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Renewable Energy Adoption in Poor Rural Areas: Why Communities Matter

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Renewable Energy Adoption in Poor Rural Areas: Why Communities Matter

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Abstract

This study examines why renewable energy technology (RET) adoptions succeed or fail in poor rural areas. It explores the role of communities in the usage and management of the RET systems to facilitate the state-centric policy interventions based on national targets and policies. It hypothesizes that inducing local participation that focuses on community-based activities which cultivate trust and sense of empowerment among the community members will yield a higher possibility of successful RET adoption. The involvement of the communities in the creation and evolution of the RET's hardware, software and orgware could result in long-term and sustainable adoption of the RET systems. This paper makes use of the case study approach and survey analysis from empirical data gathered from fieldwork in the rural island communities in the Philippines. This study establishes the RET policy intervention framework that is community-driven and specifically applicable in poor rural areas which lack energy access and are also susceptible to natural disasters.

Keywords: renewable energy, renewable energy adoption, community development, sustainable energy transition, rural communities, community participation

I. Introduction

Even with steady progress to address the lack of energy access globally, around 2.8 billion people are still dependent on conventional fuels as their primary energy source. 789 million people, mostly from developing countries, have still no access to electricity. According to International Renewable Energy Agency (IRENA), one of the solutions to provide sustainable

energy to these energy-poor areas is through renewable energy technologies (RETs) deployment which enables clean energy access, drives economic growth and local employment, and improves the health of the population (IRENA, 2019). Developing countries like the Philippines try to address the lack of energy access and security by implementing policies that encourage renewable energy technologies (RETs) in both on-grid and off-grid areas. The national strategy is to triple the share of RE in the country's energy mix by implementing large-scale energy projects and utilising market-led incentives to encourage private investments in clean and renewable energy projects. The Philippine government prioritises rural electrification through solar home systems or electricity subsidies for off-grid and remote areas. However, even with national targets, the implementation appears more challenging, especially at the community-level. Scholars and practitioners argue that the awareness, engagement, and participation of the communities are important factors in effectively achieving clean energy transition (Alkire, 2001; Blanchet T, 2015; Dongier, 2003; Klein & Coffey, 2016).

A community is defined as a "locality or small geographical area, a group of people sharing some interest or network of relationship at a local level" (Hubley, 1990, p. 5). Communities in a sustainable transition framework are considered examples of "niches" that can serve as incubator rooms where research, development, and learning can happen through experience (Seyfang & Haxeltine, 2012). Communities allow establishing local supporting networks that make learning more manageable and the adoption of new knowledge and technology more relevant. In community-based energy projects, the users participate in the RET adoption process through their involvement in the decision-making of the deployment, maintenance, and repair of the RE components and the RE system's sustenance in general.

The paper investigates the impact of the community-based approach on the success (or failure) of the long-term RET adoption in poor rural communities. The key question is, "what

determines the success or failure of the community-based RE projects or interventions in poor rural communities?" We argue that the long-term RET adoption is most likely to be achieved if community members are included in the co-production and co-evolution of the RET adoption process. Using participatory governance, this paper examines how and why the community-based approach works. We also examine the agent and structure-based explanations on what a "successful RET adoption" means and present an alternative perspective, the relational approach to technological diffusion. Using the case study approach, we study five community-based RE projects for this paper: an energy relief initiative using RE, a centralised solar farm managed by a community cooperative, a government-sponsored individual solar home system, a rooftop solar PV project in an island community, and a one-time RE donation drives in rural areas.

II. Theoretical Framework

The community-based approach (also known as community-led, community-driven development, CDD, or induced participation) comes from the historical notions of participatory governance, which prescribes an induced participatory intervention (Mansuri & Rao, 2013). CDD focuses on enhancing participation within the community. It "supports efforts to bring villages, urban neighbourhoods, and other household groupings into the process of managing development resources, without relying on formally constituted local governments" (p.1). It targets the local groups on and below the poverty line to become partners in pursuing development while building their institutions and cultivating their resources for their benefit. The participatory framework argues that individuals who participate in community decision-making create capacity for self-reliance and collective action, also known as "social capital" (Mansuri & Rao, 2013, p. 16). Social capital is defined as the individual's attributes and relationships that augment their ability to solve collective action problems (Ostrom & Anh,

2003). At the community level, social capital is referred to as the qualities of a social organisation: the norms, networks, and trust, that improves a society's efficiency by facilitating coordinated actions (Putnam, Leonardi, & Nanetti, 1993, p. 167). Social capital is productive and facilitates spontaneous cooperation. This means that community-based RE projects utilise the community's social capital to engage its members in sustaining the RET adoption.

Following the arguments presented by scholars, it seems that if a RET project has mechanisms that induce community participation, it could lead to a successful RET adoption. This, however, presents a simplified understanding of what successful and failed technological diffusion mean. While there is already adequate literature that studied and provided explanations of how community participation works and its complexities, the scholarship on what a technological adoption is[1], especially in the energy field, is still growing (Kinn & Abbot, 2014; Quirapas & Taeihagh, 2021a). Furthermore, scholars still debate the role of agents, e.g., community members vis-à-vis the importance of structures in explaining a successful technological diffusion. Both the agent- and structural-based explanations have their strengths and weaknesses. The systems approach helps one navigate the level of analysis of adoption from the household to broader social structures or frameworks beyond the control of the end-users (Sovacool & Hess, 2017). It gives importance to the other stakeholders (project managers, local government officials, or NGOs), interests (public or private), or community institutions (formal or informal) that might affect the decision-making process and implementation of the RE project. An example is the lack of community financing schemes to maintain or repair the RE system. The system approach also emphasises the path dependency of the technological system — its ability to continue or operate along a given path caused by previous actions of numerous stakeholders, organisations, or institutions within the system.

[1] Scholars use different terms to refer to technological adoption, such as conversion, social, market or community acceptance, technological transition or innovation, diffusion, support, or adoption, to study and analyse how technologies become widely disseminated or embraced by users (Sovacool & Hess, 2017). These terms are used interchangeably in this research paper.

On the other hand, this does not mean that the transformation of a technological system can only be explained by systemic changes or overhauling the entire system. From the demand side, specific actions or desires and variations in the agents' attitudes or activities can inflict changes to the existing structure if sustained for a long time (Haddon, 2011; Silverstone, 1994; Sorensen, 1996). While the insights of the system approach give the bigger picture of technological adoption, it comes at the expense of weak conceptualisation of the agential issues, the conflict and politics involved, and the strategies and dilemmas of individual actors in the transformation processes (Genus & Coles, 2008; Smith, Stirling, & Berkhout, 2005). As such, this debate between the agential and structural explanations can represent a spectrum of how agents act within the broader social and institutional contexts (Sovacool & Hess, 2017). Structures impact the behaviour and interaction of the citizens, while changes in citizens' attitudes and actions can also affect the structures themselves. Farla et al. claim that technological transition can be studied both in the agent and system levels by looking at "the impact of the strategies, resources, and capabilities of individuals, firms and other organisations and how the changes at the system level feedback into the observed strategies of actor level" (Farla, Markard, Raven, & Coenen, 2012, p. 992).

This paper proposes a complementary and hybrid approach to evaluate both the importance of an individual's actions and behaviour as well as the structural opportunities and constraints towards a successful RET adoption – the relational approach (Rurtherford & Coutard, 2014; Sovacool and Hess, 2017; Mondal et al., 2010). It defines a long-term RET adoption as a continuous and co-evolving process made of different components: the usage of the physical features of the RETs (hardware), the knowledge and skills of end-users to operate and maintain the RETs (software), and the structures and institutions that sustain the RETs (orgware) across time and the geographic scales (Dobrov, 1979; Rutherford & Coutard, 2014). These blocks require a certain fit or appropriateness to co-evolve through time to adopt technology and

innovate successfully. The unit of analysis of the relational approach is not solely focused on actors or structures alone but on "heterogeneous configurations with co-evolving elements, and envision agency as structured by routines, rules, habits, and conventions" (Sovacool & Hess, 2017, p. 733).

Combining the participatory governance framework and the relational approach towards RET adoption, this paper proposes that the "ingredients" of a successful RET adoption at the community level lie on two significant aspects: (1) the active involvement of community members in the CDD project (through decision-making, operating and maintaining the RETs, and others) (2) the sustainability of the community's involvement in the RET adoption process, that is, their continued usage of the hardware components, the utilisation of the software skills to operate RETs, and finally, their participation in orgware which is the network of actors and institutions that manage and maintains the RETs within the community (Quirapas-Franco and Taeihagh, 2021b). As the community-based approach is highly contextual, there is no one-size-fits-all model for CDD RE projects.

III. Methodology

This study uses the case study approach with various data gathering tools to collect primary and secondary data. Alongside a desk review of related studies, reports, and publications, fieldwork was conducted from August to November 2019 in the selected island communities. In-depth key stakeholder interviews, site visits, walk-throughs, and community observations were done during the fieldwork.

A subset of the qualitative method, the case study approach is useful in theory development, generation of new evidence, and testing hypotheses (George & Bennett, 2004). It "gives a detailed consideration of the contextual factors of a research study which are extremely different from doing statistical studies" (p.19). It is also a useful research approach to identify

new variables and hypotheses of the study heuristically. The case study approach helps explore causal mechanisms and model and assess complex causal relations (pp. 19-22). Although guided by current literature and theoretical lens, this paper is meant to be exploratory and open to generate new explanations about the topic.

The typical-case approach is used to select the cases for this paper. It is an inductive approach to case selection, which helps understand broader phenomena and serves to have an exploratory role (Gerring, 2006). Each community represents a typical case—it is situated in a rural area; it has limited power supply or has no electricity at all; it is composed of low-income households that pay for high electricity rates and has received or has existing RE projects and systems. These communities are also disaster-vulnerable, making it more challenging for RET stakeholders to establish stable on-grid electrical infrastructures that can secure electricity supply. Despite the existing conditions in these communities, long-term RET adoption could still be feasible with a supportive national RE policy framework. However, even with steady growth in the economy and diversification of energy supply, 12 per cent of the total population located in the country's poor rural and remote communities is still without electricity and far from achieving sustainable energy (Olap, 2018). Why is this so? Do the rural off-grid areas reap the long-term benefits of these RE systems? Do the rural communities achieve energy access, energy resilience for disaster-prone areas, and, most importantly, sustainable energy that can benefit their socio-economic needs? By studying the Philippines' rural communities, one can analyse a typical case representing an environment with conducive and supportive conditions where long-term RE adoption can be expected. However, varying results of RET adoption are seen. This study describes and analyses the nature of participation in the RET adoption process, the social relations and interactions formed between and among the different RET stakeholders, and the characteristics, patterns, and challenges of the adoption process.

The interviewees are selected through a combination of purposive and snowballing methods. The purposive sampling is helpful to seek out the stakeholders essential to the RET adoption process. In total, 65 in-depth interviews are conducted for this research with the following representations—10 RE project implementers, 4 stewards of RE systems, 44 household beneficiaries of RE, 5 local government unit (LGU) officials, and non-government organisation (NGO) representatives, and 2 other stakeholders who are from the business and private RE sectors of the communities. The interviews are transcribed, and the data gathered from these have been categorised into themes and sub-themes for content analysis. The content analysis helps reduce and simplify the collected data, which can be measured using quantitative or qualitative techniques.

IV. Results and Findings

This paper investigates the different community-based RE projects in the selected rural island communities of the Philippines located in Eastern and Western Visayas: Bantayan, Camotes, Gilutongan, Malapascua, and Pangan-an Islands in Cebu; and Alang-alang Municipality in Leyte. The four projects were Project Enkindle as an energy relief program: Solar Farm and Solar Home System (SHS) as supported by the national government; and one-time RET donation projects in the communities. Self-bought RETs are also included in the analysis to know the motivation of households in buying solar PV on their own. Below is a table that summarises the information from each of the project and community beneficiaries.

Project name	**Project description and implementers**	**Island communities / beneficiaries**	**Type of RET systems**	**Years of operation of the RET systems**
Project Enkindle	A renewable energy deployment project aimed to empower the rural communities affected by Typhoon Haiyan. Initiated by a group of individuals in Singapore; currently managed by an NGO and a university	Bantayan, Camotes, Malapascua and Alang-alang	Class 1: community-based solar PV systems ranging from 50w to 800w capacity and Class 2: 300w hybrid RET with solar and wind energy)	2014 to 2020 for 8 Class 1 RETs; for the rest, lasted at least for 2 years
Pangan-an Island Solar Electrification Project (PISEP)	The first off-grid RE rural electrification in the Philippines which aimed to provide 24-hour electricity to Pangan-an Island. Initiated by the national government	Pangan-an	The centralised solar PV system was comprised of 504 PV modules with a combination of 80 and 90W peak, each totalling 45.36 kWp with a 20-year lifespan	1998 to 2011 was solar farm alone; 2012 to 2017 solar farm with diesel generator
Solar Home System (SHS)	Part of the national government's Total Electrification Program (TEP) to power up off-grid rural and remote areas Initiated by the national government		10Wp to 30Wp, which are enough to power up light bulbs, a small radio and charge mobile devices.	2018 to 2020

Donated RETs (general)	one-time donation drive by external organisations or donors	Gilutongan	SunEdison 5kW solar PV system donated to Gilutongan Elementary School and other one-time donations of smaller-scale solar PV	2015 to 2018 for the school; at least 2 years for individual household's solar PVs
Rooftop Solar PV Project	An ongoing community-based RE project organised by USC in Gilutongan aims to establish and sustain rural electrification in the island using RETs.		A 7.92 kWp rooftop solar PV system with 24 units of 330w solar PV panels, 2 units of 5kW inverter, and 12 units of 200 Ah battery	Started in March 2020 until 2022
	USC as part of Access to Sustainable Energy Programme-Clean Energy Living Laboratories (ACEP-CELLs) funded by EU			
Self-bought RETs	n/a		Mini solar panel with 10 to 50w to power up appliances like a bulb, mobile charger, or radio	At least 3 years

Table 1: Summary of the community-based RE projects in the selected rural communities

Although the community-based approach is highly contextual and may differ from one project to another, there were similarities among the projects: (1) setting out RET solutions that were suitable to the immediate energy needs and conditions of the communities (hardware); (2) training the beneficiaries, at the very least, to operate and maintain the solar PVs (software) and (3) engagement of the beneficiaries in different stages of project implementation and ensuring that community members have different roles and responsibilities to play in the RET adoption process (orgware) (Quirapas-Franco and Taeihagh, 2021b). Involving and engaging the community members at the initial stages of the community-based RE projects ensured active participation from the communities. This was an important step to jumpstart the RET adoption process of the community. The projects used various community-based mechanisms to ensure the beneficiaries were involved in the decision-making process of the RE project, which is the cornerstone of the CDD approach, as mentioned in the previous sections. Project implementers were able to design the RET system that was suitable, at the very least, to the immediate and basic energy needs of the island residents (Enkindle Steward 1, 2019). These RETs brought beneficial impacts to the communities and all community-based RE projects also conducted basic training to enhance the software skills of the communities in operating and maintaining the RETs (Households 1 to 3 in Pangan-an, 2019; Households 1 to 2 in Gilutongan, 2019; Households 1 to 3 in Leyte, 2019). With an established relationship at the initial stages of the project, each of the RE stakeholders accepted the "rules of the game" and the different roles and responsibilities. Each of the RE projects has brought about positive changes and benefits to these energy-poor communities.

However, the crucial turning points for the sustainability of the RE projects were when the RETs hardware components started to deteriorate, and the community's software capabilities were not enough to manage, maintain and repair the systems. From the project implementers' side, internal project management issues, like lack of funding and resources, manpower or

capability, hindered the continuous implementation of the projects (NGO Partners 1 to 2, 2019). By examining the social relationships and interactions within the community and the RE project implementers, it was revealed that the main predicament of the community-based RE projects was sustaining the orgware of the project and making sure that this component co-evolved together with the hardware and the software (Quirapas-Franco and Taeihagh, 2021b). Enkindle had difficulties in supporting the different roles and responsibilities of each RE stakeholder in their stewardship program. Although social networks like familial ties and religious affinity helped maintain the stewardship program in Leyte, this was more of an exception than the rule. Without the Enkindle team or the stewards regularly checking on the RETs, the systems were left unused or mismanaged. There were also internal and project management issues like lack of funding, stable source of human resources, and disagreement over the future direction of Project Enkindle (Quirapas-Franco and Taeihagh, 2021b). The PISEP also faced similar difficulties, especially when the solar farm started to malfunction. It was revealed from the interviews that although PICCD was the closest to other existing community energy models, the capability to sustain the RETs beyond its lifespan remained to be a difficult task. The monthly cost to utilise the solar farm was too expensive for those who needed the electricity the most. The attempts to support the low-income families failed because the livelihood projects of the cooperative were all short-lived. There were also tensions between the community residents and the cooperative due to transparency and management issues of the solar farm. The community-based RE donation projects in Gilutongan did not only experience the inability to maintain, repair or replace the hardware components but the conspicuous predicaments laid more on disagreement over community management and the overall absence of enabling and supportive environment in the community. In the case of the USC rooftop project, it was clear that the lack of energy access in the community did not only

need a technological solution. There was a necessity to increase the beneficiaries' capabilities in managing the RETs to become financially and socio-economic viable for them to sustain.

In summary, the establishment of orgware served specific purposes: (1) to build a relationship of trust between the project implementers and the beneficiaries, (2) to agree on the different roles and responsibilities of each project stakeholder, which ideally would lead (3) to the maintenance and sustainability of the RET systems (Quirapas-Franco and Taeihagh, 2021b). Its importance was crucial at the initial stage of the projects and was highlighted more after the deployment of the RETs and when the hardware components worn-off or have reached their lifespan. Table 1 summarises the most important uses and benefits and the challenges faced by the community-based RE projects based on the interviews with the beneficiaries:

Project	**Types of RET deployed by the scale**	**Most significant benefits of the RETs based on interviews with the beneficiaries**	**Challenges/Issues faced by the community-based RE projects**
Pangan-an SHS and other donated solar PV in Gilutongan	10 Wp to 30 Wp solar PV system	access to lights, mobile charging and small radios	unable to buy spare parts or replace damaged components; lack of technical capabilities to maintain and repair the system
Project Enkindle	Class 1 system: 50 W to 800 W solar PV (with modular and easy to deploy design)	(a) and (b) for households and continuous provisions of services at community centres, feeling of safety and security at night, evacuation sites with electricity, energy relief and resilience during a disaster	few of the hardware components were easily damaged, e.g., the cable used was not for outside installation; overloading that caused damage to the batteries; unable to buy spare parts or replace damaged components
	Class 2 system: 300 W hybrid solar and wind energy		no proper handover from the first steward to the current one; inability to repair damaged parts

Donated solar PV in Gilutongan School	5kW solar PV system	(a) and can power up computers and printers to aid the learning of the students	ownership and management issues of the RET (between the school and the barangay); lack of effective load management; lack of technical capabilities to maintain and repair the system
USC rooftop project in Gilutongan	7.92 kWp rooftop solar PV system with 24 units of 330w solar PV panels	(a) and additional savings from diesel cost, source of entertainment (TVs, *karaoke*)	beneficiary selection issues within the community; load management between the diesel and solar PV electricity; ability to pay of the beneficiaries for the electricity and maintenance
PISEP in Pangan-an	the centralised solar farm comprised of 504 PV modules with a combination of 80 and 90W peaks	(a),(b) and an additional source of income (ice-making, mobile phone charging business), environmental and health benefits	inability to pay for the solar electricity; effective load management from the individual household; ambivalence of the residents towards cooperative's ability to manage the solar farm
Legend:			
(a) access to lights, mobile charging and small radios			
(b) additional savings from diesel cost, source of entertainment (TVs, karaokes)			

Table 2: Benefits, impacts and challenges of the RETs at household and community level

V. Discussion

The first part of this section presents how the project implementers induced participation in the community, and the second part analyses the sustainability of these community-based approach mechanisms in ensuring long-term RET adoption.

A. Short-term RE benefits: Inducing participation in the RET adoption process

The different community-based RE projects had brought about positive impacts to the island communities. Their main objective was for the communities to have access to a clean, renewable and alternative energy source, whether by operating, managing or owning the RETs (Abundo, 2019; Enkindle, 2015; PISEP, 2001; USC Project Implementer, 2019; LGU Official 1 Gilutongan, 2019). Enkindle, the PISEP, SHS, USC's rooftop solar project and the other one-time RE donation drive aimed to provide the energy-poor and disaster-vulnerable areas sustainable RE solutions to address their lack of or limited energy access. By establishing or enhancing various forms of the community's social capital, the project implementers had encouraged the beneficiaries to take more active roles in the project's initiation and deployment stages. At the same time, the communities benefitted from the projects' RET solutions that were designed to address the community's immediate energy needs.

If the projects were evaluated against their objectives of 1) providing energy access to the communities alone and the benefits that the RETs brought into the communities and 2) inducing participation from the beneficiaries to be more involved in the RET adoption process at the initial stage of the project, all the projects could be considered to have successfully achieved these two goals. The communities had benefited from the electricity the RETs provided – they were able to utilise the RE to aid them in their day-to-day activities. The agent-centric theories on RET adoption can support this evaluation. Agent-centric theories define a successful adoption as a change in a person's behaviour due to the utility the technology brings,

despite the uncertainty (Rogers 1983). It is also when new and unfamiliar technology becomes incorporated into one's daily routine and everyday life or domesticated (Haddon, 2011; Silverstone, 1994).

Also, all of the community-based RE projects (apart from the one-time donation RE drive) regarded that a successful RET adoption is a systemic change not only on the usage of physical components of the RETs but also on the social institutions and networks within the community. Enkindle, PISEP, and even the smaller solar-scale projects like SHS and USC solar rooftop project had invested in creating and enhancing local mechanisms, relationships or organisation to maintain and manage the RETs. The stakeholders involved were not only the users of the RETs and the project implementers but also the other community members, formal and informal institutions like the barangay officials, NGOs, community associations, religious affiliations and family ties. There were formal structures in place, like community deliberations and voting, to engage the island residents in the decision-making process about the solar farm. In short, the community-based RE projects recognised the roles of the social and immaterial components of the community to the success or failure of RET adoption of the community.

B. Long-term RET adoption: sustainability of the community-based approach

The question remains whether each of the projects has resulted in a sustainable RET adoption by the community. As emphasised in the analytical framework, the paper defines a long-term RET adoption using the relational approach. It is when the different components (hardware, software and orgware) coproduce and co-evolve along with each other over time. It is a process that is circulated among the various actors and stakeholders across time and geographic scales (Sovacool & Hess, 2017, p. 733). This study reveals that each of the projects faced challenges in sustaining and maintaining their community-based approach to ensure an extensive diffusion of RETs into the communities. The problems became more prominent when

the physical components (hardware) of the RETs started to deteriorate, and the capability of the community to repair and replace the spoiled parts (software) was not enough. Most importantly, the project's community-based RE mechanisms and structures (orgware) were not sustained beyond the RET's lifespan

The intended outputs of each project were met, and these brought about beneficial impacts on the communities. However, the assessment of success for each community-based RET project ***varies*** whether the different components of the RET adoption process were still in place and whether they co-evolved to address the current energy needs of the communities at the period of study. Specifically, this refers to whether 1) beneficiaries are still using the physical components of the RETs (hardware) to provide at least their basic energy needs, 2) they can continuously operate and manage the RETs (utilisation of software) and 3) the community and project mechanisms to sustain the RETs are still present (orgware). *In this case, except for the 8 Enkindle RETs in Alang-alang and the two ongoing projects (SHS in Pangan-an and the USC rooftop in Gilutongan), most community-based RE projects have failed to continuously produce, evolve or maintain the different building blocks of long-term RET adoption process.* The next paragraphs will explore this in-depth.

Most of the one-time donated RETs in Gilutongan were left to the care of individual households or beneficiary (in the case of the school). Once they started to malfunction, they were left unused, especially for low-income families with discretionary funds to buy spare parts. Similarly, there were 12 Enkindle RETs unmonitored or unreplaced with the new components to function continuously. The basic knowledge and skills of the communities were only enough to operate the RETs while they were still in good condition. Likewise, the PISEP in Panga-an had a promising start with their centralised solar farm managed by the PICCD. The island was solely dependent on solar energy for 13 years until the conditions of the batteries, solar panel, and other hardware components started to fail. The orgware of each

project faced constraints that affected sustainment. RE stakeholders (both the project implementers and the community) failed to play the "rules of the games continuously" and their roles in managing and sustaining the RE projects.

On the other hand, the DOE's SHS programme in Pangan-an and the USC's rooftop solar PV in Gilutongan projects were recently launched last August 2019 and March 2020, respectively. From the gathered data during the fieldwork, all the RET hardware components were still working, and the community mechanisms to drive the RE project were still in place. There was a feeling of direct control on the energy consumption at the household level since the SHS and rooftop solar PV were installed inside their houses, and the beneficiaries could easily monitor their usage. At the community level, the orgwares of both the SHS program and USC solar rooftop were also in place to regularly monitor and manage the RETs. The SHS users in Pangan-an elected their RE management team per sitio, while the USC team used the phased approach[2] to build the technical and management capacity of the 11 selected beneficiaries. They can directly monitor their electricity consumption, monitoring and collection of monthly fees were more manageable since the households are located near to each other.

Similarly, informal institutions also played a crucial role in the sustainability of the community-based approach of the RE projects. Enkindle Alang-alang have active RET stewards with strong communal ties with the beneficiaries. The mutual trust and close personal relationship made managing the RETs easier. There was a feeling of assurance that each RE stakeholder was doing their role to take care of the system because of *hiya* (sense of shame)

[2] In technology-based and development projects, the phased approached is usually associated with initial stages or the initiation phase that focuses more on gathering first-hand information about the beneficiaries, their characteristics and cultural nuances (PM Alliance, 2010). This is followed by the planning phase where the technology and project management systems can be designed and rolled out, the execution which involves tracking, monitoring, facilitating and managing the technologies and finally, the closing which includes documentation, evaluation and reassignment of tasks and responsibilities (Thamhain, 2014; PM Alliance, 2010).

and *utang na loob* (debt of gratitude). These households were either related by blood, friendship or religious affiliation, and they lived close to each other.

The phased approach of the USC team proved to be efficient not only in establishing trust between the project team and the beneficiaries but knowing the more resonant societal characteristics of the island. The interviews with the project team revealed that the central part of the project was not the deployment of the physical components of the RETs alone but the preparation work before the actual deployment. The USC project implementers invested more time in the initiation phase of their rooftop solar PV project in Gilutongan before deploying the RETs on the island. This is crucial in building the community's capabilities to adopt the RETs and *adapt* to the possible changes that the deployment may bring to the island.

VI. Conclusion

The findings of this study have implications on how community-based RE projects are planned, designed, and implemented. First, the conceptualisation of a successful technological diffusion presented in this study challenges the current and future RE projects to (re)evaluate their definition of what a successful RET adoption means. Beyond just the deployment of the physical components of the RETs, a successful adoption needs a long and continuous relationship and engagement with the community. Secondly, distributed energy systems are more suitable in off-grid communities with relatively low-income households than large and centralised RETs. These households are mostly living on a day-to-day basis, and their ability to control their electricity consumption would be helpful in their allocation of everyday expenses. Beneficiaries of SHS also felt that they had more responsibility to monitor and take care of the solar PVs because the system was installed inside their houses, and they could see it every day. The main caveat of the effectiveness of distributed energy systems is that they should be accompanied by decentralised management or organisational structure located within the community. One of the advantages mentioned by the recipients of the SHS programme was

that they could easily approach the SHS management team whenever they had technical difficulties with their RETs. The collection of electricity payment and monitoring was observed to be easier in smaller groups than in an extensive centralised management system like the PISEP and PICCD.

Third, capacity development of the community-based projects should not be limited to the technical know-how on operating and maintaining the RETs; it should also involve load management, an improvement on energy consumption to induce savings or other practical concerns to maximise RE use (Quirapas & Taeihagh, 2021a). For bigger scale RE projects like the solar farm, capacity building should also be accessible to the RE management team and the rest of the community. The skills needed to manage these types of RETs include energy planning, forecasting and modelling of demand and consumption and business modelling for potential livelihood projects.

Finally, the multi-faceted nature of the structural and individual constraints in the community requires community-based RE projects to acknowledge that there are limitations to CDD as a development approach. It could not address all other community problems and how far communities can participate in the RET adoption process. Such a situation poses two critical challenges to RE project implementers and policymakers: (1) to have continuous, inclusive, and support mechanisms for the communities to participate in the RET adoption process (this moves beyond a "one-time big-time RE donation drives); and (2) to provide a holistic technological and socio-economic solution to the community (this emphasizes that electricity access is not the end goal but only a means for individuals to have a better quality of life and environmentally sustainable development) .

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