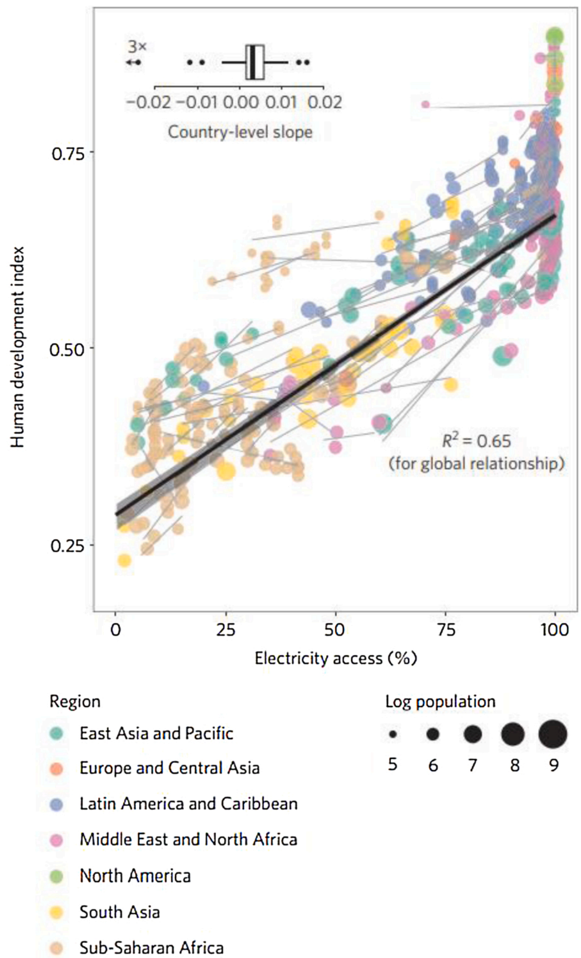

Fig. 1. Relationship between electricity access and HDI between 2000 and 2010 (Alstone et al., 2015).

how innovation, based on the introduced paradigm of approaching energy access issues, is helping communities in Nigeria and the United States.

2. Energy poverty – a different approach

The current paradigm of research and intervention efforts to address the issue of energy access is based on the position that access to energy is something that some people do not have, that is technical unavailability, and they should be given. Fig. 2 describes this technical unavailability structure. Here the problem of energy poverty is caused by poverty, which is caused by a lack of capital, which are technical or financial resources that could lead to energy access. The goal then is to turn technical unavailability to technical availability. Once there is technical availability, technical calculation comes into the picture. Let us take the example of a small off-grid community. The technical unavailability here with respect to energy is the absence of a substation and a generating plant that connects the community to the grid and the financing to make them available. Technical calculation is the combination of technology resources that are available to produce electricity for the village. The combination of using a solar PV array and lead acid batteries financed through a grant from a development finance institution (DFI) to provide a village electricity is technical calculation.

Governments in developing countries, multilateral organization, international aid agencies and non-governmental organizations (NGOs) have based their strategies and plans on bringing about energy access on this financial and technical targeting. Therefore, five-year, or ten-year master plans on how to bring about energy access or add renewable energy to the mix are common. These plans rarely ever achieve their stipulated goals.

For example, in 2005 the Energy Commission of Nigeria (ECN) with the aid the United Nations Development Programme released a RE master plan. The goal was to install 56 MW of RE based power generation by 2007, 746 MW by 2015 and 2945 MW by 2025 (Energy Commission of Nigeria, 2005). Multiple studies analyzing the potential of RE in Nigeria have been done and proposals have been made over the last 2 decades (Akuru et al., 2013; Ogbonnaya et al., 2009; Ajayi, 2007; Oji et al., 2012; Bamisile et al., 2017) Today the installed generating

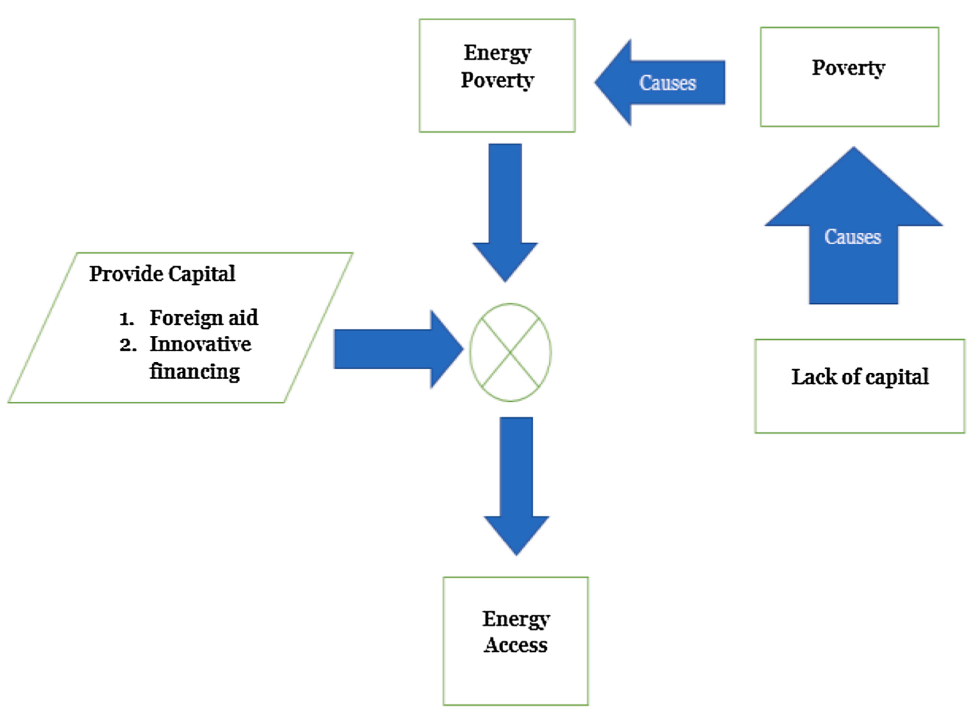

Fig. 2. The current approach to the problem of energy poverty (Kemabonta, 2021).

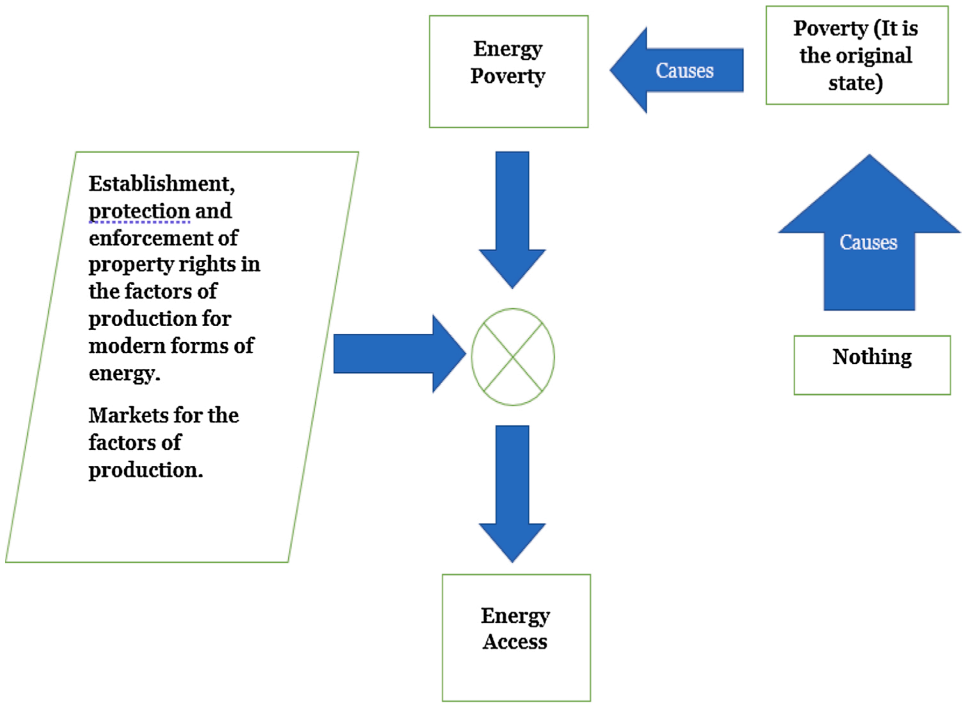

Fig. 3. Alternate paradigm for bringing about energy access and reducing energy poverty (Kemabonta, 2021).

capacity of the country is barely 12,000 MW with only 50 % of that capacity available for a country of 200 million people, and almost none of it is RE based (USAID Power Africa Fact Sheet, 2018).

These plans do not work for two major reasons:

1 The approach to the problem: t tt he energy poor suffer from technical unavailability because they do not have capital. That is not necessarily an effective way of looking at the problem. A better way of looking at the problem, which is a foundational part of the new paradigm proposed here is enshrined in a statement made by economist Pey Bylund, "What causes poverty? Nothing. It is the original state, the default and starting point. The real question is, what causes prosperity?" In the same tradition, we then could say. "What causes energy poverty? Nothing. It is the original state, the default and starting point. No community just out of thin air has the infrastructure that makes electricity available. The real question is, what causes electricity prosperity? (Kemabonta, 2021)." Fig. 3 describes this better. It also shows how other certain factors like the protection of private and community property rights in the factors of production for electricity addresses the problem of energy poverty.
2 Technical calculation, once there is technical availability, while important is not enough to provide energy access. Economic calculation is what is needed to bring about energy access. Many SDG stakeholders completely ignore economic calculation in their plans to bring about energy access.

2.1. Economic calculation

A major reason why these plans to not come to fruition is because energy access and SDG 7 stakeholders neglect economic calculation. The theory of economic calculation was introduced in the 1920s by economist Ludwig von Mises and expounded upon by his student, the Nobel prize winning economist Friedrich (Mises, 1920; Hayek (1935). To efficiently allocate resources in the proportion that they bring about energy access in the quantity and quality demanded one must be able to calculate economically.

To help us understand this better let us take two examples. The first one from economist Leland Yeager and the second from (Mises (1920); Yeager, 1994).

If we have a goal to provide public transportation in a city.

"Should it be supplied by buses burning gasoline, by electric streetcars, in some different way, or not at all? The economically efficient answer depends on more than technology and the physical availability of inputs. It depends also on substitutability and complementarities among inputs, on alternative uses of those inputs, and on consumers' subjective appraisals of various amounts of the various outputs of those alternative uses, as well as on appraisals of various amounts of various kinds of public and private transportation. The economically efficient answer even to the relatively simply question of local transportation depends, in short, on unimaginably wide ranges of information conveyed, in abbreviated form, by prices (Yeager, 1994)."

And from Mises

"The art of engineering can establish how a bridge must be built in order to span a river at a given point and to carry definite loads. But it cannot answer the question whether or not the construction of such a bridge would withdraw material factors of production and labor from an employment in which they could satisfy needs more urgently felt. It cannot tell whether or not the bridge should be built at all, where it should be built, what capacity for bearing burdens it should have, and which of the many possibilities for its construction should be chosen (Mises, 1920)."

This is a common problem SDG 7 stakeholders face. Off-grid energy system developers must decide on what combination of technology (technical calculation) they use to bringing about energy access. But they also have to make these decisions with respect to other alternatives. Before utilizing their resources to produce electricity one way, they must be able to calculate that the chosen way is the most economically efficient choice to allocate their resources. Do they use diesel or solar PV or a combination of both? What manpower do they have at their disposal, and how do they allocate them? Do they get their solar PV panels from China, or do we get them from the U.S.? Do they put an energy kiosk on one side of the village and not on the other side of the village? How would their customers use their product? What are the alternative uses of the proposed land they plan to locate their system? This goes beyond the technical calculation question, which is only concerned with the technology and how they are arranged to bring about energy access. Economic calculation deals with the combination of possibilities in allocating the different factors of production – land, labor and capital (technical availabilities).

Economic calculation allows us to make these important decisions as reflected through the prices of the different factors of production for electricity. Whatever decisions made by energy developers would eventually lead to a price of electricity. For simplicity, based on the price of electricity, SDG stakeholders can decide if a village should be powered with solar PV or diesel or a combination of both.

Prices are determined by what single individuals' value, and if they are willing to exchange their resources to get the thing they value. So, if people value electricity they will be willing to exchange their money with the electricity producer to get electricity. You cannot exchange what you do not have. And in an advanced economy the prices of any commodity arise because people are willing to exchange what they own for what the need (Mises, 1920).

Economic calculation is only possible when there is private ownership in the factors of production (Mises, 1920). By private we do not necessarily mean one person. It could be a group of people or a community. They must be able to appraise the value of the factor production because this will determine if they want to utilize the factor of production for their own use or exchange it for something they need. E.g. leasing land for the construction of a mini grid, to get electricity in return. You cannot exchange what you do not own. It is through the process that a price, which is usually reflected by amounts of money, arises.

A price, in general, is also a mechanism for incentivizing discovery and innovation. For example, based on the price of electricity, entrepreneurs can, using this price as a guide, combine different arrangements of "technical calculations" to come up with an appropriate energy access solution. Economic calculation guides their technical calculation.

Hence if the factors of production that bring about electricity, like land, steel, copper, etc. are not privately owned, either by an individual or group of individuals, the appropriate prices that would be a guiding light for economic calculation does not arise, and the energy access investment needed to happen does not take place (Kemabonta, 2021). Many developing countries have tried to solve this problem by completely nationalizing all the factors or production for electricity and fixing a price and providing electricity through vertically integrated utilities. This has just led to more people remaining energy poor.

For example, 21 out of 48 SSA countries have no private participation in their electricity industries. The ones that do still have heavy involvement of government participation in the industry as a market participant and not just as a regulator (Eberhard et al., 2016). For example, in Nigeria, while there is private participation in the electricity sector, the transmission side of the electricity chain is completely owned by the government, and the government retains 40 % of ownership in all the local distribution companies (discos) in the country (Kemabonta and Kabalan, 2018; Federal Republic of Nigeria, 2005).

This has left many state-owned utilities in SSA unable to provide electricity in the quantity and quality demanded. According to a World Bank report, out of 39 SSA countries surveyed only utilities in 2 of them were fully recovering their capital and operational costs. Almost all of them suffered from insolvency issues (Kojima and Trimble, 2016).

2.2. Mandatory rules in energy access plans

Another factor for the failures of many rural electrification or energy access plans in SSA countries is instituting mandatory rules in those plans. First, creating mandatory rules to guide the implementation of a project that has never been done before is not a best practice. Second, it stifles innovation and discovery which come about by trial and error. People can conceptualize all kinds of cool energy access technologies and business models, but they have to test them out to know if they work or not. The rules that should guide any industry, whether mandatory or not, should be built from ground up and dependent on what the consumers want. This is how market-based regulations come about. When this is the case, rules adapt with consumers behavior and preferences. But this is not the case in the many energy access or rural electrification plans by SSA countries.

For example, the 2016 Nigerian Mini Grid regulatory framework gives only two options on what should happen when the local distribution company (DISCO) extends their grid to an isolated mini grid. The mini grid can either interconnect with the DISCO and sell energy to them or the disco can buy the asset for the book value of the asset plus revenue earned by the mini grid developer in the previous 12-month period (Nigerian Electricity Regulatory Commission (NERC), 2016). The policy leaves very little room for negotiations between the community being served by the mini grid, the disco, and the mini grid developer. There is no discussion of utilizing other methods for asset valuation like discount cash flows (DCF). And this has the potential of either undervaluing or overvaluing the asset in question (Kemabonta et al., 2019). In any case, someone losses, if they cannot agree on a price based on the two options made available to them by the regulatory framework. Since no disco has extended their grid to a mini grid's area, this is an example of setting mandatory rules for something that has not yet happened.

Another example is the National Policy on Renewable Energy and Energy efficiency, released by the Federal government of Nigeria in 2015 with the goal "to remove the key barriers that put renewable energy and energy efficiency at economic, regulatory or institutional disadvantages relative to other forms of energy" in the country (The Federal Republic of Nigeria, 2015). First, mandatory renewable portfolio standards (RPS) were recommended, and then renewable energy targets were stipulated.

By 2020, the following renewable electricity targets would have been achieved: Solar, 1,343.17 MW; Biomass 631.41 MW; Wind 57.40 MW. In the same year the national policy was released, the Nigeran Electricity Regulatory Commission (NERC) approved a feed-in- tariff (FIT) for renewable energy sources and then mandated the local discos to procure 50 % of their energy from renewable energy sources (Mittal and Technica, 2015). At the time of this writing, it is safe to say that this policy has failed to achieve its goals.

Also, these rules usually take the form of command and control. Again, it is important to state that this stifles innovation, it reduces the incentive to try new things and, in most cases, never works.

A new paradigm that includes the importance of private and community ownership of the factors of production for electricity, prevents price fixing so efficient economic calculation can take place and the incentive for innovation and discovery is not hampered is shown in Fig. 3.

3. Case studies for the private and community ownership in the factors of production

In this section we look are situations were private or community ownership to the factors of production for electricity gave rise to appropriate electricity prices and the innovation necessary to bring about increased access to energy services in energy poor communities in Nigeria and the United States.

3.1. The Nigerian mini grid industry

Around 2013, entrepreneurs recognizing the opportunity to address the issues around the supply of energy services, embarked on a mission to provide electricity for those living in off grid communities on Nigeria. This was during the time before NERC 2016 mini grid regulation, hence there were, per se, no rules that governed the industry (World Bank,

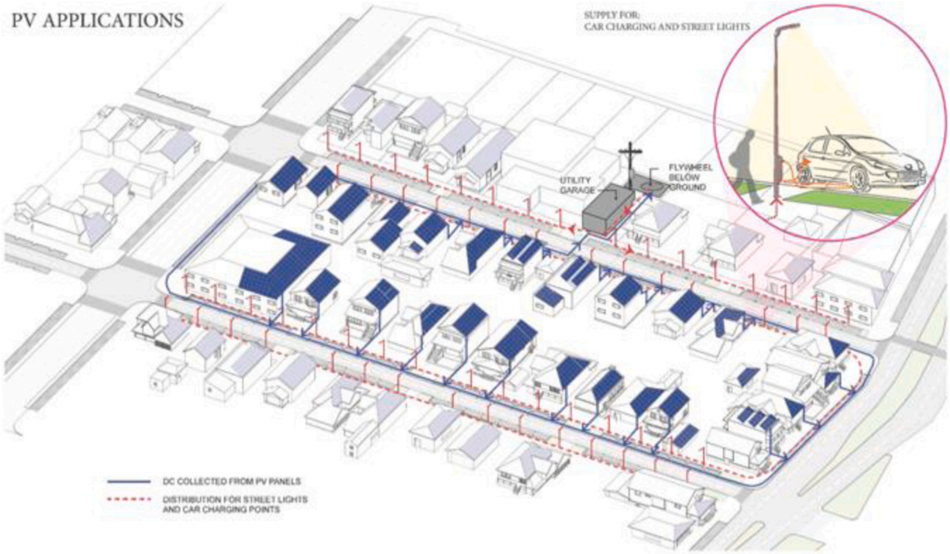

Fig. 4. The EcoBlock in Oakland, CA supported by both a community association and funding from the state Energy agency (to DMK).

Climate Investment Funds, ESMAP, 2017). Hence mandatory rules instituted by the regulation as discussed, the above section was not in force.

These entrepreneurs went into the communities and negotiated with them the use of their land. In many of these communities they had control and "ownership" of the land, (See (Kemabonta, 2021) for a discussion on the complex nature of land ownership in Nigeria). And since they could control the use of the and they were able to value it with respect to the alternative uses of the land, they came to the conclusion to exchange it for the development of energy access projects, which eventually gave rise to market prices for electricity. Hence it was possible for these entrepreneurs to develop and implement electricity projects from these communities (Fig. 4).

The communities paid between $0.38 and $0.51 per kWh for electricity (World Bank, Climate Investment Funds, ESMAP, 2017). What is interesting about this is that for communities that are connected to the national grid, being served by regulated local distribution utilities (DISCOs) pay between $0.064 and $0.080 per kWh (Kemabonta and Kabalan, 2018). These prices are regulated and are not cost reflective. Hence, they are no market prices for electricity, hence electricity is not provided to in the quantity and quality to those who are connected to the national grid. According to the World Bank, those connected to the grid in Nigeria, experience over 32.5 outages a month. And the average outage duration is about 8 h (World Bank Program-For-Results-Financing, 2018).

But those off grid communities served by mini grids get electricity in the quantity and quality demanded even with the so-called high prices (World Bank, Climate Investment Funds, ESMAP, 2017). The issue here is that those prices are only considered "high" by third party observers. Only the community members who exchanged the land with the mini-grid developer for project development and upon negotiations, were willing to pay those prices, can understand and ultimately decide what is a high price. They are the ones who know what they can use electricity for and are willing to exchange their resources (money and land) to get it. They are the only ones who understand what it cost them to travel many kilometers to buy petrol/gasoline for their small generators; they are the only ones who understand the cost of the thing they lose to marauders because their homes and surroundings are not effectively lit at night; not third party observers.

3.2. Ecoblock: A community based approach to energy access

In a pilot project we are developing in Oakland, California, a low-income neighborhood is being re-wired as a mini grid. That is not unusual. What makes this 'EcoBlock' unique is the focus on shared resources: solar collected from all rooftops is pooled in a shared battery system so that residents of greatly differing income, demand levels, and solar rooftop area can all share in the collective benefits of not only local power, but also of sales of excess power (after household needs and EV charging demands are met). The EcoBlock will also consider additional collective approaches to sanitation. The block will test a modular, scalable, neighborhood energy resiliency building block for a reboot of community energy around networked neighborhoods that provide greater access to affordable green energy than a simple model where each home or building negotiates (or accepts) a direct linkage (both technical and financial) with the large utility. California has committed to 100 % clean energy by 2045 (State Senate Bill 100), and these Eco-building-blocks hasten the process while building environmental justice into the system.

4. Conclusion

From rural off-grid communities, to community building blocks of clean, resilient power generation, to managing renewable energy connections to the utility system, the challenge of meeting energy needs for energy poor communities has often been one of technical unavailability. In the case studies and pilot projects we see energy access issues addressed effectively based on private and community control of the factors of production by those who live in energy poor communities. In this model, shared objectives lead to planning around resilient community approaches (Nathwani and Kammen, 2019).

Funding Source

California Energy CommissionCEC-500-2019-043.

Declaration of Competing Interest

The authors report no declarations of interest.

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