THINK GLOBAL ACT LOCAL: EXPLORING THE ROLE OF COMMUNITY RENEWABLE ENERGY IN NATIONAL ACHIEVEMENT OF AN INCLUSIVE, JUST ENERGY TRANSITION

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ABSTRACT

The global COVID-19 pandemic offers Southeast Asian countries the opportunity to reset and rethink development strategies and the potential to "build back better" – more resilient, more sustainable, and decarbonized. Agencies like the OECD and the IEA have championed "build back better" approaches for the energy sector, but the focus of these calls center on technology change and increasing deployment of renewable energy in the national electricity generation mix. For many developing countries in Southeast Asia the challenge of Renewable Energy (RE) deployment is complicated by other factors such as an urgent need to make progress on energy access goals (Sustainable Development Goal – SDG 7), the challenges of reliable generation and avoidance of blackouts, and keeping up with rapid energy demand growth. In this paper, we argue that renewable energy offers more than simply technological benefits to the energy sector; it also offers an opportunity for distributed energy resources (mini-grids, roof top solar) and community ownership and management of energy resources to advance national power development agendas. We draw on case studies from Cambodia and Vietnam to demonstrate that decentralized renewable energy options can provide rural communities with clean and affordable electricity that also offer a range of social, economic, environmental, technological and political benefits. As such, they play a crucial role in achieving national SDG targets towards universal electricity access. We argue that community renewable energy (CORE) offers governments the opportunity to reach reliable universal access faster, more equitably and with greater knock-on benefits to rural livelihoods, including strengthening community ownership of electricity services. Recognizing there are technology and governance issues challenging the sustainability of some CORE projects in the region, this study proposes a framework for investigating different dimensions of a project to identify areas for improvement.

1. INTRODUCTION

The global COVID-19 pandemic was a major disruption in the global energy sector. Lockdowns and economic disruptions saw global demand for energy in 2020 drop by 4.5% compared to the previous year (BP, 2021). These disruptions saw Renewable Energy (RE) increase its share of the global power generation mix from 10.3% to 11.7% (BP, 2021). In 2021 the global economy began the process of recovery. There is considerable optimism in the energy sector that the positive trends experienced during the height of the pandemic could precipitate a longer-lasting structural transition towards deeper decarbonization – a strategy of "building back better" with a technology shift towards RE and away from fossil fuels (United Nations, 2021). With a population of over 650 million, Southeast Asia (SEA) is a region experiencing some of the highest growth rates in electricity demand and a large dependency on fossil fuels to meet demand (ASEAN Centre for Energy, 2021). The "build-back-better" transition has also been eagerly promoted as an opportunity to increase SEA governmental commitments in their Nationally Determined Contributions (NDCs) and accelerate the deployment of RE in national power grids.

However, the build-back-better agenda is complicated by other pressing energy sector Sustainable Development Goals (SDGs). More than 43 million people in Southeast Asia and the Pacific do not have access to electricity and a further 111 million people experience unreliable electricity services with brownouts and blackouts causing major disruptions to people's quality of life and the economy. In 2018, more than 200 million people in SEA were without access to clean cooking relying on fuel wood that not only contributes to climate change but also causes health issues and loss of life within many SEA communities (ASEAN Centre for Energy, 2020).

In this paper we argue that new types of RE systems and innovation in governance and ownership of these systems offers SEA countries a better chance to balance the complex challenges of decarbonization and reliable energy access. The distributed, modular nature of RE technologies allows for electricity generation to be brought close to the site of consumption in smaller distributed networks, and this proximity to consumers opens up the possibility for greater community involvement in the ownership and management of electricity services. To "build back better" and reach this last mile, we need additional forms of energy ownership and distribution.

Community Renewable Energy (CORE) is a promising RE model where communities play an active role in decarbonization and decentralization of the energy sector, while also gaining other benefits from the projects. Examples in Australia, North America and Europe have showcased that CORE can benefit communities in a wide range of aspects, e.g., reducing greenhouse gas emission and air pollution, enhancing local ownership and decision making, generating community income, creating more local jobs, and supporting the RE industry (Hicks & Ison, 2018). Meanwhile, off-grid RE also has emerged as a cost-effective solution to provide electricity access for the hardest electrified areas in the world such as Sub-Saharan countries and other remote, mountainous areas and islands in developing countries. This synergy of community-led energy projects coupled with RE offers a unique opportunity to achieve both clean energy and universal electricity access at the same time.

This paper investigates existing CORE projects in Cambodia and Vietnam, two countries in Mainland SEA (also known as the Mekong region). We first discuss diverse forms of CORE that have been adopted globally, the motivation and benefits to communities and wider society. Then we review the electrification history and current policy of Vietnam and Cambodia on reaching the last mile. In the main section, short case studies are used to explore how communities get involved in and gain benefits from CORE projects and what elements make a project more or less successful. We argue that community ownership can leverage the distributed nature of RE to obtain better SDG outcomes for Mekong region communities and that governments should actively support community renewable energy.

2. UNDERSTANDING COMMUNITY RENEWABLE ENERGY

2.1 Multiple dimensions of community energy

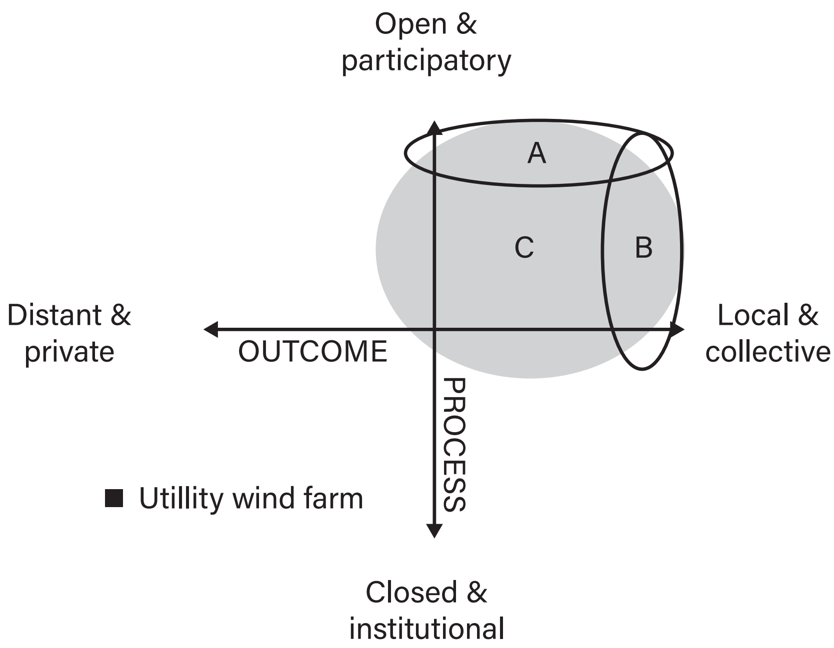
Community Energy (CE) generally refers to decentralized energy projects where communities own, lead and gain direct benefit from electricity services, either on the supply side (renewable energy generation and storage) or demand side (energy demand reduction, energy efficiency, community-based energy distribution). Whilst there is precedent for community involvement in electricity provision since the earliest days of electricity grids, the emergence of CE as a viable model for electricity services is closely linked to the rise of distributed RE[1] technology and the maturation of cooperative and social enterprise models emphasizing social and environmental benefits (Berka, 2017). These conditions for CE first emerged in developed nations and hence much of the global experience with CE is based in developed countries usually alongside the adoption of RE (see, for example, Bauwens et al., 2016; Gorroño-Albizu et al., 2019; Hicks & Ison, 2018; Seyfang et al., 2013; Walker & Devine-Wright, 2008). The number of CE projects globally has increased rapidly and today there are more than 4,000 CE projects mainly in Australia, Europe and North America (IRENA, 2020). There are varied definitions of 'Community Energy' due to the diverse array of legal, organizational and financial forms they take.

In an investigation of how project developers interpreted CE in the UK, Walker and Devine-Wright (2008) proposed conceptualizing CE by two dimensions: process (whom the project is developed by) and outcome (whom the project is developed for). This approach, although simplistic, is intuitive and useful to sense the "community" character of a project. In particular, the authors suggested a project can be labeled as community energy when it meets one of the following criteria:

- **Open & participatory:** Involves a high level of participation from the local community in different development stages of a project such as planning, design, installation, operation and maintenance (Figure 1 - Zone A); or
- **Local and collective:** project benefits are heavily centered on the local community regardless of their participation in the project (Figure 1 – Zone B); or
- **For and by communities:** the project shows both a certain level of community participation and community benefit. (Figure 1 – Zone C)

1. The distributed nature of renewable technology, such as solar PV and wind, allows for smaller electricity generation plants which align better with community managed systems and cooperatives.

Figure 1 Two dimensions of Community Energy



Source: Walker and Devine-Wright (2008)

The combination of dimensions for process and outcome significantly broadened the spectrum of community energy such that it is more problematic to draw a border between what is a legitimate community energy project and what is not. Practitioners involved in developing or advocating for CE have elaborated on these dimensions in an effort to provide clarity. For example, organizations like Community Energy England (CEE), Coalition for Community Energy (C4CE), and International Renewable Energy Agency (IRENA), take into account different forms of community participation such as the extent to which ownership and decision-making power rests within the community, how communities are involved in the development and design of the project (as sub-dimensions of process), and elaboration of the wide range of different kinds of social, environmental, economic and political benefit-streams that emerge from CE for communities (see Table 1). There are some differences in definition. For instance, CEE only focuses on the role of community in controlling or owning the project regardless of its outcome. C4CE and IRENA attempted to tighten the definition, setting stricter and clearer boundaries for community energy. IRENA's definition requires the community to make up the majority in ownership, controlling power and benefits from projects. In the two-dimensional axes pictured in Figure 1, CEE's definition is in line with zone A, C4CE's definition corresponds with zone C, while IRENA's definition is a combination of zone A and B.

Table 1 Community Energy defined by CEE, C4CE and IRENA

	Community Energy England (CEE)	Coalition for Community Energy (C4CE, Australia)	IRENA – International Renewable Energy Agency
Definition	CE refers to the delivery of community-led renewable energy, energy demand reduction and energy supply projects, whether wholly owned and/or controlled by communities or through partnership with commercial or public sector partners.	CE is the term used to describe the wide range of ways that communities can develop, deliver and benefit from sustainable energy. A CE project is founded on more than one of the following elements: • Ownership and/ or decision-making power involves local **individuals and stakeholders** • Project development and design is driven by locals • Benefits from the project go to locals	CE is the economic and operational participation and/or ownership by citizens or members of a defined community in a renewable energy project. CE is any combination of at least two of the following elements • Local stakeholders own the majority or all of a renewable energy project • Voting control rests with a community-based organization. • The majority of social and economic benefits are distributed locally.

Sources: CCE (2021); C4CE (2021); IRENA Coalition for Action (2018)

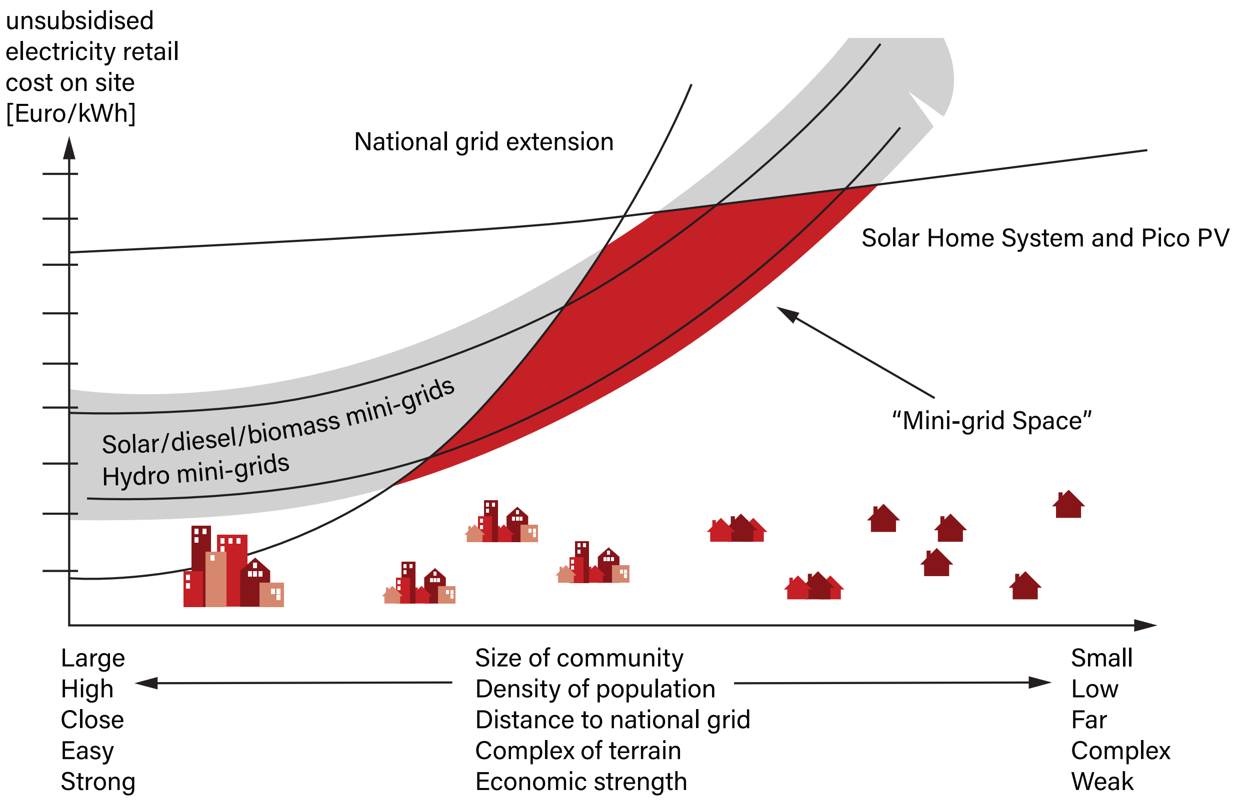
Although community usually means people who live geographically proximal to each other, there are also communities-of-interest, e.g., C4CE is a community of interest whose members are from across Australia and they have a shared interest in decarbonization and decentralization of the energy sector.

Examples in Australia, Europe and North America demonstrate that community energy projects can involve not only individuals but also a range of local/non-local stakeholders (Hicks & Ison, 2018). There can be different combinations of actors, ranging from "only local individuals" (usually associated with the highest level of community based on locality) to "only non-local organization, business and government" (usually associated with highest level of community by interest). In between, there are different forms of project co-development by local, individual actors and non-local, organizational actors.

2.2 Community Energy in Developing countries

In developing countries, where energy access is typically not universal, CE is usually discussed within the context of decentralized models for universal electricity access as a cheaper alternative to grid extension (see Figure 2). Community-based mini-grids have shown success in expanding electricity access to remote, low-density populations in mountainous areas or islands where the techno-economic feasibility of grid expansion is questionable (RECP, 2014). Historically this model was based on diesel generators, while in some agrarian communities, bio-gasification (of rice or coconut husks, for example) were also deployed. Water resource-abundant communities, such as in Southeast Asia, also deployed micro hydropower as a source of generation for mini-grids. Although mini-grids showed significant promise, they were hindered by operating costs (in the case of diesel), technical complexity, and environmental concerns (water and air pollution).

Figure 2 Cost of off-grid energy system relative to community size. Source: RECP (2014)



The rapid global deployment of utility scale non-hydro renewables (primarily solar PV and wind) has seen their technology cost drop significantly over the last decade which, combined with the modular nature of the technology, has reinvigorated interest in mini-grids powered by RE. RE mini-grids are widely seen as a viable, faster pathway to achieve universal electricity access for off-grid communities without the high technical and economic operating costs, or the environmental concerns of diesel mini-grids (see, for example, Murenzi & Ustun, 2015; Come Zebra et al., 2021). Consequently, mini-grids feature with increasing prominence in national development strategies for developing countries still striving for universal electricity access. In 2017, the International Energy Agency (IEA) estimated that 48% of the additional generation needed to achieve universal electricity access by 2030 would be provided by mini-grids (Eales et al., 2019). At the same time, the simplicity of the technology, modest capital investment, and low operational costs, has stimulated strong private sector interest in mini-grids (Bellanca & Wilson, 2012). However, the private sector model also suffers from a number of barriers including regulatory issues, low demand levels, and high payment default rates (Peters et al., 2019).

There is a growing appreciation that energy access may unlock a wider suite of social and livelihood benefits for remote, rural communities, or as noted by the UN Secretary General in 2018: "Energy is the golden thread that connects economic growth, social equity and environmental sustainability" (Eales et al., 2019). The success of community energy models in developed countries where communities are actively involved in decision making, ownership and management of mini grids has also heightened interest in the role that CE could play in threading together SDG priorities for social, economic and environmental benefits at the community level.

Apart from mini-grids, CE projects can be based on other forms such as electricity charging and solar home systems (SHS), as found in this study. Solar home systems are operated and managed at the household rather than community level, yet they can be considered to be CE when closely related households collectively benefit from a project.

2.3 A working definition and framework for community renewable energy

In this study we use the term Community Renewable Energy (CORE) as a development strategy to achieve universal, reliable and affordable energy access in the Mekong region. The role of RE and CORE models in expanding electricity access is rarely discussed in developed country contexts as these countries have already mostly achieved universal electricity access, but it is a driving motivation in developing countries where large numbers of people do not yet have reliable electricity access. In Southeast Asia and the Pacific, at least 43 million people remain without electricity and a further 111 million experience weak-grid conditions with regular and persistent outages (IFC, 2020).

We define CORE based on the process and outcome dimensions outlined by Walker and Devine-Wright (2008; see figure 1) with further modification.

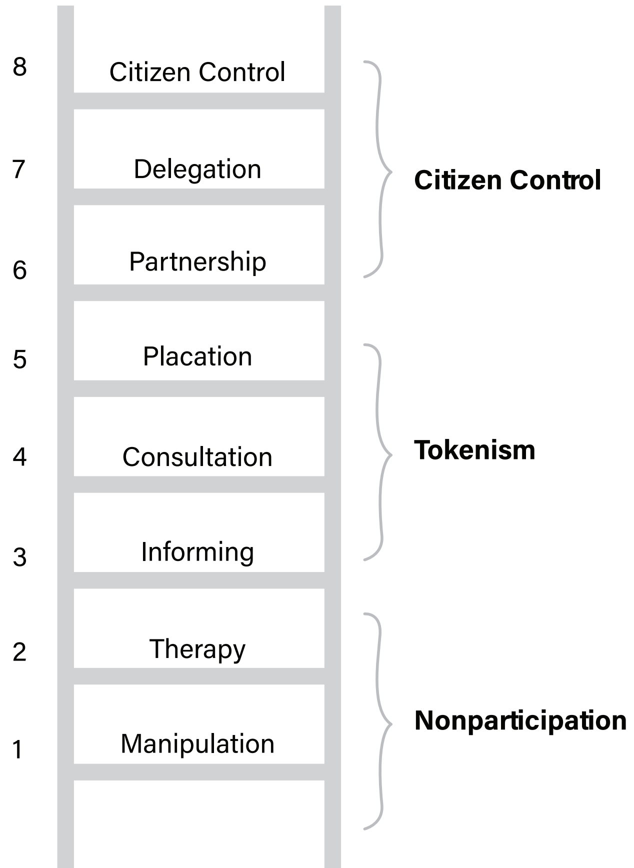
First, we unpack the “process” dimension into a number of overlapping sub-processes:

- **Techno-engineering process:** includes the exploitation of engineering knowledge to design, build, operate and maintain the technology and infrastructure of a CORE project.
- **Financial process:** includes the exploitation of financial resources to invest in the infrastructure of CORE projects, the payments for electricity services and the utilization of project profits.
- **Governance processes:** includes the motivation behind starting a CORE initiative, and decisions about who develops and owns the project, the roles of different stakeholders and how benefits are to be distributed among different stakeholders. This is a critical process for CORE and is based fundamentally on how different stakeholders deliberate and make decisions, what kinds of technical and financial capacity stakeholders can offer, and the business and institutional modalities acceptable in the national legal and regulatory context.

These process dimensions will guide the exploration of the CORE systems in the case studies and help identify what specific sub-processes are present in CORE projects in the Mekong context.

We also integrate Arnstein’s (1969) Ladder of Citizen Participation as increments to the process dimensions outlined by Walker and Devine-Wright (2008). There are eight gradations of participation that Arnstein introduces (see Figure 3) of which the lowest two (manipulation and therapy) are considered as “non-participation” and thus excluded from "open and participatory" space. The remaining six levels of participation are placation, informing, consultation, partnership, delegated power, and citizen control.

Figure 3 Ladder of participation. Source: Arnstein (1969)



Second, the x-axis in Figure 1 currently characterizes outcome dimensions as either "distant and private" on one end of the spectrum, or "local and collective" on the other. However, we recognize that this pairing does not always align and it may be possible for outcomes of CORE projects to be "local and private" and/or "distant and collective".

In this paper, we do not consider projects where benefits concentrate in the private sector only (locally or at a distance) as CORE, while the combination of "local and collective" is in alignment with CORE of a geographical community and "distant and collective" is a CORE involving a community of interest. The case studies we explore show that there can be a mix of private and collective benefits in a project. As such, we further disaggregate "local and collective" into "local and private-collective mix" where there is a fair share between those two groups of actors, and "local and collective" where most of the benefits are concentrated in the local community. In summary, it is a CORE project when the benefits are:

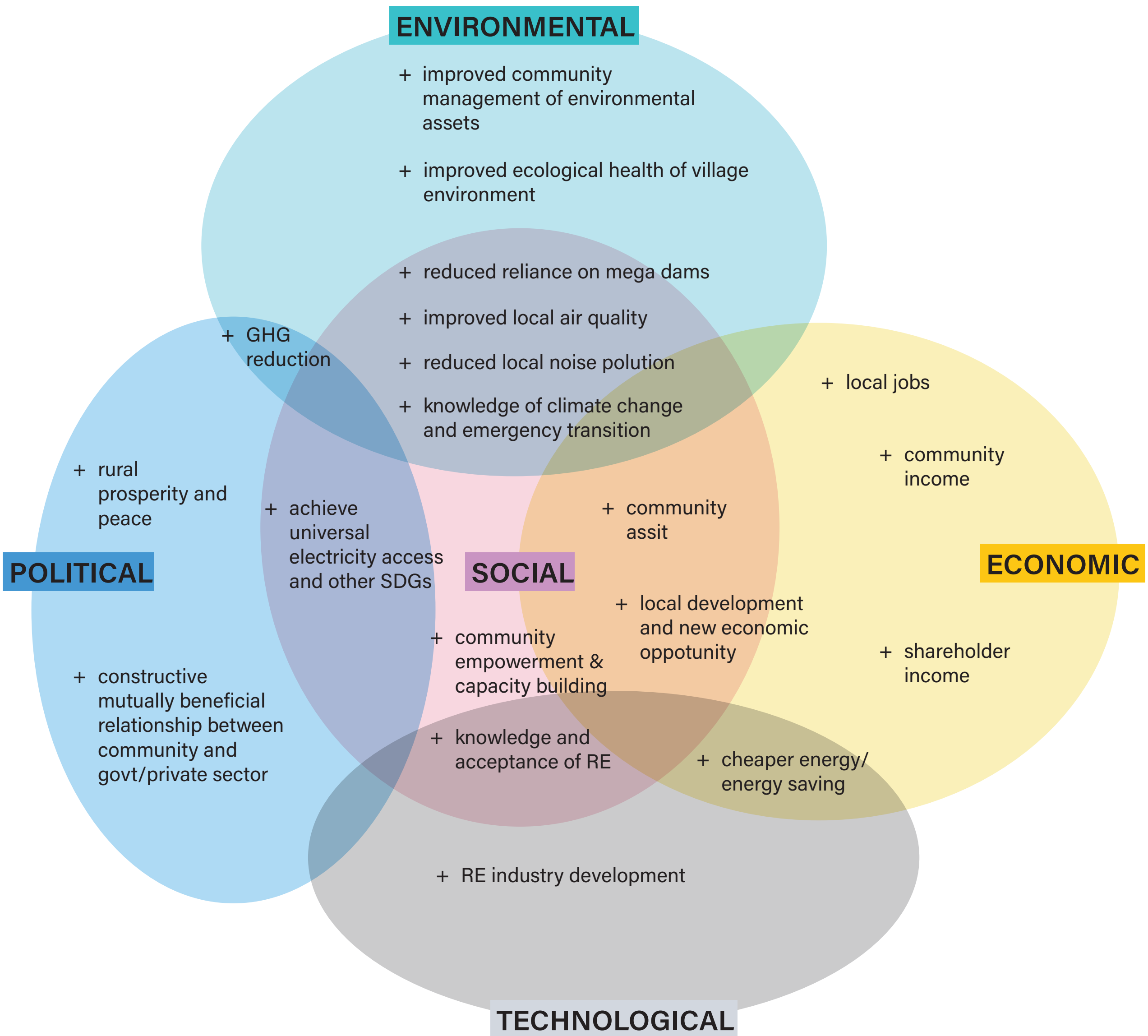
1. Distant + collective

2. Local + private and collective mix

3. Local + collective

Furthermore, the specific benefits that communities gain from CORE projects are explored using the STEEP framework (Social, Technological, Environmental, Economic and Political aspects), developed by Hicks and Ison (2018). We adjusted the framework to represent the benefit streams that CORE projects could provide to Mekong communities (see Figure 4).

Figure 4 Social, Technological, Environmental, Economic and Political Benefits of Community Energy. Adapted from Hicks and Ison (2018).



3. DATA COLLECTION

This paper draws on four case studies from Cambodia and Vietnam to explore the relative importance of different 'process' and 'outcome' elements identified in our working definition of CORE described above. We use these case studies to draw conclusions about how CORE initiatives should be developed and what kind of a contribution CORE could offer Mekong government SDG7 agendas.

The case studies were selected from a wider review of community energy in the Mekong region through the project "Establishing a Community Renewable Energy Association for the Greater Mekong." The project was commissioned by Oxfam and implemented by AMPERES (The Australia – Mekong Partnership for Environmental Resources and Energy Systems) between January and October 2021. It aimed to investigate the successes and barriers of various CORE projects in three Mekong countries (Vietnam, Cambodia and Myanmar) in order to understand the need for and design a regional CORE association that has functions of information sharing and knowledge creation, coordination and collaboration, capacity building, innovation promotion and policy advocacy for CORE in the three countries.

The case studies are based on semi-structured interviews conducted with a range of stakeholders (local government, project implementation organization, project management group, and communities). Information was collected on each of the projects, including the origin initiatives, roles of communities, management structure, performance, success, barriers and other saline features of the project. Due to the surge of covid-19 cases in the three countries in mid-2021 and the political situation in Myanmar, not all identified cases were examined. Interviews were also conducted virtually via zoom and phone calls instead of face-to-face interviews and fieldtrips as previously planned.

4. ACCESS TO ELECTRICITY AND RENEWABLE ENERGY ADOPTION IN CAMBODIA AND VIETNAM

4.1 Vietnam

Vietnam has gained remarkable success in rural electrification compared to other countries in the Mekong region. In 2021, urban and rural electrification reached 100% and 99.26% respectively (Anh & Bùi Hùng, 2021). However, 153,911 households in remote mountainous areas or islands of the country still have no access to electricity, while an additional 717,352 households receive unreliable and unstable electricity (Anh & Bùi Hùng, 2021).

During the first 15 years after re-unification, progress on electricity access was slow, increasing from 2.5% of households in 1976 to 14% in 1993. Rates of access accelerated as Vietnam's economy liberalized, achieving more than 60% access by 1996 and 87% by the time the National Electricity Law was passed in 2004 (World Bank, 2011). Local involvement was crucial to progress on energy access during this period. Before 2004, Commune Electricity Groups (CEGs), District Energy Groups (DEGs) and local cooperatives provided the majority (50-70%) of rural electricity supply. Both cooperatives and energy groups were tightly organized and controlled by government but their organization at commune-level resulted in many features consistent with the CE definition: they relied on small-scale generation exploiting energy resources located close to community loads (micro- and pico-hydropower was particularly important), and there was open channels for discussion and influence between local community and local government in terms of management of energy systems.

The formation of Electricity Vietnam (EVN) in 1995 and the passing of the Electricity Law in 2004 ultimately saw local involvement diminish, ceding governance to the state-owned monopoly. CEGs and DEGs were phased out entirely by 2006, although cooperatives retained a 10-15% share until 2009. During the rise of EVN, the management and operation of rural electricity distribution centered on local stakeholders, including commune electricity groups – CEGs (appointed by the communes), cooperatives and customers. End-users could pay part of the cost of grid connection to their households. In total, during the electricity takeoff between 1993 and 1998, customers' investments made up 48% of the total funding in medium and low voltage networks in the nation. This cost-sharing strategy among a range of stakeholders from national to local levels successfully mobilized available resources for the electrification target, creating a diverse ownership of energy systems.

There were some critical drawbacks, however, as it still left behind poorer households who could not afford to pay for grid connection by themselves. In addition, the technology was not standardized; the electricity supply in many places remained poor and unreliable and later caused problems of interconnection as the infrastructure for a unified central grid continued to develop.

During the early 2000s, the Government of Vietnam initiated wide-reaching regulatory reforms focused on the expansion of EVN and its power companies and the shrinkage of local ownership. In 1998, the government adopted a ceiling price for rural electricity so that it would be more affordable to all citizens. By 2004, the majority of rural communes were still managed by CEGs. However, as this entity was not given a clear legal status, they were gradually converted into joint stock cooperatives and companies. EVN also started to develop low-voltage distribution networks at the local level and bought up the medium-voltage networks previously developed by other entities. As of 2009, the power companies supplied electricity to three quarters of rural households in the country. Together with all these changes in institutional arrangements towards a more centralized direction, the power system was also rehabilitated, better synchronized, and became more reliable.

Reaching the last mile of electrification is a more challenging task compared with the earlier stages because unelectrified communities are those living in the most unfavorable locations. In 2013, the Prime Minister issued Decision 2081/QD-TTg on the Approval of Electricity Supply Program for Rural, Mountainous Areas and Islands for the Period of 2013-2020, which was then revised with Decision 1740/QĐ-TTg for the period 2016-2020. The program under Decision 1740/QĐ-TTg aimed to extend the national grid to 1,055,000 households and supply electricity to 21,000 households using off-grid RE systems, so as to achieve universal electricity access by 2020. However, the program did not fully succeed due to a big shortage (81.5%) in budget mobilization (Anh & Bùi Hùng, 2021). As a result, only 204,737 additional households gained access to electricity by end of 2020, of which 204,120 households were connected to the grid and 617 households had off-grid solar PV systems. For mountainous areas like Cao Bang, off-grid solar PV systems proved to be advantageous – approximately 330 million VND (USD 14,350) was saved per household installing off-grid solar PV instead of extending the grid (MOIT, 2021a).

For the period 2021-2025, a new program aims to electrify the remaining 0.74% of rural households and improve electricity reliability for another 717,352 households (MOIT, 2021a). These households are scattered in 6,811 villages and 2,197 communes. In areas with high RE potential, mobilizing citizen investment will be prioritized. In other areas, funding will come from the central budget, EVN or other sources (MOIT, 2021a).

Vietnam's universal electrification target is also discussed in chapter 12 of the draft[2] proposal for National Power Development Plan for the period of 2021 - 2030, vision 2045 (referred to as PDP VIII; MOIT, 2021b). According to the draft, for areas that are not cost and technology effective to extend the grid, off-grid solutions based on small/micro hydropower, solar PV, wind turbine coupled with battery storage and diesel power will be considered. Electricity supply in a lot of islands has been generated from diesel-based technology at a subsidized cost of 50 UScent/kWh. In the draft, it is estimated that the shift from relying on diesel only to a combination of diesel, RE and battery storage or a combination of RE and battery storage will significantly reduce the generation cost to 38.6 UScent/kWh. While these costs are high by global standards they do point to a significant potential for RE plus storage solutions in the future.

Solar PV has been the preferable technology base for electrifying the last mile in Vietnam. More generally, the distributed nature of solar PV also offers opportunities for grid-connected consumers to own, generate and export electricity on the grid via distributed rooftop solar (RTS). By end of 2020, Vietnam reached 19,400 MWp or 16,500 MW of installed solar, of which 9,300 MWp comes from rooftop solar connected to the national grid (EVN, 2021). Reflecting on the period 1993-1998 when consumers were the actors who made the biggest contribution to rural electricity distribution, Rooftop Solar PV also saw the emergence of new actors and consumers generating electricity themselves to sell surplus to the grid.

4.2 Cambodia

Cambodia's progress on electricity access has been slower than Vietnam's but accelerated during the last decade. Grid expansion was, and continues to be, the Cambodian government's electrification strategy for connecting the last mile population. Initially the Government set a target to achieve universal access (100% of villages) by 2020 (MIME, 2009), but slow progress has seen the government delay the target until 2023 (Chan, 2021), predominately due to the challenge of providing access and reliability to remote, rural populations. A number of hard-to-reach communities in mountainous areas inhabited by ethnic Lao and indigenous Tampuan and Brao communities continue to be left without electricity access. Furthermore, structural issues of performance and affordability persist with Cambodia's grid services: 69.3% of grid-connected households face frequent unpredictable power shortages (World Bank, 2018). These challenges disproportionately affect poor households. Another major issue is the generation mix for both grid and off-grid systems. The national grid is heavily dependent on fossil fuels (45.23%) and controversial large-scale hydropower sources (45.60%); both of these technologies have significant social and environmental impacts.

2. Referred to in this paper is the third draft released in Feb 2021.

Out of the total 3,099,990 households connected to the grid, less than half (1,213,386 households) are supplied by the state-owned company, Electricite Du Cambodge (EDC), and the remaining are jointly covered by Rural Electricity Enterprises (REEs). REEs have played a crucial role in electrifying rural areas. They have received financial assistance in the form of subsidies and grants provided by EDC through the Rural Electrification Fund (REF) in order to extend and/or develop new electricity supply infrastructures in rural areas. However, they are facing a number of challenges. As they depend on transmitting electricity through Medium and Low Voltage (MV & LV) transmission lines, they have to bear system losses of around 23%, whereas EDC's losses are only about 8% as it uses High Voltage (HV) lines. REEs also need to purchase electricity from EDC at a high price of USD 135 per megawatt hour (MWh). The remaining off-grid areas are uneconomical for REEs to connect due to their difficult geographical location including mountainous areas and islands where population densities are low (UNDP, 2019). Therefore, in off-grid areas, many communities and especially those located near Cambodia's borders utilize diesel power generation for electricity (33 villages or 0.23% of total villages) and a larger number (372 villages or 2.63%) depend on imported electricity (EAC, 2020).[3]

Recently the Cambodia government has recognized the potential of (non-hydro) renewable energy. Large-scale solar farms have gradually increased to 150 MW in 2020 in response to a government pilot auction scheme. By 2022 the deployment of non-hydro renewables is expected to reach 340 MW for both wind and solar. Electricity generated by the newest solar projects such as in Khampong Chhnang province is sold to EDC at the price of USD 3.877 cent/Kwh (ADB, 2019). This is less than half the cost of electricity produced by coal power projects being built in the country (USD 7.3 cent/kWh; see Inclusive Development International, 2021). Meanwhile, in 2020, the state's off-grid subsidy for solar home system covered 9,834 families or 45,236 people through EDC's Department of Rural Electrification Fund (EDC, 2020). This number will continue to grow, however, targeted villagers are treated as a traditional electricity buyers and aid recipients. The intention to encourage participation from local communities is not visible in the government's recent electrification strategy, which focuses almost exclusively on centralized grid approaches.

For the time being, meaningful participation from the relevant government institutions to promote a community model remains unclear, as the government is still skeptical about the reliability and affordability of distributed renewable energy. Even the development of large-scale solar PV is not included in the Power Development Master Plan, and continues to be examined by the Ministry of Mines and Energy and EDC for its suitability in connecting to the national grid (EAC, 2018). Off-grid community renewable energy is

3. Based on government available data. There are possibly other hard-to-reach households who are not documented.

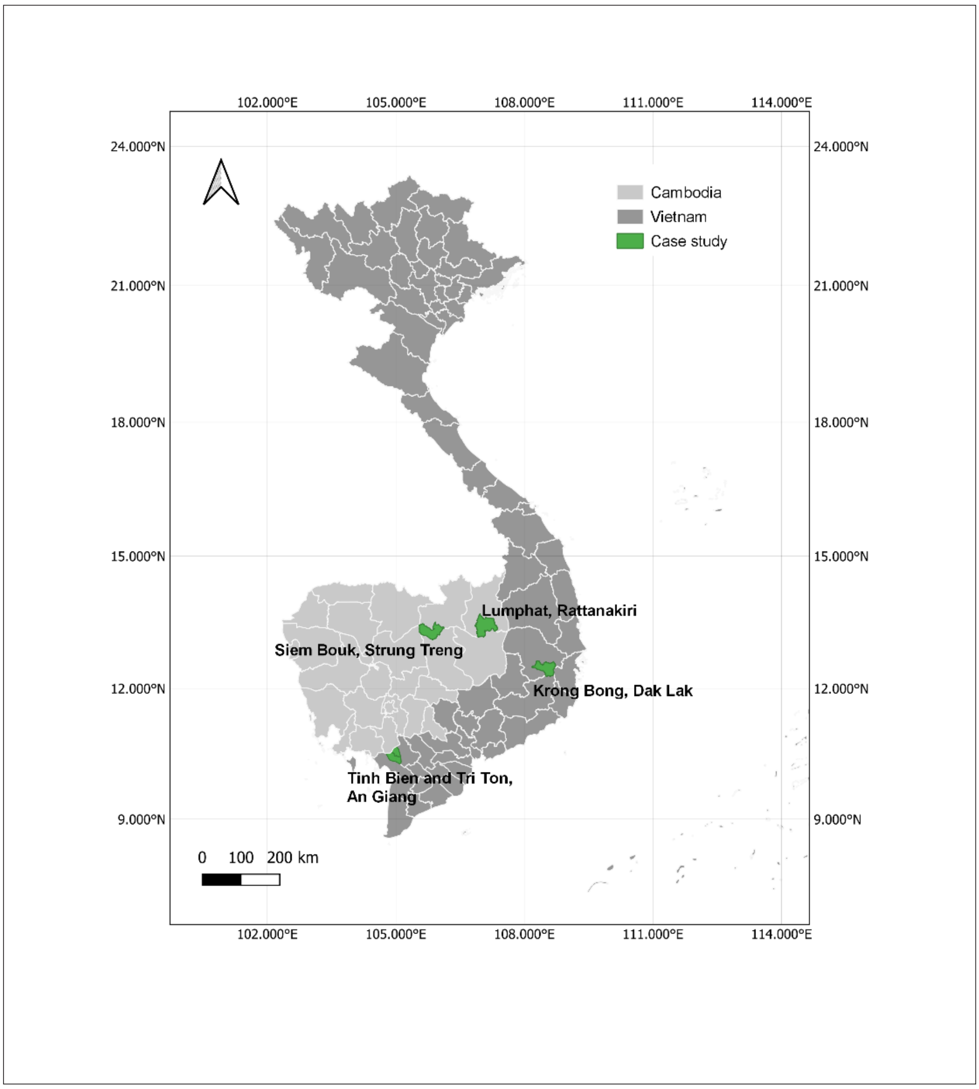
receiving less attention, given its lack of legal recognition and provisions for long-term operation. Critically, when a national utility such as EDC is the dominant power shaping the country's energy development, there is little room for fair competition from a wider investor community including off-grid decentralized community energy distribution systems. As a result, the speed and direction of national grid expansion among other things continues to be unpredictable without an effective check-and-balance mechanism. While this approach marginalizes community approaches, it also provides risks for private sector investors who could potentially be contributing more to accelerate RE deployment at all scales.

The delays and slow progress by the government in rural electrification has resulted in other actors taking a proactive role in this area. Notably, civil society organizations (CSOs) and donor agencies have looked to the technological advantages of RE to accelerate distributed energy systems in rural Cambodia. Because these actors have a strong bias towards poverty alleviation, rural empowerment and livelihood improvement, these efforts have shown a strong interest in distributed CORE models that involve local stakeholders in project ownership, management and operations. Such initiatives were implemented with heavy dependence on donor funding, although they have yielded some very useful community renewable energy models that could potentially be expanded.

5. CASE STUDIES: COMMUNITY RENEWABLE ENERGY PROJECTS IN CAMBODIA AND VIETNAM

Four case study CORE projects are reviewed in this paper. The two projects in Cambodia were facilitated by Democracy Resource Centre for National Development (DND) and Cambodian Rural Development Team (CRDT); while the two in Vietnam were supported by Green Innovation and Development Centre (GreenID). Figure 6 shows the location of the case studies.

Figure 5 Location of case studies



5.1 Veal Kambor community solar-powered battery charging station (Cambodia)

The Veal Kambor community battery charging station is located within a Community Protected Area (CPA) of the Lumphat Wildlife Sanctuary in Rattanakiri province. The CPA was established to strengthen local communities' rights and access to forests and other natural resources. In exchange, communities take an active, leading role in patrolling the protected area and protecting it from illegal logging, poaching and land grabbing (WWF, 2018). In the three villages of Phum Thmey, Srae Chhouk and Dei Lo village, 80% of the population is ethnic Lao and the rest are Tampuan, Brao and Kraol. Community livelihoods are dependent on collecting non-timber forest products (NTFPs), rotational cultivation and wage labor in agro-industry factories in the area (mostly young people).

Figure 6 Veal Kambor Solar-power battery charging station (Photo by local CORE operator, May, 2021)

As population density is low and scattered, Rural Electricity Enterprises (REEs) have shown no interest in expanding their business to the area, leaving local households reliant on car batteries for lighting, phone charging, television and other household uses. Historically the batteries were centrally charged by a diesel generator, which required people to take batteries to a charging station regularly. In 2016, a non-governmental organization (NGO), the Democracy Research Centre for National Development (DND), began working with the local community through their elected representatives to co-design a solar battery charging station to replace the diesel generator. The CORE system serves approximately 536 families or over 2,000 people with its capacity to charge 30 to 40 batteries. Community representatives played a significant role consulting local villagers during the establishment phase with DND funding. In 2017 the grant funds ceased and the project continued under the direct operation and management control of CPA representatives.

Initially, grant financing from the NGO was instrumental in covering capital costs for the system. Community representatives also contributed in-kind support through the provision of land and labor. A community representative who allowed the solar system to be installed and operated on his land and who had experience communicating with several organizations including DND, has since been appointed (by the other community representatives and endorsed by DND and the involved local authorities) as the local community renewable energy operator. Four to five individuals who expressed interest in supporting the renewable system were tasked to form a committee to govern the solar battery charging station and work hand-in-hand with the operator.

The solar battery charging station has provided local villagers with a cheaper alternative for charging batteries and reduced villagers' travel time, as the diesel charging station was located farther away in town. It is quite meaningful for the community to be able to charge their batteries locally, and to have a system that is managed by their local representative whom they can easily coordinate and communicate with compared to outside businessmen. Villagers are also impressed by the solar charging system, which takes better care of their batteries compared to the diesel generator because it has a controller that stabilizes the electricity current during the charging process. Community members are also pleased that the solar system does not cause air and noise pollution like the diesel generator, although not everyone is fully aware of that. The money paid to the solar charging station partly contributes to the forest protection effort as well.

Despite these benefits, there has been a recent decline in the usage of the solar charging station as a number of diesel-based generators for charging batteries have been introduced to the community.[4] The diesel generators offer a much quicker battery charging service than the community solar charging station and it is now made available in the community where the villagers do not have to travel far away to charge like in the old days. These time savings are valuable to the community and even though the cost of diesel charging is higher, it has become increasingly popular and preferred by community members. The declining demand for the community solar charging service is straining the service model, reducing revenues and the involvement of the committee, such that the system operation is often managed by the local owner/operator. This circumstance is causing concern for the village chief, commune council and ordinary villagers about the transparency and accountability of how project income is being managed.

4. Since mid-2021, the local operator of the CORE reported that two diesel-based generators have started running their bus iness in the community where the solar battery charging station is located.

5.2. Koh Sampeay community's mini-hydropower dam (Cambodia)

This CORE project operates in Stung Treng province where most of the villagers are ethnic Lao. Their livelihood depends largely on fisheries from the Mekong River while also generating additional income from eco-tourism. Before the CORE project, local villagers were still using kerosene and car batteries charged by a diesel generator for lighting, which contradicted the philosophy behind the eco-tourism business.

Figure 7 An ethnic Lao woman's TV is electrified by the mini-hydro in Stung Treng province, Cambodia (CRDT, 2010)

In 2001, a local entrepreneur (who later became the dam operator/manager) developed a mini-hydropower dam using his own financial and technical resources. He learned the skill from the neighboring community in O' Porng Morn Loe[5]. The micro-hydropower station was installed on the local river O' Porng Morn Kraom with a power generating capacity of 12kW. Initially it ran as a local private enterprise and provided electricity for approximately 70 households. The enterprise had license to operate the system, however, the process of licensing was complicated and expensive and the operator involved another partner who understood the process but who exploited the profits from the system.

In response to growing community demand for electricity, and the governance and technological challenges in increasing the dam's capacity within the enterprise partnership, the owner sought financial and technical support from a local NGO, the Cambodian Rural Development Team (CRDT), to expand the system to 40 kilowatt and improve the management of the system. With CRDT support the hydropower plant was then turned over to community operations and management based on an agreement between the owner, local community representatives and CRDT.

5. He learned it from a solider family in O' Pong Morn community who received funds from King Norodom Sihanouk in the 1990s to install micro-hydropower to generate electricity for domestic consumption. The solider family could also share surplus of generated electricity from the mini-hydro to the other villagers.

The agreement covered details about how the system would be managed as well as establishing a ceiling tariff to ensure that electricity would be affordable to all interested community members, as well as identifying productive uses for which the electricity would be provided free of charge for collective community benefit (i.e. the eco-tourism project and a clean water supply system[6]). CRDT provided capacity building and training related to managing the system (under the community-based organization or CORE model) to the owner of the hydropower in order for him to co-manage the mini-hydro together with other community representatives, although the local operator had to rely on himself alone in dealing with the technological aspects of the expansion of the hydropower as CRDT did not have that expertise.

However, collaboration between the owner and community representatives began to erode as there were different interests in making use of the generated electricity. Some representatives wanted more of the electricity for the clean water pumping project, others wanted more for the eco-tourist project, whereas the owner wanted to preserve more for selling to villagers and increase income. The management structure did not include an adequate mechanism to resolve these conflicts of interest, nor was the agreement sufficiently clear to build consensus at the outset. The capacity upgrade of the micro-hydropower dam was completed but did not function adequately, which provoked criticism among the community regarding the efficiency of the system. Some groups in the community joined together to request the provincial government to help give them access to the central electricity grid system, which they believed was more reliable (they got connected a couple years later by the Rural Electricity Service Company under EDC funding). In the meantime, efforts to train community representatives in joint operational management were not successful and the dam owner remained fully responsible for operating the project, even as the revenue from the project diminished in response to community preference in free energy for water and the ecotourism business.

After the end of CRDT's support in 2012, and after a decade of the plant in operation, the system was converted back into its original form as a private business and continued operating for a couple more years as a local electricity supplier until the national grid arrived. The entire community has then turned to use the grid system instead, and the mini-hydro is now used to generate electricity for the dam owner's ice-making business. Although there is some criticism about the efficiency of the dam's generation and the capacity to meet community needs, there is also continued interest from the community (especially the representatives who used to be in the dam management committee) in hydroelectricity, which offers a cheaper form of electricity than the national grid. The owner of the dam and the former dam committee members (some of them became local authorities) are still

6. A twin project carried out by CRDT in line with the community's mini-hydropower project.

discussing how to re-utilize the dam's potential to continue serving the local community's critical social and economic pillar, most importantly, ecotourism and clean water supply. Both of these were once electrified free-of-charge by the dam but now depend heavily on the costly electricity from the grid system.

5.3. Community managed water-energy system (Vietnam)

The CORE project[7] is located in Dak Lak in the central highlands of Vietnam. Dak Lak is a mountainous province with generally lower levels of economic development, higher rates of livelihood insecurity and high proportion of ethnic minorities. The CORE project is located in Earot village, a H'Mong ethnic village of 168 households who are mostly involved in subsistence agriculture. Before the CORE system was introduced, the community did not have access to reliable electricity. Some households utilized lead acid batteries but charging them required a 20km trip to town, and there were seasonal and pollution issues with the spring water supply.

Figure 8 Community managed water-energy system for H'Mong ethnic group, Dak Lak, Vietnam

A Vietnamese civil society organization (CSO), GreenID, received funding from the McKnight Foundation to pilot community-managed electricity and water access in EaRot. The system was designed through a consultation process with the community and facilitated by GreenID. A solar engineering company was commissioned for the technical design and construction. The solar power generation contains twelve solar panels (installed on an area of 30 square meters) with design capacity of 6.24kWp and capable of producing 20kWh per day. The solar system is integrated with a reverse osmosis (RO) water purification system including three water pumps, three stainless steel water containers (one container of 2,000 liters and two containers of 1,000 liters), and a battery energy storage system (BESS). The CORE project cost 400,000,000 VNĐ (USD 17,600), which was financed by the McKnight Foundation, whilst the local community contributed land and labor, including building the roofing structure to house the project. Local commune-level government was actively involved, especially in seeking consent from local villagers to participate in the project.

7. This summary also benefits from a separate paper: Khanh, N.Q., Hai, H.H. (in press) Enabling universal electricity-water access to remote villages: a decentralised renewable energy-water approach

The energy-water system supplies electricity to 23 households and one church in the village. During the daytime, electricity from the solar panel system is used to power the water purification system with a capacity of 600 liters/hour, and to charge the four batteries. The batteries are then used to supply electricity to the 23 connected households, predominately for household lighting. Purified water is bottled in 20-liter jars and sold to all households in the village. Based on consultation with villagers and commune officials, electricity tariffs were set at 2,000 VNĐ/kWh (USD 0.088/kWh) and water fees at 7,000 VNĐ (USD 0.310) per 20L water jar. The revenue is used to support the management group and maintenance of the system.

5.4. An Giang solar home system (SHS) (Vietnam)

Despite Vietnam's rapid progress in rural electrification, several hundred thousand households remain without access to electricity. In the Mekong delta these households are typically poor, ethnic minority farmers living close to the grid services but at such low densities that grid connections have not been viable. GreenID received funding of 2,500,000,000 VNĐ (US$ 109,700) from Bread of the World and WWF Vietnam to establish a community-led solution for basic household electricity access in ethnic Khmer households of An Giang province. Starting in 2016, the project is implemented in two phases and is expected to support 1,000 households from seven communes by 2022.

Figure 9 A local household in An Giang receiving the solar home system

A community mini-grid was deemed impractical because of the dispersed nature of the target households. Instead, GreenID developed a household system that included as a set a 220kWp PV array, 12V-200Ah rechargeable battery, rack system, switches and light bulbs. For households who wanted capacity for electric rice cookers, kettles, refrigerators and other appliances, an additional set would be required. The cost of each set was 4,200,000 VNĐ (USD 184) in phase 1, of which GreenID supported 35% and households paid 65%. GreenID also provided training to households for the safe use and maintenance of the systems.

During the second phase of the project the capacity of the PV panels was increased to 300-360 watts, and households could also register for installation at a higher capacity, if their demand increases. Although the solar capacity of each household set increased, the cost decreased to 3,500,000 VNĐ (USD 154) reflecting the dramatic drop in technology costs between phases. GreenID continued to subsidize the system by providing 50% of the total, while households matched the rest.

The local Women's Union played an important role in the project, particularly in the early phase to explain the system and encourage local people to participate. A technical group of community members was established and trained by GreenID to undertake trouble-shooting and maintenance of Solar Home Systems (SHS) in the community. As the project grew, other households became aware of the initiative and came to observe the systems and speak to household owners. This sharing of experience by word-of-mouth played an instrumental role in allowing the initiative to scale up. As a result, 100% of households in the communes registered for installation. Before the CORE intervention by GreenID, most of the households did not have access to electricity, only more affluent households could afford a much more expensive solar technology with lower capacity (approximately 110 watts) backed-up by a diesel generator.

6. DISCUSSION

The community renewable energy (CORE) models in this paper are centered on rural off-grid communities whose livelihoods were challenged by the absence and/or high cost of electricity access. The four CORE cases from Cambodia and Vietnam demonstrate a diversity of technology, finance and governance processes. They also show that through genuine support and facilitation from local CSOs to implement off-grid CORE systems, many livelihood barriers facing rural communities could be addressed. The processes and outcomes of the four case studies are summarized in table 2.

Table 2 Summary of case studies

	Community solar powered battery charging station	Community micro-hydropower	Community energy and water services	Household solar systems
Location	Phum Thmey village, Chey Otdom commune, Lumphat district, Rattanakiri province, Cambodia	Koh Sampeay community, Siem Bouk district, in Stung Treng province, Cambodia (along the Mekong river)	Krong Bong, Dak-Lak, central highlands, Vietnam	Tinh Bien and Tri Ton, An Giang province, Mekong Delta, Vietnam
Current Status	Barely operational and requires strategies to deal with declining community interest.	Shifted from community-driven to family business	Operational	Operational
Actors	NGO: DND Solar battery charging committee (under Veal Kambor Community Protected Area - CPA) Landowner - Chief of the Veal Kambor CPA	A local entrepreneur (the original hydropower owner) NGO: CRDT Community dam committee	NGO: GreenID Local government Management team (3 people selected by the people's committee)	NGO: GreenID Local government Women's Union Local technical team Community members
Number of households or people provided electricity	536 families ~ 2000 people from 3 villages	70 households	Electricity: 23 households and a church Water: the community and neighboring villages	250 households in the 1st phase and 500 households in the 2nd phase
Techno-engineering process				
Design	Off-grid solar power system battery bank	Hydropower-based Mini-grid	Solar-based Mini-grid Capacity: 6.24kWp	Hybrid system (solar home system including solar panel and battery)
Who designs/ decide the design of the system	DND and CPA	The original dam owner CRDT	GreenID	GreenID Each household decides the capacity of their own system.
Financial process				

Funding sources	UNDP's Small Grant Program through DND: USD 43,020 Community: land and labor work to install the system: USD 15,031	Original system owner: USD 20,000 CRDT: USD 50,195 In kind contribution from Community: USD 14,470	McKnight: USD 17,600 Community: land, materials, and labor to build the system shelter.	Bread for the World & WWF Vietnam through GreenID: USD 109,700, covering 35-50% of each SHS. Community members cover 50%-65% of each SHS.
Benefit distribution	Community members pay for the electricity they consume. Revenue: 20% to solar battery charging committee; 30% to land owner; 20% to forest patrolling 15% for maintenance of the solar system and 15% for community development activities	Community members pay for the electricity they consume Revenue: 50% to community development activities 20% to the community's dam committee. 30% to the private owner.	Community members pay for the electricity and water they consume. Revenue: Used to maintain the system. A small portion is to support the system managers (4UScent/electricity-bill/month, and 4UScent/water jar)	Households use electricity generated from their SHS
Governance process				
Who decides the commencement of the project	DND, CPA. There was consultation with community members.	The original hydropower owner and CRDT. The hydropower system was originally owned by a local entrepreneur. CRDT supported to mobilize more resources to rehabilitate and upgrade the system. Dam committee was then established.	GreenID and Cu Pui commune people's committee (CPC) designed the system and selected the villages that meet the given criteria (no access to electricity, limited access to clean water, sufficient households living in a cluster)	GreenID and local authority. GreenID surveyed and decided to install stand-alone solar home system. Each household decides to install the system and must co-fund the system. They can upgrade the base capacity to meet their needs.
Who decides terms and condition of the system, e.g electricity price, revenue management and distribution	DND CPA Includes consultation with community members	The original dam owner CRDT Dam committee	Local government GreenID Includes consultation with community members	Not applicable
Who is responsible for operation of the system	The landowner and the committee	Mainly the original dam owner	Management team nominated by the local government	The SHS owner (community member)
Who is responsible for maintenance, refurbishment and upgrade of the system	The landowner and the committee	Mainly the original dam owner	Management team and the local government	The households with support of the technical team and GreenID. The technical team includes local people who are trained by GreenID. They are paid by the household for their services.

Who manages the revenue generated from the system	The landowner and the committee	The dam owner and CRDT	Management team	Not applicable
Benefits				
S Social T Technological En Environmental Ec Economic P Political	• Access to cheap electricity (S, Ec, T) • Time and effort saving due to travelling to distant charging stations (S) • Income for the patrolling team (Ec, En) • Fund (15%) for community development activities (S, Ec)	• Access to cheap electricity (S, Ec, T) • Improved eco-tourism facilities (Ec, En) • Access to clean water (S)	• Access to cheap electricity (S, Ec, T) • Access to cheap clean water (S)	• Access to cheap electricity (S, Ec, T) • Job creation (the local technical team) (T, Ec) • Knowledge of SHS (S)

Techno-engineering process

The technologies and models employed in CORE projects in this study range from solar-based battery charging, SHS, solar, and micro-hydropower mini-grids. The system design determines the technological and financial feasibility of the projects, and is thus a major factor of CORE project success. It is important to have the technology and system design tailored to communities' social context. For instance, in the two cases in Vietnam, GreenID took into account population density and community needs (electricity and clean water) to decide to adopt a mini-grid in Dak Lak, and stand-alone solar home systems in An Giang.

The technological solutions in the study were usually brought to communities by CSOs. In case 2 a CSO was brought in to upgrade an existing hydropower system, which had been developed by a local entrepreneur through peer learning. In case 4, each household was given flexibility in the decision to upgrade the base capacity (one set of SHS) to meet their own demand. This flexibility makes the solution better tailored to each of the families.

Financial process

The financial support from CSOs usually made up the majority of CORE projects while local stakeholders (local private actors, community representatives, community members) provided in-kind contributions in the form of land and labor, and sometimes finance (case 2). This points to the important role played by external donors in CORE projects in Cambodia and Vietnam, in contrast to CORE projects in Australia, Europe and North America where communities have a major role in leading the project. Case 4 is an exception where the matching fund from the households was greater than the external grant. Although an external actor initiated the project, the co-financing arrangement with households is a good proxy for their understanding, acceptance, consideration and deliberate decision-making in participating in the project. Other factors shaping success of this CORE project is the involvement of the local women's union in disseminating information and persuading households to participate. Secondly, the solution proved to work effectively in phase 1, which encouraged more people to adopt the solution in phase 2 of the project.

As a result of the different financing structures, the distribution of benefits from the projects varied case by case. Where community members did not fund the project upfront, they need to pay for the electricity they use. The revenue is distributed in accordance with what has been agreed. When the community co-financed the solution, no further expense is paid to use electricity but households pay for maintenance costs when needed.

Governance process

(1) Design stage

Different sub-processes are embedded in the governance process of CORE projects. In the design stage of the projects, it included decisions of commencement of the project, solution design and establishment of an agreement among the stakeholders that regulate all matters related to operation of the system.

The CORE initiatives were typically conceived prior to community involvement and generally tied to the stakeholder providing funding for the initiative. The introduction of the initiative to the communities typically began with close consultations between CSOs and community representatives and/or local government to test the suitability of the initiative to meet the community's needs.

The Veal Kambor solar-power charging station is a good example of early-stage consultation and engagement of a group of elected community representatives. Efforts were also made to enhance awareness and understanding of business models through exposure visits to existing CORE projects and lessons-sharing discussions between communities with CORE projects and those exploring their options. In 2016 (a year before setting up the Veal Kambor charging station), 13 representatives from this community were taken by DND to visit a community solar-powered battery charging station in Kompong Leng district, Kampong Chhnang province, which had been operational since 2006. After the exposure visit, the Chief of the Veal Kambor CPA, who later became the operator of the solar-powered battery charging station, said: "we were very inspired by the solar-powered battery charging system and it would be great to set it up in our community too in order to reduce villagers' time in traveling to charge batteries and save some cost from the charging with a more expensive diesel generator".

Establishing clear and transparent agreements on the role of stakeholders in electricity generation and distribution, revenue management and utilization, is a key feature for a successful project. Ensuring an active community voice in decisions and agreements about roles, responsibilities and operating models for projects is a key feature of CORE projects. Typically, representatives from the community broker this engagement. However, it is important that there are legitimate modalities of representation that connect community representatives to the community at large both for informing and awareness raising, and also for mediating diverse voices (including those of women and other marginalized groups), and establishing consensus and buy-in.

(2) Operation stage

Operation of CORE projects involves community actors in the management and operational processes that are needed for systems operation, maintenance, refurbishment, upgrade and revenue management. Most of the case studies established a new management modality by mobilizing local representatives or existing institutions as part of a process to hand over management control from a CSO to the community. These management units were mandated all operation and maintenance affairs of the system (case 1 and 3).

Support was given to build the capacity of community committee members with varying degrees of success. In the An Giang case, local technical backstopping mechanisms have been instrumental for the effective operation of the system. Skills and jobs were created at the local level. A technical team was established among community members who were trained to troubleshoot basic technical issues. This service is paid directly by households.

The Koh Sampeay community micro-hydro project required higher-level skills to operate and maintain. The project group struggled to fix operational issues with the dam, upgrade system capacity to match increasing demand, and ensure timely maintenance. The original owner who became a shareholder of the CORE system remained the key person in charge of operation and maintenance. There was a need to upgrade the system and modify the agreement to meet growing demands for electricity in the community. However, conflict happened because the private hydropower shareholder and the committee members had different opinions on how they should allocate electricity to meet increasing demands in eco-tourism, clean water projects and domestic use. This conflict to an extent contributed to the termination of the project.

Other community members were mainly electricity consumers and played a minor role in operational processes. This position in fact gave them flexibility to switch to more attractive energy alternatives when the CORE system started to flounder instead of working together to address the problems (case 1 and 2). Although designed for the "community", the vision for these CORE systems seemed to be less driven by the community majority and more limited to a small management group. When regular community members turned away from the CORE service, they also gave up the advantages that it brought such as cheaper electricity and income for other community development activities.

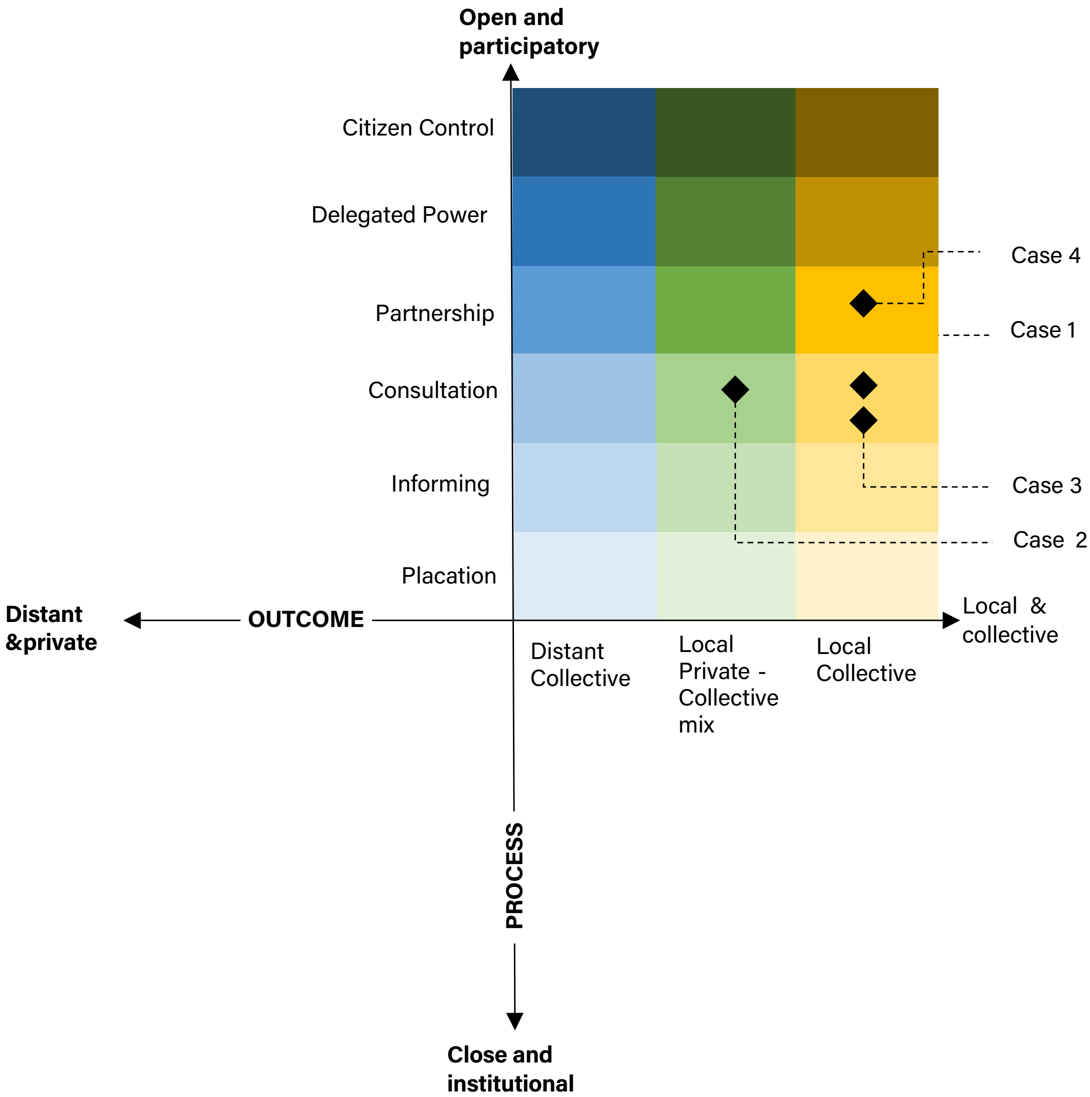
Outcome

In all four case studies, communities were able to enjoy clean and cheap electricity for domestic use from CORE projects. These projects also contributed to the development of eco-tourism, pumping water and supply of purified drinking water. Revenue generated from selling electricity and water was used to compensate management personnel, maintain the systems, and fund community development activities. More local jobs were created in maintaining the system in An Giang. This project had a further positive socio-economic impact on the people who were not involved in the initial projects, yet became aware of them and adopted the systems with their own resources.

Benefit-sharing mechanisms vary from case to case, depending on how the project was funded and who is involved in its operation. Almost all the direct benefits (electricity or revenue) went to community members in the Vietnam cases. In Veal Kambor community, revenue is distributed among local stakeholders, with the majority going to the CPA (patrolling team), the solar battery charging committee (which is a sub-group of the CPA) and the land-owner/operator. The wider community members share 15% of the revenue that goes to funding community development activities. In the community micro-hydro project case in Cambodia, revenue was shared between the dam operator (30%) and the community.

The four cases are plotted on a modified CORE framework diagram in Figure 10, with explanations provided. Among the four cases, An Giang is deemed to have the highest level of participation because wider community members are co-funders of the system and have a high sense of ownership over the project. This framework does not attempt to rank projects. The purpose is rather to understand the functional and relational characteristics of CORE projects to better understand the challenges and conditions for success.

Figure 10 Participation and benefit distribution of community renewable energy projects



Case 1 – Rattanakiri

Process: *DND (NGO), members of the CPA and local representatives decided to co-design a solar battery charging system. A committee (a subgroup of CPA) is established to operate and manage the system. Community members were consulted during the preparation phase of the system. They pay to use electricity.*

Outcome: *Community members benefited from cheaper electricity service. 15% revenue is committed to be used for community development activities, the rest goes to the committee (20%), the landowner (30%), the patrolling team (20%), and maintenance of the system (15%).*

Case 2 – Stung Treng

Process: *The hydropower system was initially established and run by a local entrepreneur. It then expanded and converted into CORE with assistance from an NGO. There was consultation with the community; electricity was closely connected to an eco-tourism and clean water project.*

Outcome: *Community members benefited from cheaper electricity service. 50% of the revenue is committed for development activities; 20% for the community's dam committee and 30% for the original owner.*

Case 3 – Dak Lak

Process: *GreenID (NGO) and the Commune People's Committee designed and selected the villages that meet the given criteria to install the system. There was consultation process with community members to set the price of electricity and water.*

Outcome: *Community members benefited from first-time electricity access and cheaper/clean water access. A small portion of revenue goes to the management team, the rest is used for maintaining the system.*

Case 4 – An Giang

Process: *Each household made the decision on co-funding the SHS and the number of SHS sets to be installed based on their own needs. The households are fully responsible for operation and maintenance of the system with support of GreenID. Outcome: The households fully use electricity generated from their SHS.*

Sustainability of CORE and its challenges

Currently, the two CORE systems in the Cambodian case studies have been declining or totally transformed to a private-owned project. Even so, it is hard to deny the benefits the projects used to provide to the communities when they were most needed. When they were established, electricity generated from CORE helped address an essential need of households. This continued until the system became overloaded and alternatives emerged. Both cases demonstrate how the sustainability of CORE projects can be compromised by techno-engineering and governance issues. Overall, the key issues that challenge the long-term sustainability of CORE projects in Cambodia and Vietnam are as follows:

- Systems are overloaded by increasing demand: Systems introduced to off-grid communities are usually designed to meet their basic needs. However, after having access to electricity, households tend to purchase more electrical appliances, increasing demand over time. This places a significant stress on the system. If supply and demand are not managed and adjusted accordingly, the system may not meet the needs of its users and alternatives will need to be found.

- Complicated technical skills requirement: Power systems based on technology like hydropower required a higher-level skillset compared to solar PV. Frequent disruptions can easily frustrate users.

- Disconnect with community members: When a project is structured so that decisions are mainly made within a small management unit while the majority of the community are positioned as electricity consumers, their connection to the project can remain weak. This lack of ownership may not be an issue when the system works effectively, but when things start to go wrong the community's support for the system and commitment to stick with it and resolve the problems may be diminished. Therefore, community members at a minimum should be kept informed on the project's operation and benefit-sharing mechanism. A transparent process for decision-making will help to gain trust and commitment from the community.

- Lack of mechanism to resolve conflicts: an agreement among relevant stakeholders prior to the project commencement is essential for successful project delivery. This should include rules and procedures on how to manage operational changes and settle disputes in the future.

- Arrival of the grid: CORE projects and the national grid both provide communities with access to electricity. From that perspective they should be seen as complementary technologies. Yet, the grid still often brings termination to CORE projects regardless of their ongoing use and advantages. The two systems can be either integrated or co-exist independently. In the former case, engineering challenges may exist, particularly when CORE is built based on low, incompatible technology. A vision of grid integration, therefore, should be taken into account when designing the system. On the other hand, the grid and CORE can also be utilized for separate purposes. For example, even though the grid arrived in Strung Treng and the community hydropower project ended, there is still a strong interest in the hydropower system because of its cost advantages compared to the grid. The community is currently discussing how to re-utilize the system for eco-tourism and clean water pump.

7. CONCLUSION

Community Renewable Energy (CORE) initiatives are a viable approach to providing clean and affordable electricity to rural communities that also offer a range of other social, economic, environmental, technological and political benefits. In doing so they form an important tool in national SDG aspirations towards universal electricity access. The following conclusions are drawn from the four case studies assessed in Cambodia and Vietnam.

First, off-grid communities in these countries often rely on external technological and financial resources to initiate a CORE project. As such, there is space for communities of interest to support geographical communities to access technical and financial resources which they do not typically possess. Sharing experiences between neighboring homes and villages utilizing similar systems is effective for some technical issues; however, more complicated issues will require formal mechanisms for community of interest actors to engage and support local communities. CSOs and NGOs can serve as excellent conduits to a wider community of interest even while government interest remains weak.

Second, decision-making power, management structure and benefit-sharing arrangements among stakeholders in CORE projects must be made clear in an agreement and widely disseminated to all relevant actors. Transparency must be maintained during the implementation of the agreement.

Third, a geographical community's right to make decisions about the nature of electricity services in their village should be matched by a financial commitment from community members. The general experience in the case studies is that the larger the community's financial investment in a project, the more likely it will continue functioning successfully in the long term. However, the financial capacity to invest in CORE projects within communities varies. Requirements for community investment contribute to the success of a project but they may also exclude poorer and disadvantaged members from effective engagement. Other forms of in-kind non-financial investment should also be integrated into projects to allow for wider participation.

Fourth, peer-to-peer knowledge sharing is one of the best ways for communities to appreciate the value and learn the operating models of CORE projects. Case studies in both Vietnam and Cambodia used 'word-of-mouth' sharing among neighbors to raise awareness, interest and commitment in CORE projects.

Fifth, the grid and CORE projects can draw on their complementarities to benefit communities. CORE systems can often provide communities with cheaper electricity compared to the grid. System design and management must take into account local contexts. The intermittency of RE can be improved with battery storage, and systems can be combined with water purification or linked with other community activities (e.g. eco-tourism, water pump, agricultural activities). System design should also prepare for the possibility of grid integration in the future by taking into account technical compatibility with the grid.

In summary, the emergence of distributed renewable energy provides communities in the Mekong region with energy systems that suit their scale and needs. The CORE model has the potential to contribute to Nationally Determined Contributions and climate action by reducing emissions from the energy production process. The case studies also show that CORE projects often provide the cheapest form of electricity to households and are a faster way to achieve universal energy access than grid expansion. Affordable electricity can also unlock a range of agricultural and small industry productive uses that have historically been too expensive to justify with diesel systems. Finally, CORE project tends to foster community ownership and management of their energy systems which can be empowering for communities and often leads to fairer, more equitable and inclusive economic development. While there are challenges facing CORE sustainability in the region, the framework proposed in this paper can be useful to assess CORE projects and identify space for improvement.

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