COBENEFITS STUDY

October 2019

Electricity access and local value creation for the un-electrified population in Vietnam

Assessing the co-benefits of decarbonising the power sector

Executive report

GreenID
IASS POTSDAM
IET International Energy Transition
COBENEFITS

This study has been realised in the context of the project "Mobilising the Co-Benefits of Climate Change Mitigation through Capacity Building among Public Policy Institutions" (COBENEFITS). This print version has been shortened and does not include annexes. The full version of this report is available upon request.

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag. The COBENEFITS project is coordinated by the Institute for Advanced Sustainability Studies (IASS, Lead) in partnership with the Renewables Academy (RENAC), Independent Institute for Environmental Issues (UfU), International Energy Transition GmbH (IET) and in Vietnam the Green Innovation and Development Centre (GreenID).

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based on a decision of the German Bundestag

INTERNATIONAL CLIMATE INITIATIVE (IKI)

COBENEFITS of the new energy world of renewables for the people in Vietnam

Vietnam is in the midst of an energy transition, with important social and economic implications depending on the pathways that are chosen. Vietnam's chosen energy pathway will define the basis for its future development, including economic prosperity, business and employment opportunities as well as people's health. At the same time, current policy and investment decisions in Vietnam's energy sector will have a substantial impact on combatting global warming and securing the livelihoods of people in Vietnam and elsewhere.

In view of the social and economic implications of the course set by the Government of Vietnam, political decisions on Vietnam's energy future link the missions and mandates of many government departments and agencies beyond energy and power, such as environment, health, labour as well as green industrial development and investments. Hence, the timely debate on Vietnam's energy future boils down to a single question:

How can renewables improve the lives of the people of Vietnam?

Employing scientifically rigorous methodologies and the most recent technical data, the study at hand contributes to answering this question. It also provides guidance to government departments and agencies on further shaping the enabling political environment to unlock the social and economic co-benefits of the new energy world of renewables for the people of Vietnam. Under their shared responsibility, the Green Innovation and Development Centre (GreenID), as the COBENEFITS Vietnam Focal Point, together with the Institute for Advanced Sustainability Studies (IASS) invited ministries and government agencies such as MONRE, MOIT, MPI, MOLISA, MoH and VUSTA to join the COBENEFITS Council Vietnam to provide guidance to the COBENEFITS Assessment studies along with the COBENEFITS Training Programme and Enabling Policies Roundtables. Since its constitution in August 2017, the COBENEFITS Council Vietnam has guided the programme in framing the topics of the COBENEFITS Assessment for Vietnam and in ensuring their direct connection to the current political deliberations and policy frameworks of their respective ministries.

We are also indebted to our highly valued research and knowledge partners, for their unwavering commitment and dedicated work on the technical implementation of this study. This COBENEFITS study was facilitated through financial support from the International Climate Initiative (IKI) of Germany.

Vietnam, among 185 parties to date, has ratified the Paris Agreement to combat climate change and provide current and future generations with opportunities to flourish. With this study, we seek to contribute to the success of this international endeavour by offering a scientific basis for harnessing the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just transition, thereby *making the Paris Agreement a success for the planet and the people of Vietnam.*

We wish the reader inspiration for the important debate on a just and sustainable energy future for Vietnam!

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Executive Summary

COBENEFITS

Electricity access and local value creation for the un-electrified population in Vietnam

Assessing the co-benefits of decarbonising the power sector

Energy access is essential for economic and human development and is an important driver for the economic development of a country. Access to modern forms of energy, especially electricity, becomes even more important for the socio-economic development of rural areas (which lag behind urban areas in terms of infrastructure development). "Full electrification" to achieve social and economic development goals (and SDGs) in Vietnam requires 24/7 electricity access for every household, family, farming settlement and local enterprise, even in rural communities. To achieve this goal, the government of Vietnam has focused primarily on providing access by extending the centralised grid. Approximately 98% of households in both urban and rural areas of the country have been electrified through this means, but electricity access to the remaining 2% of the population, predominantly located in regions with terrain unfavourable to grid expansion, has become a techno-economic moot point. To this end, discussions have explored whether cost-effective, off-grid renewable energy (RE) alternatives could assist the electrification of these remaining populations and further drive the socio-economic development of these population groups.

Thus, this study centres on providing answers to two main questions:

- What is the best approach to provide electricity access to the remaining 2% of Vietnamese households located in rural areas: grid expansion or off-grid renewable energy options?

- Can cheaper off-grid alternatives engender local value creation in rural areas?

This study is carried out in the context of the COBENEFITS project with the aim of assessing the range of additional benefits[1] resulting from a low-carbon energy transition in Vietnam.

- **Policy message 1:** Vietnam has tremendous potential for off-grid renewable energy systems, which are cost competitive against grid extension in rural areas with challenging terrain that hinders navigation and connection. Deploying low-wind-speed wind turbines to electrify clusters in rural areas with a levelised cost of 9087 VND/kWh is the cheapest means of providing low-cost energy access to remote areas of Vietnam.
- **Policy message 2:** The private sector or organised community groups need to be encouraged to invest in the off-grid renewable energy sector and be made exempt from import taxes for supplying electricity to households or businesses in rural communities. If effectively implemented, this can stimulate the localisation of skills for the off-grid solar PV and small wind turbine value chains in Vietnam.
- **Policy message 3:** In order to effectively drive the adoption of low-cost off-grid renewable energy systems in remote areas of Vietnam, there has to be close dialogue between the government, private sector and financial institutions at the national and provincial levels concerning suitable financing mechanisms for farming communities (with low electricity consumption levels) located more than 10km away from the nearest medium voltage line.

[1] The term 'co-benefits' refers to simultaneously meeting several interests or objectives resulting from a political intervention, private-sector investment or a mix thereof (Helgenberger et al., 2019). It is thus essential that the co-benefits of climate change mitigation are mobilised strategically to accelerate the low-carbon energy transition (IASS 2017a).

KEY FIGURES:

- Renewables are a cheaper way to provide electricity to rural areas especially with off-grid wind being 20% cheaper (9,087 VND/kwH [$0.392[2]/kWh]) than extending the grid (11,300 VND/kWh [$0.487/kWh]).
- For more remote areas where the distance from the nearest MV line exceeds 25km, the cost advantage for off-grid wind even more than doubles against extending the grid (17,445 VND/kWh [$0.752/kWh]).
- For smaller villages, off-grid solar (11,873 VND/kWh [$0.512/kWh]) is cost competitive with extending the grid (11,300 VND/kWh [$0.487/kWh]) for longer distances; this is particularly the case for villages with about 15 households that are more than 5 km away from the nearest MV line.
- To electrify households in rural areas, irrespective of distance from the nearest medium-voltage line, costs 9,087 VND/kWh ($0.391/kWh) with a low-wind speed wind turbine, while the cheapest grid extension cost is 11,300 VND/kWh ($0.487/kWh).
- It costs approximately 17,445 VND/kWh ($0.751/kWh) to electrify households and rural settlements with grid extension when the distance to the nearest medium-voltage line exceeds 25 km. This is approximately 8,358 VND/kWh ($0.360/kWh) more expensive than the cheapest off-grid renewable energy alternative.

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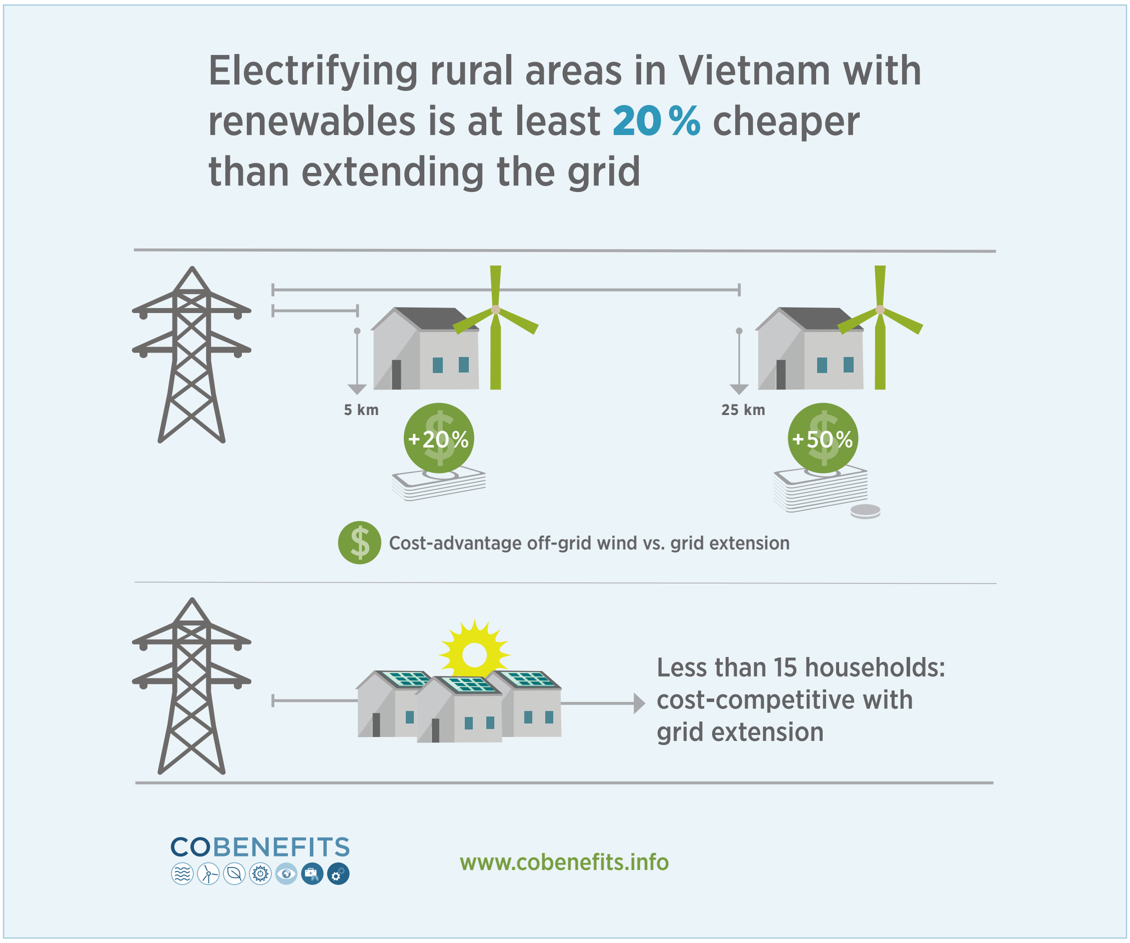
KEY FINDINGS:

- Communities in Vietnam that are far (>5 km) from the nearest medium-voltage distribution system **are best served by off-grid renewable energy technologies**. Grid extension is only viable in rural communities that have large clusters of households per unit area.
- **Small (locally manufactured) wind turbines** are the most cost-efficient means of electrifying most un-electrified rural households in Vietnam. Stand-alone solar PV is cost-competitive in rural locations with low energy or demand density.
- Access to electricity **improves rural households’ access to information and value-added extension services** (e.g., in the agricultural sector), thereby improving opportunities to generate additional income.
- **Opportunities for direct employment** in the local renewable energy value chain can be fostered through effective collaboration between local technical schools and the private sector for planned projects; this essentially aids „localisation of industry“, which in turn drives local employment creation and skills transfer.

[2] 1 Dollar ($) = 23201.9 Vietnamese Dong (VND): Exchange rate as of September 2019.


Electrifying rural areas in Vietnam with renewables is at least 20 % cheaper than extending the grid
5 km
+20%
25 km
+50%
Cost-advantage off-grid wind vs. grid extension
Less than 15 households: cost-competitive with grid extension
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1. Understanding the context of electricity access in Vietnam

Vietnam has seen major economic growth over the past three decades. The rapid growth experienced at every level of society has been the result of the government's commitment to liberalising markets and investing in social sectors and rural development. The construction of roads and other rural infrastructure – combined with the extension of grid electrification, amongst others – have helped improve quality of life and living standards for people in rural Vietnam. These complementary investments have a proven synergy. Roads have helped people in rural areas gain access to markets; extensive grid electrification has enhanced education access and also improved local productivity levels. Power generation, grid extension and power supply have been facilitated not only by EVN's own investment (EVN: Vietnam Electricity vertically integrated power utility responsible for development, management and operation of the state's electricity power industry assets) but also under BOT (Build-Operate-Transfer) and IPP (Independent Power Producer) schemes through the participation of the private sector. Since the early 1990s, electricity consumption has grown at a rate almost double that of GDP growth. Figure 1 presents a milestone overview of rural electrification objectives since 1995. As disposable incomes have grown from very low levels in the mid-1990s, there has been strong growth in energy use, particularly due to increased household appliance ownership.

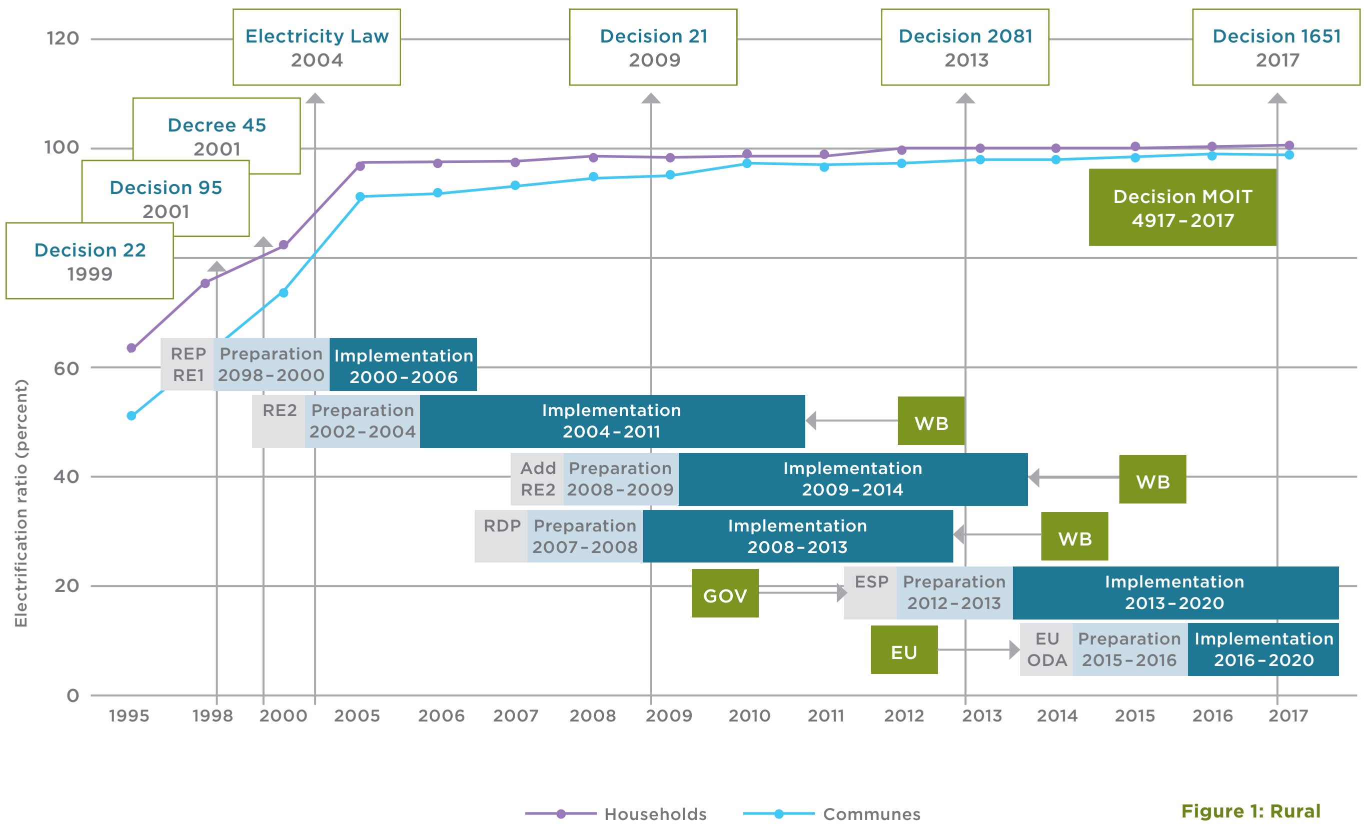

Figure 1: Rural electrification milestones in Vietnam

Source: own

Conversely, over the years, policy frameworks were put in place to plug the country's rural electrification gap, from the "135 program" set up in 1998, to the national master plan for power development (2011 to 2020), developed in 2011. These programs aimed to electrify 100% of Vietnam's communes and rural areas by the year 2020, and have helped ensure that approximately 98% of the country is electrified to date (cf. Figure 1).

Notwithstanding these seemingly well-articulated plans and the government's ambitious pre-2020 national electrification plan, the challenge remains of how to effectively and affordably electrify areas that cannot be reached easily through grid extension. These account for approximately 2% of the country's households (comprising hundreds of thousands of rural households), located particularly in the mountainous northwest and central highlands (cf. Figure 2). Most of these rural areas are located very far from the existing grid network, and the options for grid expansion to these areas appear unfeasible (ADB 2017). Hence, aligning these electrification objectives and the socio-economic development of un-electrified areas is necessary in order to understand the best approach for making energy access affordable and reliable. Therefore, the option of enabling off-grid renewable energy generation to drive the associated socio-economic development in these rural areas has become a growing concern for policy makers and developmental partners whilst still facing the question of whether grid extension programs into rural areas should be re-prioritised.

1.1 Scope of the study

This study examined the viability of enabling off-grid renewable energy generation in rural areas that have restricted access to distribution grid infrastructure. The aim is to quantify how rural electrification, based on off-grid renewable energy solutions, can help ease and accelerate access to electricity for the remaining un-electrified 2% of Vietnamese households, in order to broadly enhance the socio-economic development of rural areas nationwide. The study tries to provide both qualitative and quantitative answers to the following questions:

- What are the shortcomings involved in electrifying the remaining thousands of households through grid extension? Can renewable energy-powered off-grid systems help to better achieve this aim and drive local value creation in these areas?

- What are cost- and sustainability differentials of extending the grid into these rural areas versus enabling renewable energy-powered stand-alone or hybrid off-grid systems? If renewable energy-powered stand-alone or hybrid off-grid systems provide the best competitive advantage for electrifying rural areas in a sustainable way, how can energy access through these options be better fostered, and which mechanisms must be in place to achieve this last-mile 100%?

In terms of technological scope, the study looks at solar, wind, biomass and hybrid sources of energy, having in mind that most off-grid power systems in rural areas run on solar energy.

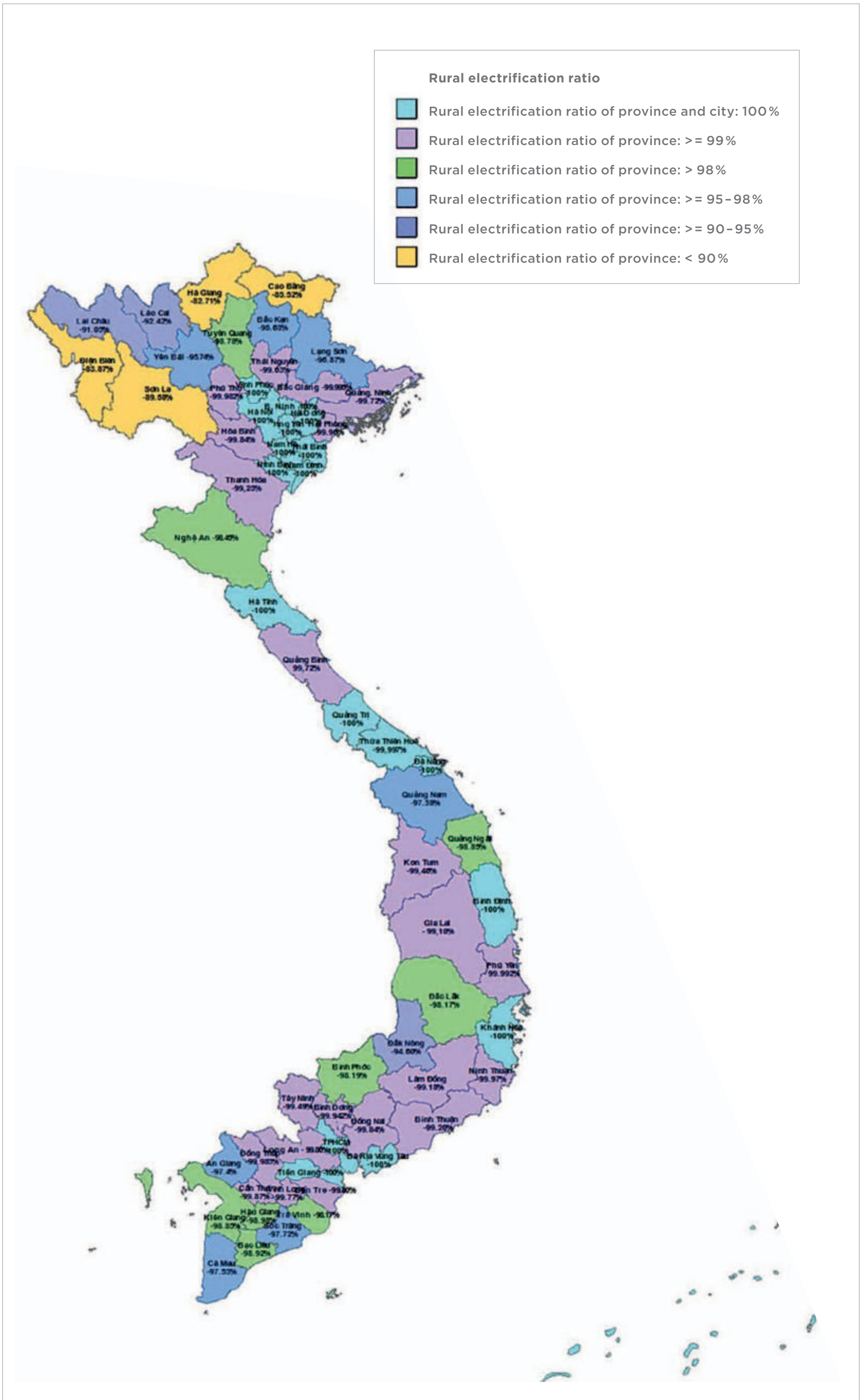

Figure 2: Provincial electrification rates in Vietnam, 2017.

Source: IE & EVN

2. Methodology

2.1 Case-study site selection and data collection

The study draws on data obtained from remote areas in two provinces. Both areas face typical challenges, including poor electricity access and limited feasibility of grid extension within the next five years. Due to the ease and access to data, as well as alignment with the energy priorities of national policy makers, Ha Giang province (northern Vietnam) and Quang Binh province (central Vietnam) were chosen as the case-study locations for this study. Further reference locations within Quang Binh Province, at which rural electrification was achieved through off-grid RE systems, are chosen to gather information on post-electrification changes in economic welfare.

Ha Giang province has one of the lowest electrification rates in Vietnam (cf. Table 1). The province is very remote, located near the Chinese border, and is surrounded by high and steep mountains that make grid extension difficult. A 2015 report[4] on the socio-economic situation of 53 ethnic minority groups detailed that approximately 93% of such households had access to the national power grid (5% lower than the national average), hence the selection of this province as a case study location. The solar irradiation and wind resource potentials of the province are shown in Figure 3 and Figure 4. Table 2 further shows monthly average irradiation in the province.

No.	District	Number of villages		Number of households			Electrified households		
		Electrified villages	Un-electrified villages	Total	Urban	Rural	Total	Rural	Electrification ratio (%)
	Hà Giang T7.2018	1,824	247	179,855	33,385	146,470	156,224	123,041	84.0
1	Thành phố Hà Giang	101	0	15,330	12,491	2,839	15,329	2,839	100
2	Bắc Mê	110	29	10,788	1,825	8,963	8,307	6,504	72.6
3	Vị Xuyên	225	36	24,425	3,702	20,723	21,426	17,724	85.5
4	Bắc Quang	222	14	27,062	4,511	22,551	25,710	21,199	94
5	Quang Bình	108	27	14,004	1,530	12,474	12,191	10,722	860
6	Xín Mần	168	19	13,045	1,032	12,013	11,245	10,215	85
7	Hoàng Su Phì	187	12	13,633	1,068	12,565	12,768	11,700	93.1
8	Quản Bạ	98	9	11,646	1,740	9,906	10,988	9,248	93.4
9	Yên Minh	238	44	18,162	1,682	16,480	14,885	13,206	80.1
10	Đồng Văn	213	12	15,780	2,189	13,591	13,346	11,202	82.4
11	Mèo Vạc	154	45	15,980	1,615	14,365	10,029	8,482	59.0

Table 1: Electrification status in Ha Giang Province

Source: own

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2.02	1.92	2.13	3.21	5.66	5.47	6.11	4.94	4.30	3.41	2.94	2.85

Table 2: Monthly average total solar irradiation (kWh/m²) in Ha Giang Province

Source: own

[4] The report "Ethnic Minorities and Sustainable Development Goals: Who Will be Left Behind – Results from Analyses of the Survey on the Socio-economic Situation of 53 Ethnic Minorities in 2015" (funded by Irish Aid, CEMA and UNDP).

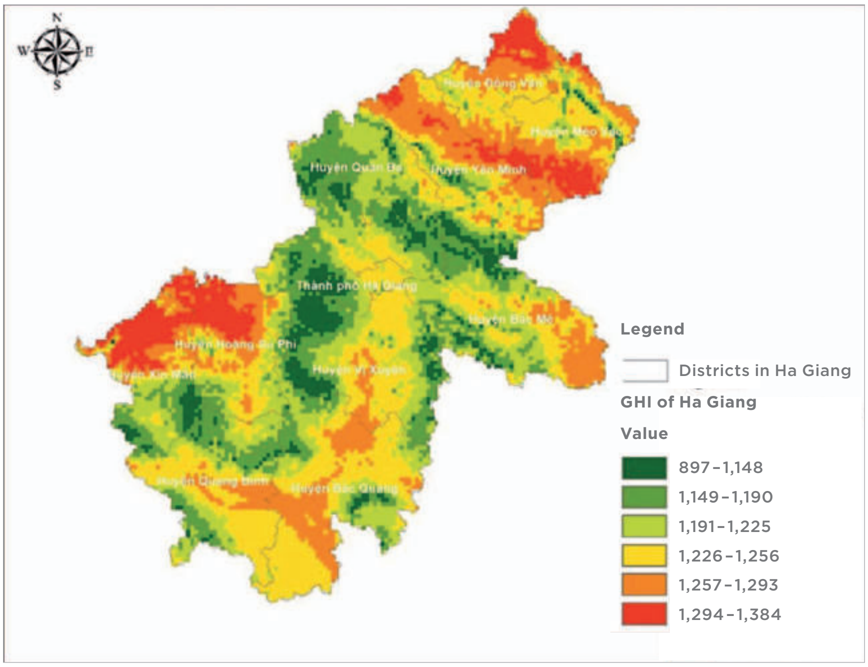

Figure 3: Global horizontal irradiance of Ha Giang Province

Source: RE Explorer

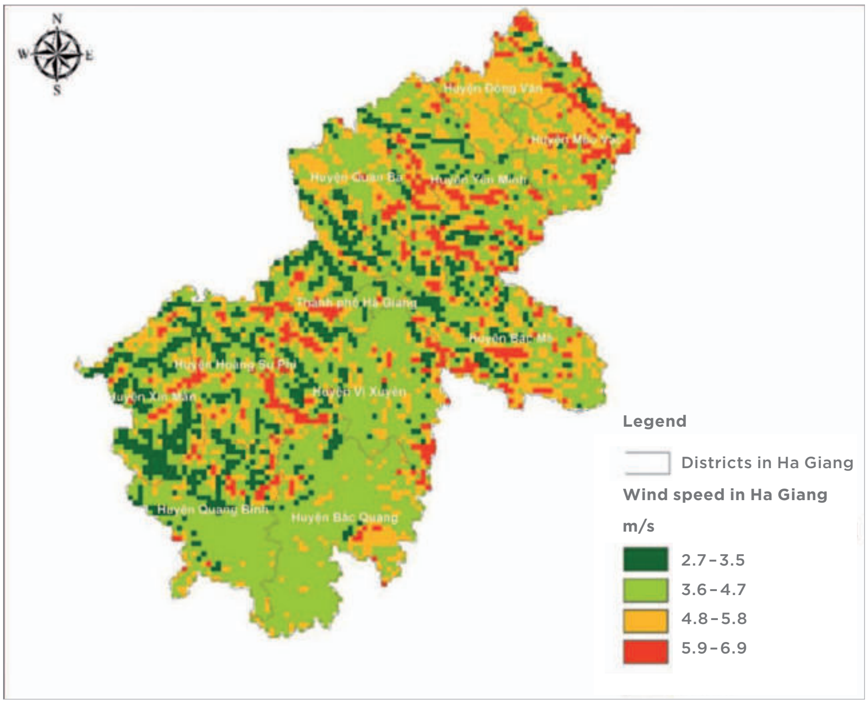

Figure 4: Average wind speed in Ha Giang Province

Source: Global Wind Atlas

Quang Binh province is located in the northern part of central Vietnam. According to Quang Binh Power Company, the electrification rate in Quang Binh Province is 99% (cf. Table 3)., achieved mainly through grid extension and in some areas through mini-grid and solar home systems. According to the literature, grid extension to the remaining villages in Quang Binh Province may be feasible; however, population densities are rather low in the conservation areas bordering Laos, and locals are averse to the risk of altering the landscape. Thus, off-grid REs are considered in this study as an option for speedy electrification of these rural areas. The solar irradiation and wind resource potentials of the province are shown in Figure 5 and Figure 6. Figure 7 shows a pictorial example of an off-grid 18 kW solar photovoltaic (PV) hybrid system built in Quang Binh.

No.	District	Number of households		Electrified households		
		Urban	Rural	Total	Rural	Electrification ratio (%)
	Quảng Bình T4.2018	56,953	187,434	156,224	243,517	99.3
1	Thành phố Đồng Hới	27,057	11,772	38,829	11,772	100
2	Thị xã Ba Đồn	13,499	15,004	28,503	15,004	100
3	Huyện Lệ Thủy	4,208	35,905	40,113	35,645	99.3
4	Huyện Quảng Ninh	2,160	23,462	25,622	23,328	99.4
5	Huyện Bố Trạch	5,831	43,760	48,960	43,069	98.4
6	Huyện Quảng Trạch		28,487	28,487	28,487	100.0
7	Huyện Tuyên Hóa	2,220	18,440	20,659	18,440	100.0
8	Huyện Minh Hóa	1,978	10,605	12,344	10,366	97.7

Table 3: Electrification status in Quang Binh Province

Source: own

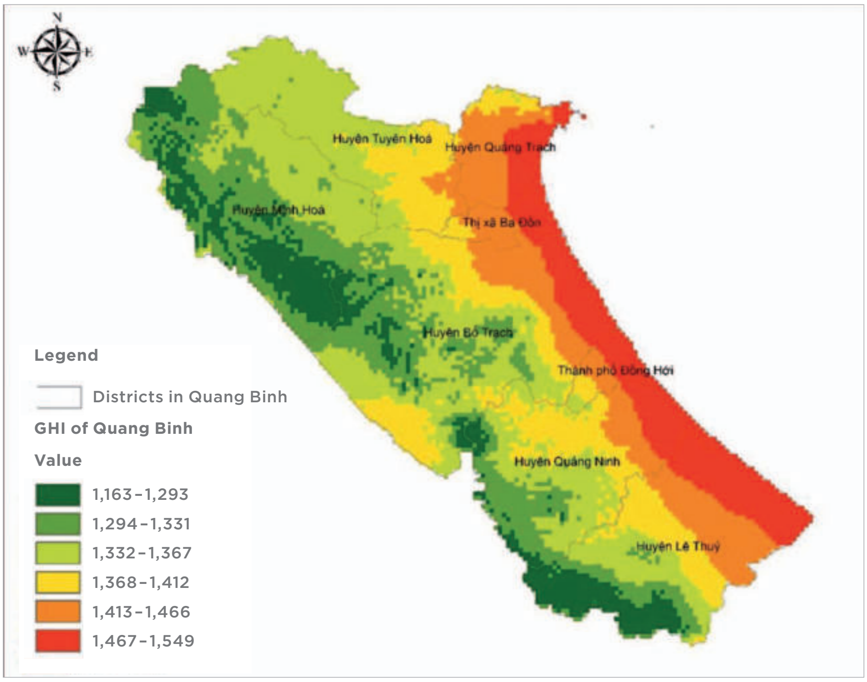

Figure 5: Global horizontal irradiance of Quang Binh Province

Source: RE Explorer

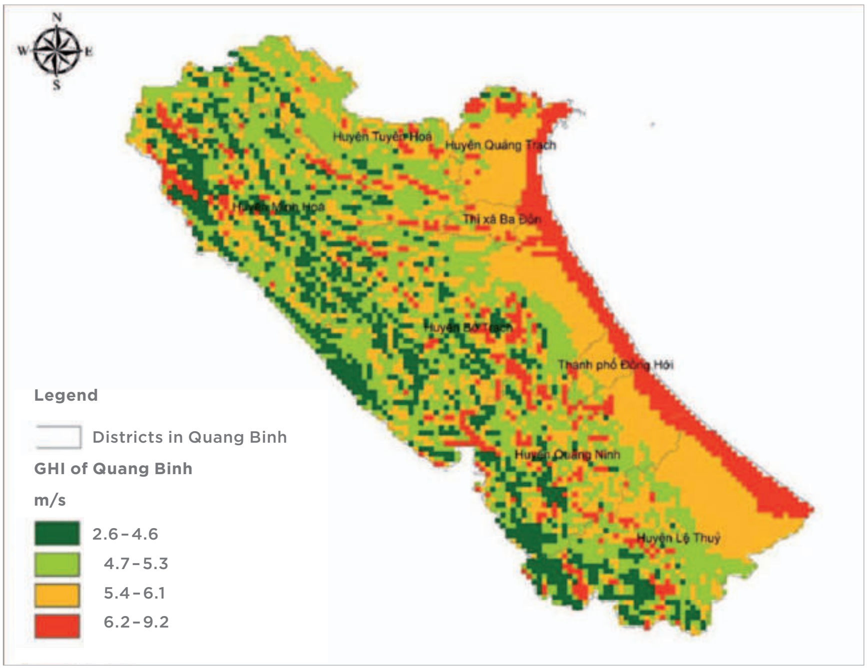

Figure 6: Average wind speed in Quang Binh Province

Source: Global Wind Atlas

Figure 7: Solar PV, battery and diesel generator (18 kW) for small villages and public administration, deployed at Quang Binh

Source: own

2.2 Overall methodological approach

The present study applies a two-tier socio-technical approach: The first tier analyses provincial electrification rates nationwide to select two case study regions containing multiple rural areas with low electrification rates (cf. Figure 8). Furthermore, through primary onsite surveys at the case study areas, the value-added benefits of electrifying rural households in Vietnam through renewable energy-powered off-grid technological options (with regard to reliability, affordability, safety, etc.) are investigated. The second tier uses an optimisation tool to assess the least-cost options for supplying electricity to the selected case study areas by means of various sources. These are thereafter compared with the cost of electrifying the rural areas by grid extension, to determine the most cost-competitive solution across different household population clusters.

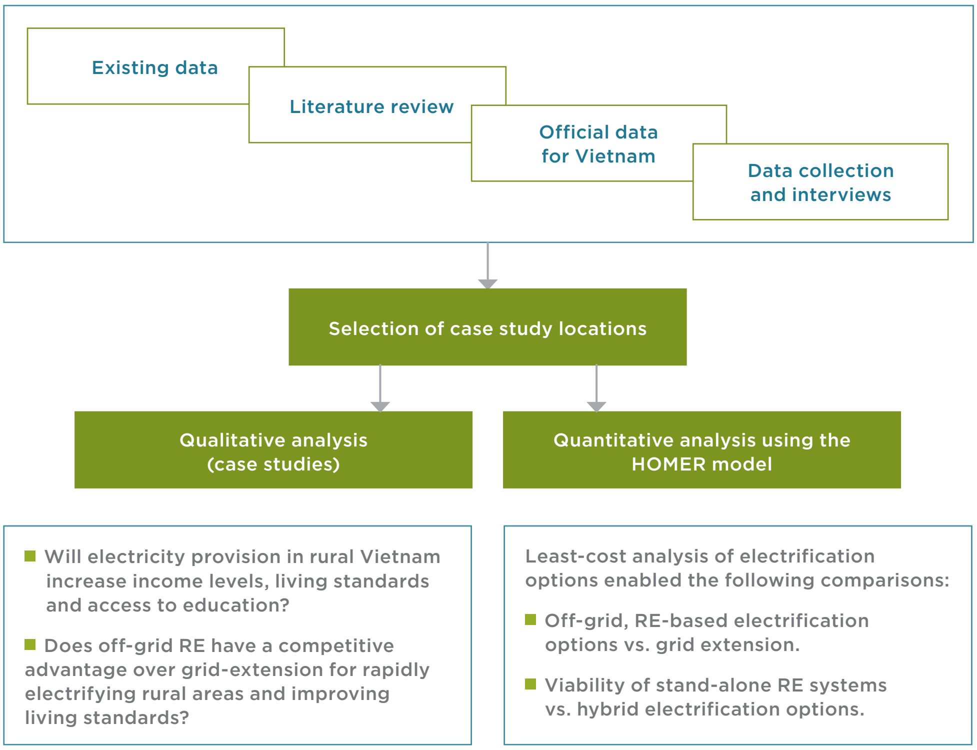

Figure 8: Schematic overview of the study methodology

Source: own

2.3 Techno-economic decision making

The decision tree shown in Figure 9 was applied when developing the socio-technical framework adopted in this study. This decision flowchart details the factors considered in selecting the optimum energy system solution (grid vs. off-grid) for electrifying a particular rural case study location. For an "off-grid" decision to be selected, the cost of grid extension (which factors in the distance from the nearest medium-voltage (MV) power line, and the size of the demand cluster (number of households per square kilometre) must be greater than the cost of implementing a stand-alone or hybrid off-grid RE solution. Techno-economic analysis of the various off-grid energy system solutions used the Hybrid Optimization of Multiple Energy Resources (HOMER) software developed by the United States National Renewable Energy Laboratory (NREL). The tool assists in navigating the complexities of building cost-effective and reliable off-grid systems that combine traditionally generated and renewable power, storage, and load management in the remote areas of Vietnam. The levelised costs for the off-grid RE alternatives are compared to the unit cost of grid extension for a particular household cluster or load density (households per square km) in order to determine the best option for electrifying the rural area. The grid extension costs are obtained in consultation with the local electricity distribution company.

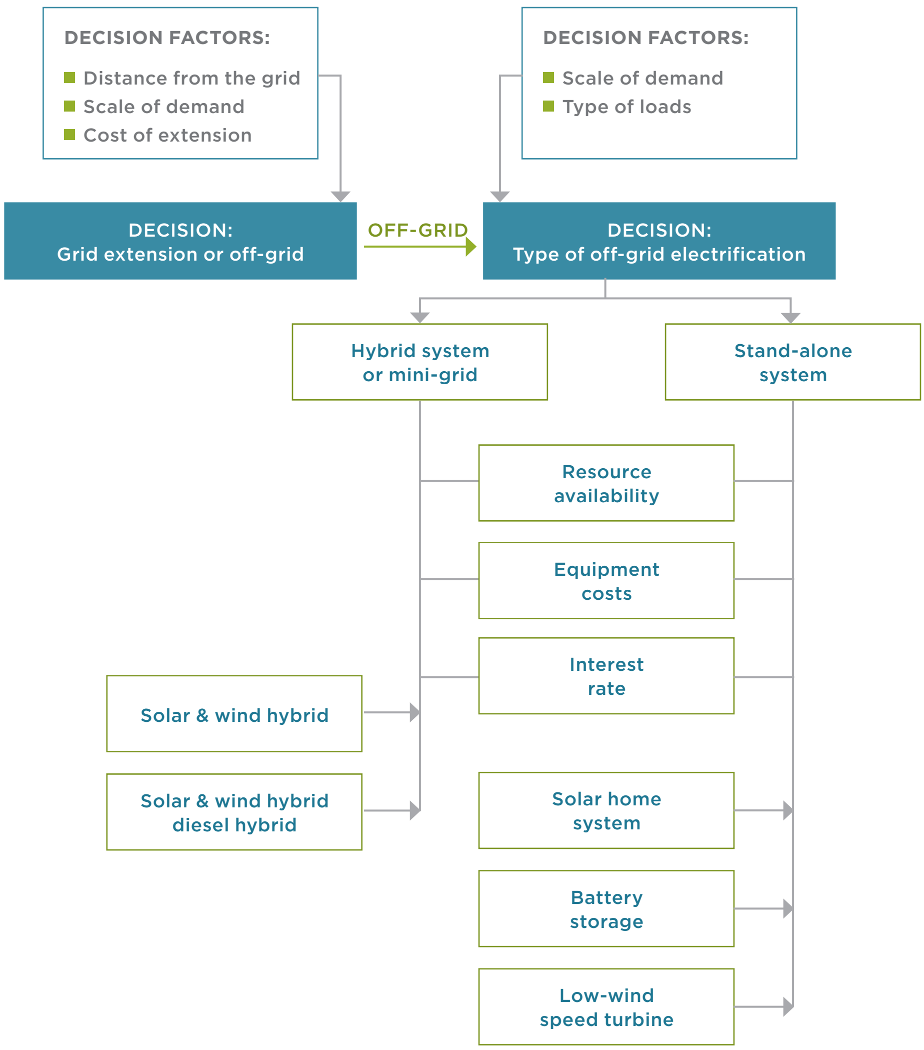

Figure 9: Schematic detailing the flow of least-cost decision making for case study locations

Source: own[5]

[5] Decision tree adopted from: https://energypedia.info/wiki/File:Decision_tree_off_vs_on_grid_norad09.jpg

2.4 Study limitations

Key amongst the challenges encountered during the study is the lack of publicly available data on RE- (non-hydro) enabled rural electrification in Vietnam, because of the centrally planned approach of the country's power system. It was therefore necessary to apply a combination of qualitative (survey) case study assesments (bottom-up) and location-specific quantitative approaches in order to address the research goals of the study and to ensure that the study outcomes are sufficiently representative for the Vietnamese context. Therefore, the conclusions derived from the present case studies can be applied to other locations in the country. This study is based on economic assumptions, technology costs and other parameters that might change over the assessment horizon; such changes could affect the approximations and should be taken into account in decision making. The present study does not include broader analyses of hydro- or biogas-powered off-grid RE system options in Vietnam, but these may be considered for similar future studies (where applicable). Other decision factors, such as the value chain and the local availability of renewable energy equipment or materials, were not analysed in this study. This study did not address questions of "connection costs", "willingness to pay", "subsidy regime" or the "ability to pay" of consumers – issues often associated with off-grid electrification in rural areas.

3. Reaching electrification goals and delivering multiple benefits

3.1 Cost-competitiveness of various electrification solutions

One of the key challenges in establishing appropriate rural electrification polices is the choice of extending the existing electricity grid infrastructure versus the viability of off-grid alternatives. In some regions of the world (for example Sub-Saharan Africa), alternative RE off-grid solutions, e.g., mini-grids, have emerged as cheaper alternatives in the long run to electrify rural clusters despite high capital costs and seeming associated technical challenges (Bertheau et al., 2017; Contejea et al., 2017). Thus, it is essential to understand which options are most appropriate for the Vietnamese context. As stated, the analysis is based on two main sources: firstly, it reviews the data on grid extension costs per kilometre, obtained from Vietnam's state-owned electricity utility (EVN) in conjunction with a review of existing literature on grid extension costs for rural electrification in Vietnam. Secondly, the levelised costs of electricity (LCOE)[6] of off-grid stand-alone and hybrid solar PV and wind solutions are obtained using the HOMER tool (cf. Figure 10). The per-km cost estimates for the various electrification options are compared to determine which is best suited to a particular rural cluster or household density. This section presents three case studies that estimate the economic viability of off-grid solutions at provincial locations 5 km, 10 km and more than 20 km from a medium-voltage station/line. The analysis shows that the farther a community is located from a medium-voltage line, the more viable an off-grid solution is under current market conditions. Similarly, it establishes the suitability of off-grid low-wind speed turbines for rural electrification in Vietnam.

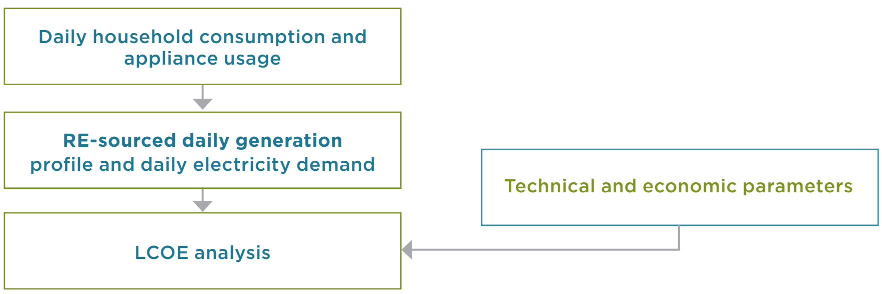

Figure 10: Analysis flow adopted in HOMER

Source: own

[6] The levelised cost of electricity (LCOE) is the net present value of the unit cost of electricity over the lifetime of a generating asset. It is often taken as a proxy for the average price that the generating asset must receive in a market in order to break even over its lifetime.

INFOBOX: Typical rural electricity consumption levels in Vietnam

1. Cluster with an average daily demand of 5 kWh, with early morning and evening peaks (during sunset). This consists of approximately 10 low-energy-consuming residences. Because the village contains a small number of houses that each have similar load profiles, the village's load profile is an aggregate sum of the individual houses' profiles.
2. Clusters with an average daily demand of 50 kWh. The demand profile also has two daily peaks (one daytime peak in the early morning and an evening peak between sundown and sunset).
3. Clusters with an average daily consumption of 500 kWh. There exist different household demand profiles (low-end and high-end households with varying appliance usage). Big public works and structures, such as hospitals and schools, are major centres of daily energy consumption during the daytime.

Case 1: Communities 5 km from a medium-voltage station

This case shows that for communities close to the medium-voltage station or distribution line, the cost of grid extension is cheaper than most off-grid options, despite a high or low household density. However, for settlements of 15 households located 5 km from a station, the stand-alone solar (11.873 VND/kWh) solution is sufficiently competitive with the cheapest grid extension alternative (11.300 VND/kWh) (as seen in Figure 11). This case shows that the off-grid stand-alone low-wind-speed wind turbine (9.087 VND/kWh) is cheap and economically viable compared with grid extension, even when more than 200 households have to be electrified in the rural area. Key criteria, why the wind-power option is techno-economically cheapest, include: the technology is locally sourced (low capital cost); and the turbine operates at low cut-in and rated speeds. From the on-site surveys conducted in Ha Giang and Quang Binh provinces, many un-electrified villages were found to comprise fewer than 15 households. These rural areas are suitable for renewable energy supply since, at present, the electricity supply radius in these remote villages is less than 10 km. Therefore, investment in grid expansion in such scenarios may be more costly than cheaper, off-grid RE alternatives.

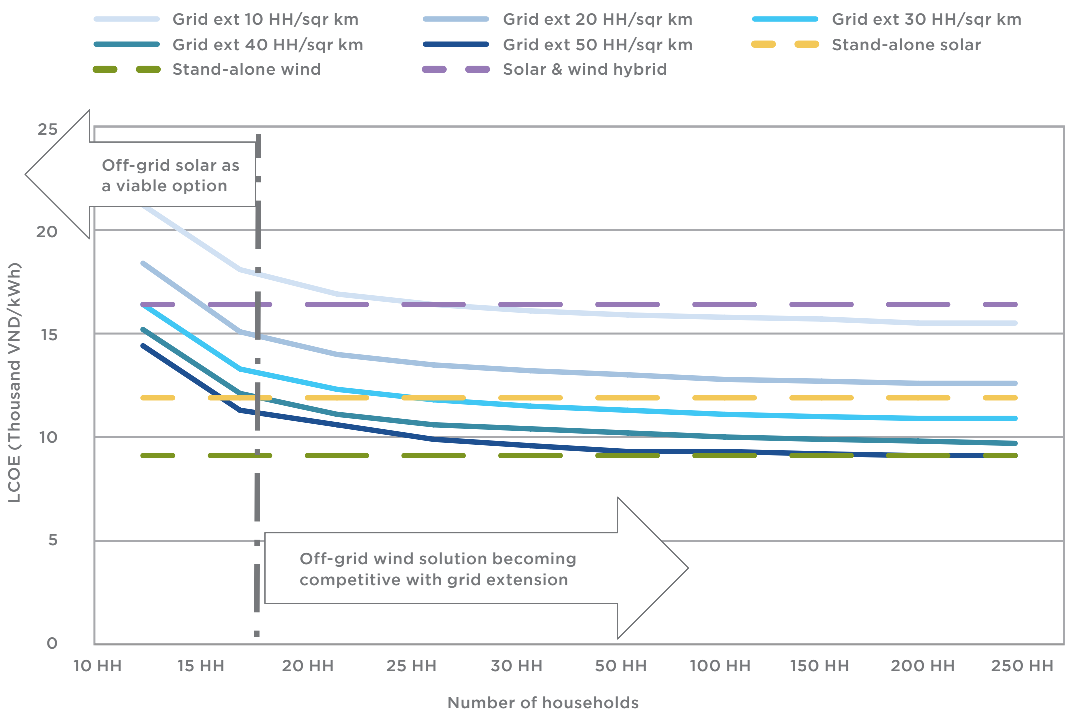

Figure 11: Electrification costs for villages located 5 km from a medium-voltage line: A stand-alone off-grid low-wind speed (locally manufactured) turbine is the cheapest option

Source: own

Case 2: Communities 10 km from a medium-voltage station

This case shows that for communities located 10 km from a medium-voltage station or distribution line, the stand-alone low-wind-speed wind turbine (9.087 VND/kWh) is the cheapest option. Stand-alone solar PV (11.873 VND/kWh) is also a cost-competitive option when the cluster comprises fewer than 25 households.

The cost of grid electrification increases with distance from the MV line. A hybrid solar PV+wind solution becomes feasible when the cluster to be electrified comprises fewer than 15 households (cf. Figure 12). The second case study gradually reveals that: When electrifying rural areas located further from existing medium-voltage lines, grid extension is comparatively costlier than the RE alternatives.

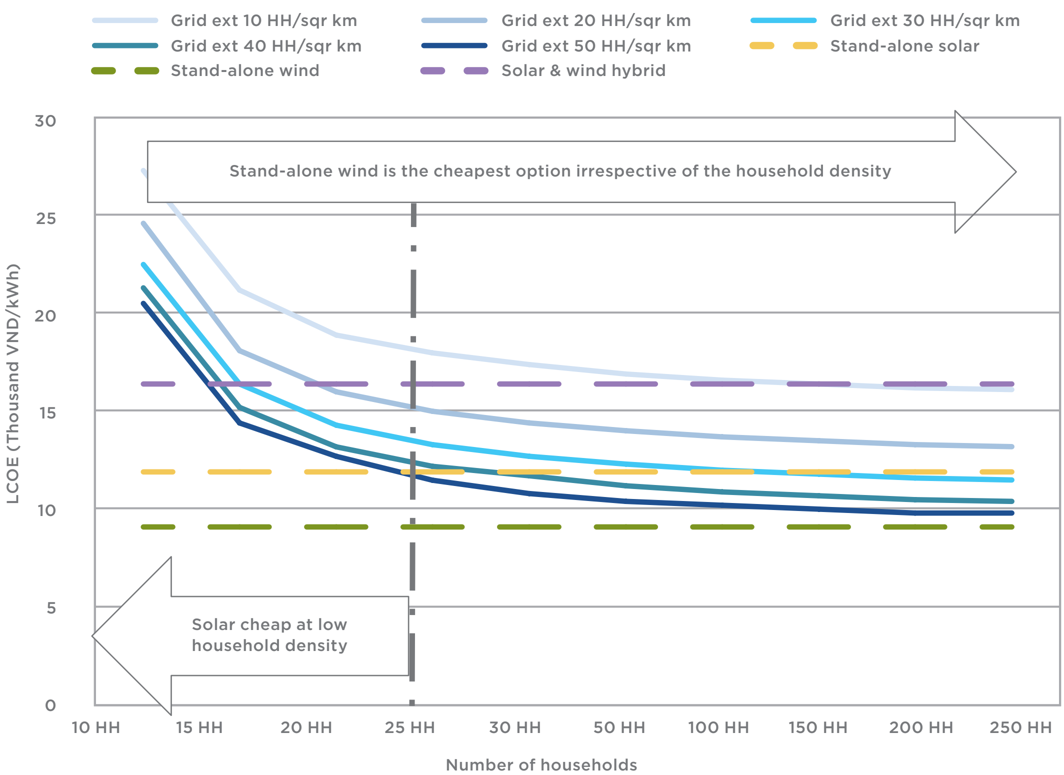

Figure 12: Cost of various electrification options 10 km away from the medium-voltage line: stand-alone off-grid low-wind speed (locally manufactured) turbine is the cheapest option

Source: own

Case 3: Communities more than 20 km from a medium-voltage station

The third case study establishes the viability of off-grid renewable energy alternatives as the cheapest options to electrify rural clusters similar to the landscape of Ha Giang Province. As established in the second case study, grid extension is a comparatively costly option for electrifying rural areas located far from existing MV lines (cf. Figure 13). Grid electrification of more than 200 households located 20 km away from an MV line would cost about 11300 VND/kWh (presuming high consumer clusters exceeding 50 HH/km²); it becomes more expensive (17.445 VND/kWh) to supply electricity to these areas at a low household density of 10 HH/km². Solar & wind hybrid alternatives also become cost-competitive against grid extension for small household clusters.

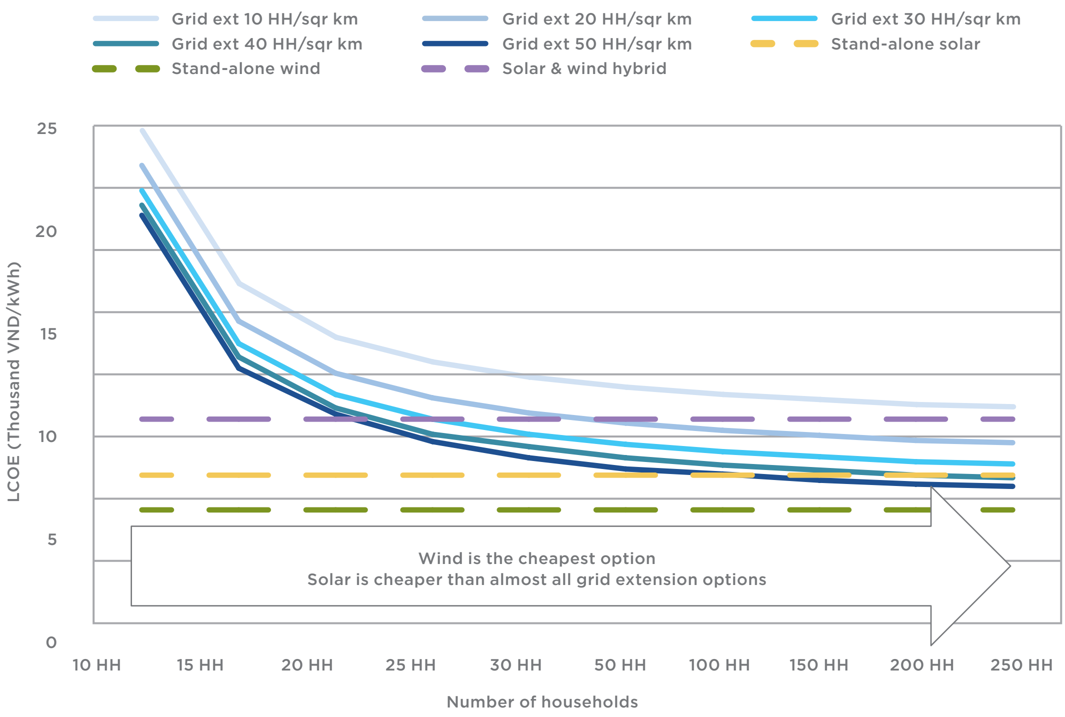

Figure 13: Cost of different electrification options for households more than 20 km from a medium-voltage line: Stand-alone off-grid RE options are the cheapest means of electrifying rural areas in the assessed provinces

Source: own

3.2 Positive impacts of off-grid renewable energy electrification on education, access to healthcare and income in rural Vietnam

KEY FINDINGS:

- Due to improved lighting conditions at home, children are able to extend their study hours; this leads to improved educational outcomes.
- Households in remote areas of Vietnam benefit financially as a result of more opportunities to generate additional income from value-added services, as well as productivity gains from farmland.

The assessment focused on two areas of local value creation, induced by installing RE off-grid energy systems in the case study locations: These related to access to information and lighting. Based on aggregate results obtained from the on-site surveys, the following hierarchy of outcomes is obtained, as detailed in Figure 14. The survey classification identifies three groups of people who are positively impacted by access to energy in remote areas of Vietnam: families, children, and farmers.

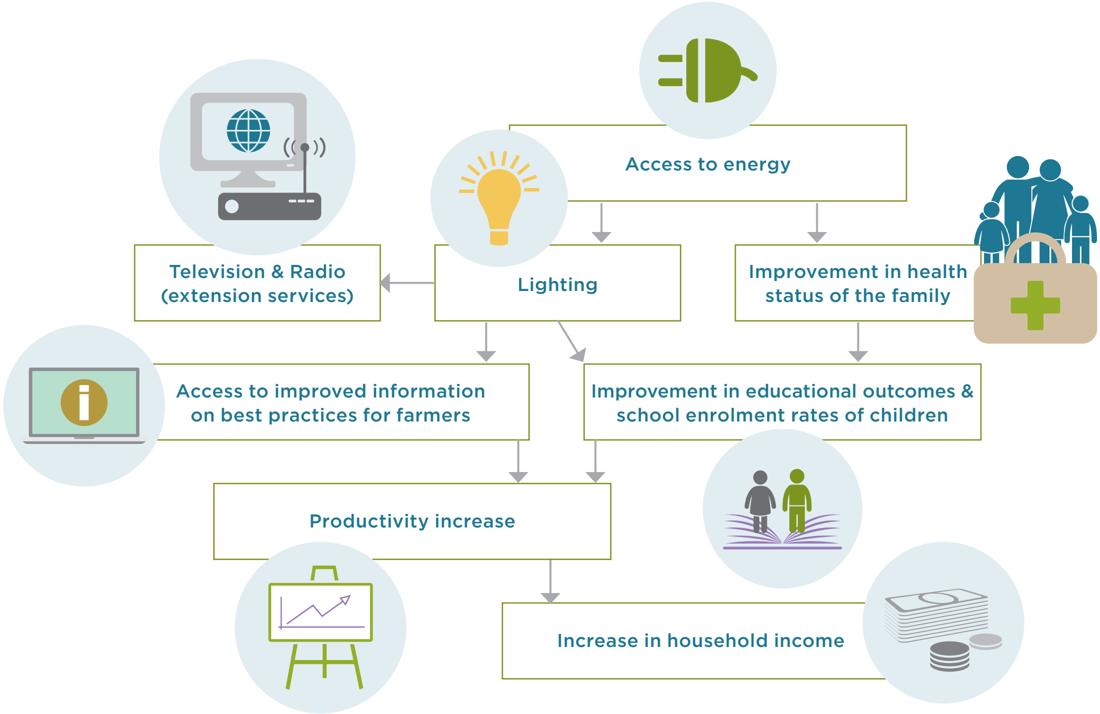

Figure 14: Local value creation resulting from energy access in rural Vietnam

Source: own

Most of the surveyed households in areas electrified with an off-grid solar system stated that children study better and more effectively in the evening when they have access to electricity; school attendance and enrolment rates were very low without access to electricity, and improved with electricity access. Farmers with a stand-alone solar home system (despite constraints on system capacity) could improve their productivity, because the ability to charge their radios and mobile phones enabled them to access better extension services. Qualitatively, the farmers surveyed at the case-study sites reported increased farm outputs and a "ripple effect" of a "doubling" in household income. Similarly, with improved lighting conditions in the household (as a result of less dependence on burning wood, candles or kerosene lamps), children's health improved, with less frequent visits to the nearest hospital. Additionally, the survey results show that, after gaining access to energy through stand-alone, low-capacity off-grid solar systems, the communes' health care facilities are better equipped to service patients' needs during the late hours of the day. In conclusion, due to the uneven geographical dispersion of un-electrified household across the country, national-scale assessments fail to identify significant socio-economic benefits of electrifying rural communities mainly through off-grid RE alternatives. Most importantly, the improvements in living standards and socio-economic parameters are more applicable and relevant at the commune level and more visible at the scale of rural-clusters.

As identified in this study, there are cases whereby off-grid renewable energy technologies present the least-cost option for electrifying rural areas (especially those with low load-density) and some specific cases where grid-extension is more cost-effective. Nevertheless, the cost and effects of delayed electrification also need to be considered when deciding on the pace and motivation for adopting off-grid RE alternatives in the un-electrified rural areas of Vietnam. Conversely, although not evaluated in the survey, the local manufacture of wind turbines in Vietnam can provide options for employment and value creation. Low-wind speed wind turbines were found to be the cheapest option for electrifying most households in rural Vietnam. Thus, further analysis is required on the potential for this technology to provide "technically skilled" rural employment.

4. Creating an enabling environment for least-cost electricity access in Vietnam

This COBENEFITS study shows that off-grid renewable energy systems are predominantly the cheapest option for electrifying the remaining un-electrified areas in Vietnam, and can promote local value creation benefits of electricity access in rural communities. The socio-technical analysis conducted shows that off-grid stand-alone low-wind speed turbines provide the cheapest solution for electrifying the assessed areas (LCOE of 9087 VND/kWh), followed by stand-alone solar PV systems (LCOE of 11873 VND/kWh), despite the cost-competitiveness of grid extensions to large household clusters. The economic viability of these alternative rural electrification options needs to be improved within the next five years in order to deliver on the Vietnamese government's goal of 100% rural electrification by 2025. Thus, in order to drive the necessary social acceptance and also enhance the local value creation benefits that electricity access will provide through these least-cost alternatives on a micro scale in rural areas: Effective policies, which combine the roles of the private and developmental sectors, need to be developed and put in place.

It is commonplace that, due to low income levels in rural areas, grid-electricity consumers are subsidised by the government at the state level through different mechanisms, despite this not being the least-cost electrification option for rural areas. Therefore, by replicating similar adoption mechanisms for these alternative solutions, the seemingly "high" initial cost burden that may be placed on off-grid consumers in rural areas can be ameliorated.

What can government agencies and political decision makers do to unlock the benefits of energy access based on renewables and rural electrification in Vietnam?

How can other stakeholders unlock the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just energy transition?

Building on the study results and the surrounding discussions with political partners and knowledge partners during the Enabling Policy Round Tables, debate should be considered in the following areas, where policy and regulations could be introduced or enforced in order to maximise the benefits or rural electrification within the shift to a less carbon-intensive power sector.

Integrate renewable energy off-grid solutions into national legislation, plans and programs as priority options to promote energy access in remote areas

Renewable energy solutions are appropriate, sustainable and cost-effective alternatives to grid connections for electrifying remote rural areas and communities. Linking rural electrification through RE-enabled off-grid solutions with the explicit socio-economic indicators is essential to drive energy access plans within political discourse and legislation. An exemplar approach to planning off-grid renewable energy is elucidated in Park et al. (2018). One such window of opportunity, for prioritising renewable-based off-grid energy planning in rural areas of Vietnam, is provided by the review process for the National Criteria on New Rural Communities (Decision 1980/ QĐ-TTg). Policy makers, especially at the provincial level, should therefore use available windows of opportunity to integrate RE–enabled off-grid electrification options as priority solutions in the ongoing legislative plans involving the power sector or the review process for the power development plan eight (PDP 8).

Tailor renewable energy solutions to local conditions and enable local supply

The term "remote areas in Vietnam" encompasses a variety of landscapes with unique environmental features; the communities and households in these areas are also diverse. Thus, there are varying energy access needs and demands across these communities. Given this high variety of demands, individual tailor-made and transferable technical solutions for local conditions are thus necessary. To develop solutions tailored to the individual needs of communities and people, data collection and assessment from local households are crucial, complemented by community-specific cost–benefit analyses that consider the socio-economic development dynamics and peculiarities of the areas: Rural areas which are predominantly agri-based will essentially have differing developmental objectives from tourist-focused rural communities. Such specificities also need to be considered throughout the country. To this end, adequate training is needed for professionals in provincial and local government, enabling them to effectively conduct the necessary assessments of needs and cost–benefit analyses.

Pricing of off-grid solutions and services: cross-subsidies for consumers

As electricity pricing in Vietnam is considered a social good, successive governments have sought to make electricity access affordable to even the poorest sections of society, and have rolled out a number of subsidies to achieve this. Rural domestic centralised grid electricity consumers are subsidised by the government in order to make the electricity tariffs very low and affordable. However, this benefit may not apply to private sector off-grid RE projects, even though the end-consumers may belong to similarly disadvantaged socio-economic strata; consequently, they would be charged higher unit costs for electricity supplied from off-grid systems if rural electrification is driven solely by the private sector. It is therefore recommend ed that, for off-grid RE solutions where the cost of supply is comparable to the grid (as established in the present study), the Vietnamese government should introduce a provision at the provincial level, to apply cross-subsidisation mechanisms to rural off-grid RE consumers in order to ensure parity in electricity pricing. This will not only make reliable and quality supply through off-grids affordable, but will also serve to fulfil the government's objective of transitioning to clean sources of energy.

Develop local skills to maintain growth

Ensuring the long-term operability of renewable energy solutions in Vietnam's remote areas remains a challenge. In areas with limited access, few local people have the ability to repair and maintain renewable energy equipment, and project developers often fail to consider the local capacity building for O&M (operation & maintenance) in planning off-grid projects. The potential for direct employment from off-grid RE projects, especially for low-wind speed turbines manufactured locally in the host communities, is yet to be explored in Vietnam. Opportunities for direct employment in the local renewable energy value chain can be fostered through effective collaboration between local technical schools and the private sector for planned projects; this essentially aids "localisation of industry" which in turn drives local employment creation and skill transfer.

Premised on the growth and expansion of off-grid RE solutions in Vietnam, there is a need for skilled technicians to operate and maintain such plants, and also tariff-collection staff. Thus, it is recommended to mandate skill-development programmes in order to create local employment opportunities within the community. Mandating project developers to ensure skills transfer to local people would ensure that a qualified workforce is always available on-site to repair defects and to keep the systems running. As a ripple effect, the prospect of income from maintenance activities could indirectly generate support for renewable energy options within rural communities and specifically as a source of local employment creation.

Build up capacities and awareness among provincial and local administrations, and define competencies clearly

A strong network of institutions, experts and government institutions is essential for ensuring energy access in remote areas through off-grid renewable energy solutions. The tasks and responsibilities of local and provincial administrations, in implementing off-grid electrification solutions and improving energy access for local people, need to be clearly defined at the national level. This inter-institutional planning and coordination process should be informed by guidelines and indicators for provincial and local administrations, which should be developed by the ministries of Industry & Trade, Science & Technology and Information & Communication. Provincial and local administrations (especially the local departments of Industry & Trade and Science & Technology) require training in order to build institutional capacity and raise awareness of off-grid electrification solutions; and also need to be suitably empowered to ensure effective implementation. Such capacity-building measures will further require training on specific issues such as information dissemination, communication with local communities, establishing effective stakeholder management programs and how to drive effective implementation.

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List of abbreviations

BOT	Build-Operate-Transfer
EVN	Vietnam Electricity
HOMER	Hybrid Optimization of Multiple Energy Resources software
IPP	Independent Power Producer
LCOE	Levelised cost of electricity
MV line	Medium-voltage line
O&M	Operations & Maintenance

COBENEFITS

COBENEFITS
Connecting the social and economic opportunities of renewable energies to climate change mitigation strategies

COBENEFITS cooperates with national authorities and knowledge partners in countries across the globe such as Germany, India, South Africa, Vietnam, and Turkey to help them mobilise the co-benefits of early climate action in their countries. The project supports efforts to develop enhanced NDCs with the ambition to deliver on the Paris Agreement and the 2030 Agenda on Sustainable Development (SDGs). COBENEFITS facilitates international mutual learning and capacity building among policymakers, knowledge partners, and multipliers through a range of connected measures: country-specific co-benefits assessments, online and face-to-face trainings, and policy dialogue sessions on enabling political environments and overcoming barriers to seize the co-benefits.

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