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CONTRACT NUMBER: AID-486-C-12-00008-00

OFF-GRID OPPORTUNITIES AND CHALLENGES IN VIETNAM
FINAL REPORT

Submitted to

United States Agency for International Development

Submitted by

Winrock International Institute for Agricultural Development

in partnership with

SNV Netherlands Development Organisation

24 January 2014

This report is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of Winrock International and do not necessarily reflect the views of USAID or the United States Government.

This study is carried out in the framework of the USAID Vietnam Clean Energy Program by:

SNV Netherlands Development Organisation
Contact person: Dagmar Zwebe
Sector Leader Renewable Energy
6th Floor, Building B, La Thanh Hotel
218 Doi Can, Ba Dinh, Ha Noi
Vietnam

Email: Zwebe@snvworld.org
Phone: +84 (0) 1238163324

Report written by:
Nguyen Thi Thu Ha SNV Vietnam Renewable Energy Advisor
Nguyen Thanh Quang SNV Vietnam Renewable Energy Advisor
Dagmar Zwebe SNV Vietnam Sector Leader Renewable Energy

EXECUTIVE SUMMARY

Vietnam has put a lot of emphasis on the development of the National Grid over the last decade, 96% of all households had access to electricity in 2009, and this increased to 96,4% in 2012. However there are still almost 550,000 households without access to the National Grid. Often these households are in mountainous regions, on islands and their living condition is poor.

The objective of this survey is to screen off-grid communities and to evaluate renewable energy resources, technologies, and potential funding for their electrification.

To reach this objective a desk survey has been executed, followed by a large amount of expert interviews with relevant stakeholders in the sector including many Government Representatives, private sector, financial institutions and Renewable Energy experts from institutes and businesses. It was identified that it is challenging to obtain the official list of off-grid communities in Vietnam, for this report the list of the USA based National Renewable Energy Laboratory (NREL) was combined with the results of a in 2012 executed study of the Committee of Ethnic Minorities Affairs (CEMA).

Opportunities for biomass, wind, solar, hydro and geothermal off-grid projects are studied including the different investments. Hydro is already extensively implemented in Vietnam, solar and wind project for off-grid communities are also developed but on a less commercial basis. The policy framework is elaborated upon and it can be concluded that there is a strong need for an improved enabling environment, existing out of –but not limited to- a further developed policy framework that supports the (commercial) development of access to renewable energy. At the moment renewable energy projects are implemented mainly driven by donor funds and grants, commercial investment is still limited. The electrification rates for off-grid areas are still far from the national target for 2020, the Government lacks the funds currently to fully implement its plans, and external support in knowledge exchange, the development of further supporting policies, and demonstration projects is necessary and welcomed by the Government.

Other barriers for further development of rural electrification with RE solutions are also explored including barriers linked to the affordability and financial means available, location and logistical barriers, technological barriers and the lack of high quality (but affordable) solutions in Vietnam as well as the limited capacities of the people in the local communities that are still off-grid.

There is a large number of RE project finance opportunities in Vietnam in case the business case is strong. Nevertheless there seems to be a gap between the capacity of either the project developers and/or the (commercial) strength of the projects and the offering of the financial institutions.

Additional a scoping mission has been executed to one of he two carefully (through a set of criteria) selected locations. This to potentially develop a off-grid renewable energy pilot project that provide access to low emissions energy sources that meet the needs of men and women in poor and marginalized communities. Quy Chau district (Nghe An) province and Con Co island (Quang Tri) province have been selected to conduct surveys. Due to changing circumstances of the assignment only Quy Chau district was surveyed as part of this assignment. A large potential for a mini hydro solution has been identified in the studied village Thung Khang.

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Abbreviations and Acronyms

ADB	Asian Development Bank
CEMA	Committee of Ethnic Minorities Affairs
ESCO	Energy Services Company
EVN	Electricity of Vietnam
EU	Europeans Union
FIT	Fit in tariff
JICA	Japan International Cooperation Agency
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HH	Household
IE	Institute of Energy
IOREC	International Off-Grid Renewable Energy Conference
IGES	Institute for Global Environmental Strategies
NREL	National Renewable Energy Laboratory
MOIT	Ministry of Industry and Trade
Solar PV	Solar Photovoltaic
RE	Renewable Energy
REDP	Renewable Energy Development Project
SHS	Solar Home System
SNV	Netherlands Development Organization
SWH	Solar Water Heating
ODA	Official Development Assistance
O&M	Operation and Maintenance
USAID	United States Agency for International Development
VAST	Vietnam Academy of Science and Technology
VCEP	Vietnam Clean Energy Program
VFD	Vietnam Forest and Deltas
WB	World Bank

1. Introduction to the Study

This study is focusing on the identification of the off-grid regions and communes in Vietnam, to prepare for the follow-up work that will be done as part of the Vietnam Clean Energy Program, funded by the USAID, and with Winrock International as the main implementer.

The main focus of the Vietnam Clean Energy Program, Sub-IR 2.3 is to increase public and private investment in and piloting of renewable energy technologies. This is split into 3 focus areas:

- Result 2.3.1 Developers have economically viable renewable energy projects
- Result 2.3.2 Policy framework for renewable energy facilitates private sector investments
- Result 2.3.3 Off-grid poor communities gain access to renewable energy

This study is the initial step towards result 2.3.3 on off-grid poor communities.

Off-grid is defined by the project partners to areas (households, communes) that are not connected to the national grid, which are located mostly in the rural, mountainous area or island. Communities that have decentralized diesel (or other sources) electricity generation are in this report still considered to be off-grid. The off-grid areas are generally small and dispersed communities which consisting of low-income households, unattractive to private-sector energy providers or even government electrification programs.

The Vietnam Master Power Plan VII (2011) indicates that still 818,947 households are not connected to the national grid, and 759,986 households do not have any access to electricity. These number of households scattered in 189 communes, account for 2.07% of the whole country's communes. These numbers vary depending on the source. In off-grid areas, to meet the lighting and other basic energy needs, many households continue to depend on expensive fossil fuel based sources, such as kerosene, which are energy inefficient, unsustainable and polluting.

Vietnam has diverse natural resources that can be used for Renewable Energy (RE) generation such as wind, solar, hydropower, biomass and even geothermal energy. Small and Micro Hydropower has the governments preference (MOIT, 2011) followed by PV solar solutions. Currently there are more than 1,000 wind power installations; more than 7,000 solar PV systems and 120,000 pico and micro hydropower plants installed in off-grid areas in Vietnam. As documented, most of these power projects were funded by the Government or international organizations with the different supporting mechanism. However, only few are currently operating at full capacities mainly because of the technical failures.

Additional a scoping mission has been executed to one of he two carefully (through a set of criteria) selected locations. This to potentially develop a off-grid renewable energy pilot project that provide access to low emissions energy sources that meet the needs of men and women in poor and marginalized communities. Both Quy Chau district, Nghe An province and site for Con Co island, Quang Tri province have been selected to conduct surveys. Due to the changing circumstances during the survey only Quy Chau district was surveyed as part of this assignment.

2. Identification of Off-grid Communities

This chapter will give some general information on the off-grid communities in Vietnam, its energy use as well as other general information and background on electricity prices.

2.1 Community Information

There is no official list publicly available that indicates the off-grid areas and communities in Vietnam. To obtain such information multiple meetings with local authorities (different departments in ministries as well as several government institutes), agencies, organizations and companies have been established. Different reports provide different indications of the number and the locations of the off-grid communities.

The Master Power Plan (MOIT, 2011) indicates the following; by September 2009 the national power grid covered all 63 provinces and its cities and 536/547 districts (98%). Of those, 11 rural districts had not connected to power grid yet but electricity was distributed via local diesel power and local small hydro power plants. On a community level 8,931/9,120 communes have access to electricity (97.93%) - in which 8,890 communes (97.5%) connected to power grid, 41 communes (0.5%) accessed electricity by local power production. Currently, there are 189 communes left in Vietnam living without electricity and another 41 communes with off-grid solutions. Division over the country is:

- 97% of 5,523 communes in the North
- 99.3% of 1,557 communes in the Centre
- 99.4% of 2,048 communes of the South

On household level the numbers are slightly lower, 94.7% of all rural households, or 96% of all households in Vietnam are connected to the national grid according the Master Power Plan (there are 14,671,836 rural households or 20,758,415 total households in 2009 in Vietnam). An additional 58,961 households access electricity from local decentralized power generation. Division over the country is:

- 94.5% of 7,444,127 households in the North
- 94.7% of 2,214,058 households in the Centre
- 94.2% of 5,013,651 households in the South

There are still 818,947 households were not connected to the national grid in 2009, and 759,986 households do not have any access to electricity provided by the Government/EVN.

Figures of EVN's individual companies (5 large power companies in total, with underneath several smaller subsidiaries), also of 2009, indicate similar figures 784,470 households with no connection and 56,010 households with decentralized electricity supply (this was 862,050 and 52,315 in 2008). The 2012 figures of EVN show that this has reduced to 549,131 households country wide, and an additional 30,925 households that are sourced with decentralized units.

The World Bank (2011) report on The Vietnam Rural Electrification Experience, indicates that little over 600,000 households does not have access to electricity (3.7% of all households in Vietnam). The most recent survey, which was done by the Committee of Ethnic Minorities Affairs (CEMA) in 2012 has shown little over 73,000 households (in 79 communes) without access to electricity.

Multiple governmental institutes, organizations and companies in Vietnam like GIZ, ADB, WB, VinaForest, Tan Viet Solar, Golden Bridge etc. as well as local agencies as Department of

Network Planning under Institute of Energy, Department of Electricity Grid under General Directorate of Energy (MOIT), Rural Electricity Network and Business Department of EVN, the Institute of Energy were met to increase understanding of the current electricity situation in Vietnam, as well as opportunities and challenges in the field of rural electrification and electrification rates, as well as trends and strategy for electrification for next 10 years. Only the database as developed by Committee of Ethnic Minorities Affairs (CEMA) was shared and public. All other databases were indicated to be sensitive and/or non-public.

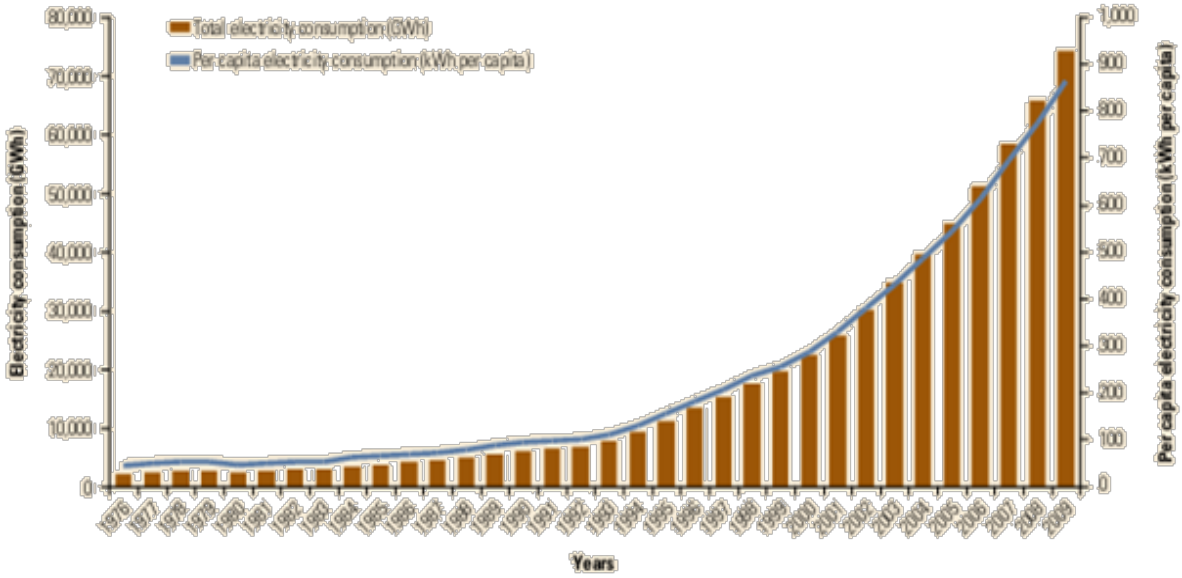
Based on the Governmental figures in the Power Plan and the other sources we have to conclude that it is unlikely that this database is a full list of un-electrified communities in Vietnam. Unfortunately the CEMA list is the only information available in the public domain and therefore it was decided by SNV – in cooperation with the Winrock team - to move forward with this list for the GiS mapping and the selection of the communes for further investigation. The list is modified by SNV based on (more recent) literature on existing electricity projects in Vietnam.

In this list, information on village (hamlet), households, populations, primary economic activity, climate condition, natural resources, income, poverty rate, official ranked status, energy access has been identified. The detail information of this list has been found separately from this report in Annex 1.

2.2 General Assumptions on Energy use and Electricity Prices

Electricity consumption in Vietnam is growing from a very low base. In 1995, total power sales of 11.2 TWh amounted to only 156 kWh per capita per year. Even after growth in electricity use to 74.9 TWh about seven times the 1995 level by 2009, total per capita electricity consumption amounted to only 865 kWh per capital per year. The Vietnam average electricity consumption shown quite low compared with other East Asia and Pacific countries (1,883 kWh/cap/year (2007)) and other low and middle income countries worldwide (1,606 kWh/cap/year) (MOIT, 2011).

Figure 1 Per capita and total electric consumption in Vietnam. Source: World Bank, 2011



According to the statistic data of Vietnam on current energy consumption for household scale in different areas, the average energy demand for rural household is estimated at 30 - 70 kWh

per household per month. Nevertheless there is a distinction of usage between the different rural areas as shown in Table 1 below. Electricity needs for off-grid households is really small, very often not more than a lamp and some other small appliances. It was estimated at an average of 17.8kWh/month per household by Ky, 2003 for off-grid households. It is common knowledge, and many researches and experts interviews indicate that after off-grid communities get access to electricity, usage levels will rise to the average levels in Vietnam. The World Bank report (2011) shows that it takes in Vietnam on average 5-6 years to get stable. Nevertheless investments and the designed power projects need to take this growth into account. The expected energy demand for rural households that are on-grid is shown in Table 1.

Table 1 The foreseen energy demand for rural household in Vietnam (WB, 2011) (MOIT, 2011)

Unit: kWh/household/year

No	Area	2010	2015	2020
1	Town	1000 – 1200	2500 – 3000	3000 – 4000
2	Rural Plain area	800 – 1000	1500 – 2500	2200 – 3000
3	Rural midland area	500 – 700	800 – 1200	1500 – 2000
4	Rural mountainous area	350 - 500	650 - 900	1000 - 1500

Electricity prices were increased with 5% in August 2013 (following the decision of the Ministry of Industry and Trade). The electricity price was increased with VND71.85 per kWh to VND 1,508.85 per kWh on average, these prices are charged by The Electricity of Vietnam Group (EVN) (Phuong, 2013). More specifically the price range will be from VND993 per kWh (US$0.05) to VND 2,420 per kWh ($0.11) for local households[1]. In case of poor and low-income households there are special policies in place (see also Chapter0), and therefore the first 50 kWh used by this group of people will be for the lowest price of VND993 per kWh mentioned in the range. Poor households will enjoy a subsidy of VND30,000/household per month (US$1.42) per for their electricity bills (see Decision No. 268/QD-TTg dated 23/02/2011 on providing electricity sale price). "Poor households" in Vietnam is defined by having less than VND400,000 income per month (US$20) (Decision 09/2011/QD-TTg).

With an average price and an assumed consumption of 550 kWh per year in the (extremer) rural areas the average cost per household on energy is VND825,000. For the poorest households, which are most often also the households that are still offs-grid an assumed electricity use per year is 400 kWh, which would cost them VND575,000 per year.

2.3 Off-grid Areas Electricity Prices

A new regulation[2] came in place in 2013 in rural areas, highlands, and island that are not connected to the national grid (off grid areas), the retail electricity prices for domestic consumption are approved by the provincial People's Committees, and shall not exceed the following ceiling price and floor price (yearly adjusted):

- The floor price: 2,263 VND/kWh ($0.11)
- The ceiling price: 3,772 VND/kWh ($0.18)

[1] Circular No 19/2013/TT-BCT, Provisions on electricity selling price and implementation guidance, dated 31/07/2013, MOIT
[2] Electricity Law 2012 and the Circular No. 19/2013/TT-BCT dated 31/07/2013

In case of decentralized electricity production, the owner or investor will formulate the schemes for the retail price for electricity serving local customers on profitable basic and specify the subsidy for the loss of electricity sale for local households at the set prices as indicated above that is lower than the investor's profitable basic prices, this gap will be met by state budget. Such schemes will be sent to the Department of Industry and Trade for verification and to report to the Electricity Regulatory Authority. The Electricity Regulatory Authority will send official letter with comments on the price schemes to provincial People's Committees for approval. Off-grid electricity price will be annually adjusted following same process. Some examples in this report have lower prices as the projects were developed before this new regulation came in place.

Without the government subsidies on operation/electricity prices and support in investments for both capitals it is unlikely that decentralized (off-grid) power production can be successful. Incentives for (commercial) companies are limited, as the affordability of the households is not in line with the costs of production (See Box 1 for an example). Often off-grid decentralized power generation is through the use of diesel, an expensive source of energy as well besides RE.

Box 1 Example of decentralized power production, prices vs. costs

The example of Ly Son Island (ADB, 2008)

A central diesel power system with a total capacity of 3MW has been installed with a 22 kV power distribution system to serve 3000 consumers. The system was owned and operated by EVN (ADB, 2008). The electricity price was subsidized at a fixed price of 750 VND/kWh ($0.04) to the households, while the production cost is informed to be around 5300 VND/kWh ($0.26). The financial gap was mainly covered by EVN (informed to be VND 9 billion in 2007 ($450,000)) and partly compensated by the Government. Therefore the power plant was in operation only few hours per day (17:00 to 23 PM) and supplied electricity to only half of the consumers in shifts every other day. The incentives to increase power productions are low, as every kWh produced will costs the state money.

Several consumers on the island also invested in their own individual diesel power generators (1-30 kW units) to be able to access electricity for 24 hours (self-served). The individual production was found to be inefficient, at estimated cost of around 10 000 VND/kWh (0.5 USD/kWh). Such investments are of course not available for the poorest people.

Furthermore in the off-grid area, besides the energy provided by EVN or the commune (if any) people have a large demand (for household use, transport is not included in this) for kerosene, LPG and car batteries (World Bank 2011). In the off-grid areas, the consumption of kerosene and LPG and car battery for lighting purposes were accounted for approximately 18% of total energy consumption for household's use, which is estimated about 75,000 VND/year ($3.75) (2008).

In another survey report in 2003 for Giap Trung, a poor commune in Northern Province of Ha Giang (Ky, 2003), 72% of households have access to pico-hydro (through – sometimes shared-ownership) but kerosene is still widely used in the commune as a main source of energy for lighting. 97% of households reported using kerosene for lighting with a monthly average consumption of 1.5 liter per household, cost about 7,500 VND ($0.5) per month (2003) based on the fuel cost VND 5,000 ($0.25) per liter. The dry cell battery is also used for

torches and powering radio and cassette player in the. As an average use of 4.4 pairs per household per month adds 9,600 VND ($0.48) to the monthly energy budget.

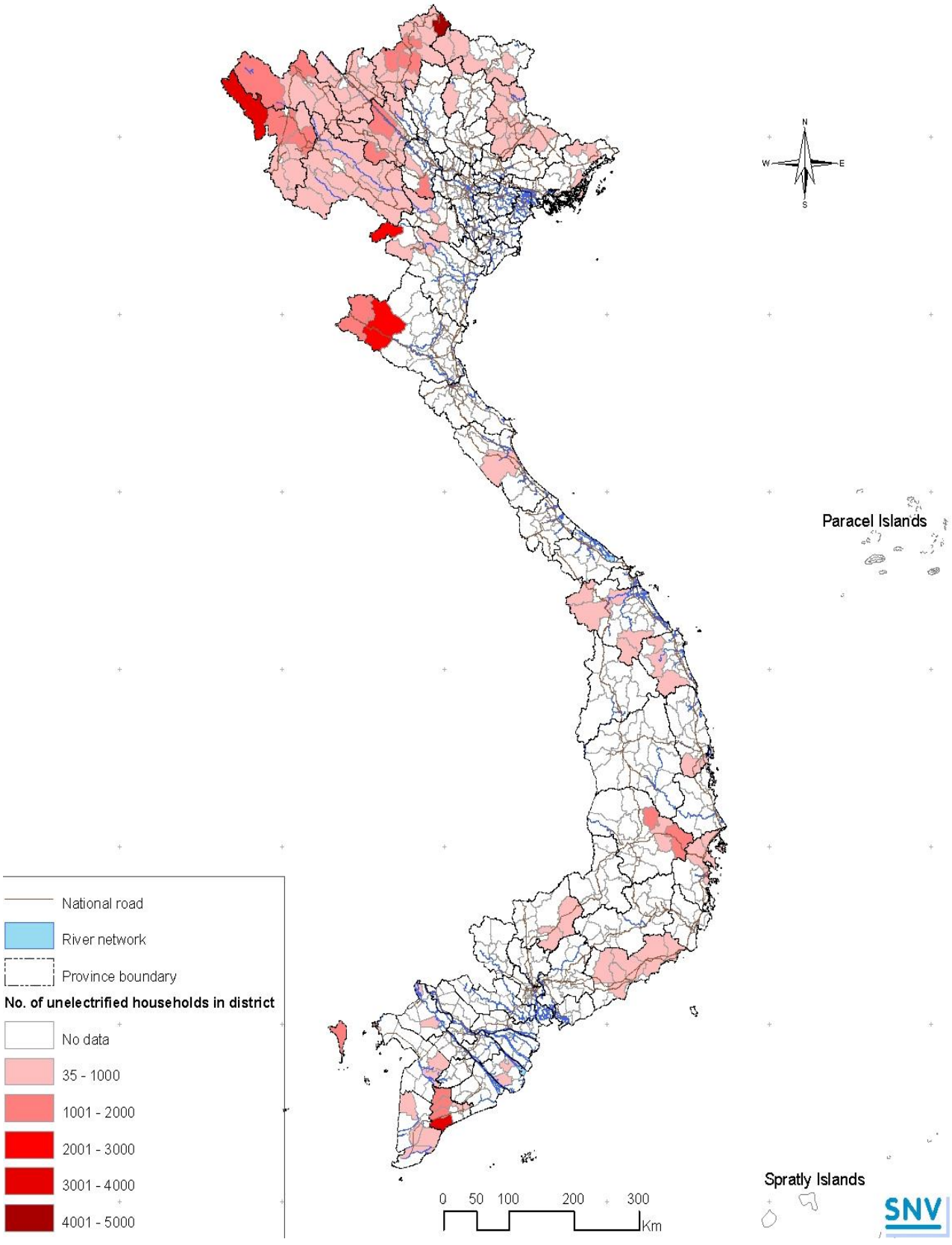
2.4 Mapping out the Off-grid Communities

The USA based National Renewable Energy Laboratory (NREL) has developed Geospatial toolkits for a large amount of developing countries including Vietnam (NREL, 2012) (funded by USAID). These maps were developed in cooperation with the Government and show a wide variety of RE resources in Vietnam, as well as the off-grid communities. The list of off-grid communities used for the NREL map is not fully complete as a total over slightly over 16.6 million households is reflected in the map, of which 78% has access to electricity (almost 13 million) while there are more than 20.7 million households in total in Vietnam. The Geospatial Toolkit is extremely useful for RE project development and planning for Vietnam. With additional support directly from NREL, SNV was able to extract the data, and use the developed maps for further analysis of the RE potentials in Vietnam for this study (see also

Figure 5 and Figure 7).

The GiS map is designed based on the number of households in each district that does not have access to electricity. This choice was made as a certain density of people creates a more favorable situation for RE solutions, and also to make the map's additional to the work already done by NREL.

Figure 2 GiS Map of the number of households that don't have access to the National Grid



(Source: CEMA data)

Additional maps, and the original size map are available from SNV upon request.

3. RE Opportunities for the Off-grid Communities

Being an agricultural country, having monsoon tropical climate, a 3,200km long coast receiving winds from the ocean, and a vast sea area, Vietnam has diverse natural resources that are potential energy sources. The research and development on making use of these natural sources has been high on the priority list of Vietnam for decades. Although the outcomes – actual implementation- of the R&D results throughout the country remain limited, the results have shown the importance of the use of such renewable resources, especially in the remote areas that have no access to the national grid.

In this chapter the following resources will be studied on a general basis, based on available literature and researches.

- Wind power
- Solar PV (does not cover solar water heaters, SWH)
- Geothermal Power
- Hydro power (mini, micro or pico system)
- Biomass to electricity

In many cases the report will touch upon the hybrid power solutions, but this will not be widely covered as the study is focused on RE only.

3.1 General Assessment of Wind Energy

3.1.1 Wind potential

Vietnam has a good potential for wind energy in general. There are about 150 meteorological stations that provide the main wind data. Typically, annual wind speeds that are recorded at these stations (at 10m) are (VUSTA, 2007):

- Land in the range of 2 to 3 m/s
- Coastal areas around 3 to 5 m/s
- Islands ranging from 5 to 8 m/s

Wind potentials are calculated through two steps, first the theoretical potential which determines the maximum wind energy output in a certain region or area - determined by using a reference wind turbine, wind speed distribution data and the available sites in that region. Followed by the technical potential which assesses in which areas it is actually really possible to have a wind turbine constructed, at what heights and what the real wind levels are.

Wind speeds are not constant, to estimate the power output of a given commercial turbine; suppliers provide power curves to calculate its potentials. An example of a power curve of two different wind turbines are shown below in Figure 3 and Figure 4.

The small wind turbines with a capacity lower than 1000W normally have larger range of working wind speed at 3-30 m/s (survival wind speed up to 60m/s). Whereas, the higher capacity wind turbines (>1kW) work at the range of 4-25m/s (survival wind speed at 50m/s).

Figure 3 Power Curve of HY-2kW Wind Turbine[3] in Vietnam

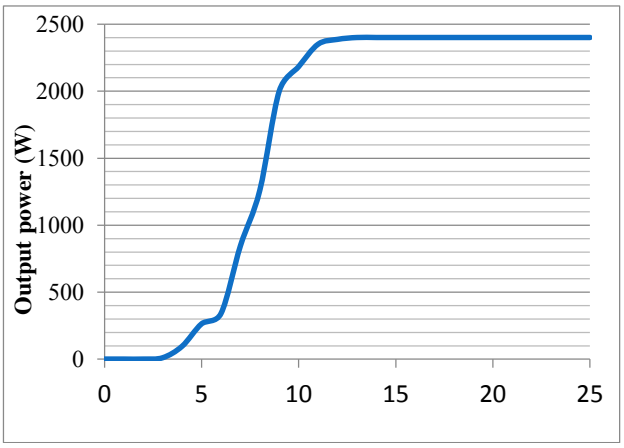
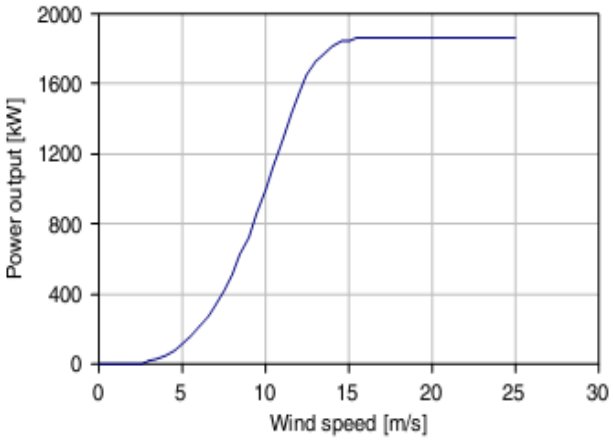


Figure 4 Power Curve of V66-1650kW Wind Turbine (Nguyen, 2006)



The wind power potential has been studied over the years by different parties in Vietnam, the insights have changed over the years. An indication of the different insights is:

- A study in 2001, shows a potential of 8,878 MW for Vietnam (8-9m/s)
  According to the World Bank's Wind Resource Atlas (WB, 2001) prepared for the 4 Southeast Asian countries of Vietnam, Cambodia, Laos and Thailand, indicates that at the altitude of 65 m (above the ground level) Vietnam has the greatest wind resources of all regional countries with the theoretical wind energy capacity reaching 513,360 MW. Of which, the good potential areas having wind speed at 7-8m/s account for 102,716 MW; very good potential at wind speed at 8-9m/s is 8,748 MW; and the excellent potential with 452MW falls in areas having wind speed >9m/s. The potential areas of large resources in Vietnam are the coast, the Central Highland and the South.
- A study conducted in 2007, showed a potential of 1,785 MW for Vietnam
  The research on wind resources and identified potential areas for wind power development conducted by EVN has found numbers that are smaller, the technical capacity is estimated at 1,785 MW. In which, the Central Coast is considered as having the largest wind resources of 880 MW, concentrating in Quang Binh and Binh Dinh provinces, followed by the south Central Coast with 855 MW, mainly in Ninh Thuan and Binh Thuan provinces.
- A study conducted in 2010, showed a potential of 2,400 MW in Vietnam
  In 2010, the MOIT and WB together conducted a survey at 3 sites for observative data to be included in Vietnam's wind resource atlas at the altitude of 80m. Results show that the wind power potential at the altitude of 80 m is 2,400 MW and that the annual average wind speed is 7 m/s.

Since 2012, a joint research has been conducted by the MOIT and the GIZ Wind Energy (

[3]Turbine provided by Viet Tan Group, a wind turbine supplier, see more about this further in this paragraph.

Average wind speed	<4m/s	4-5m/s	5-6m/s	6-7m/s	7-8m/s	8-9m/s	>9m/s
Area (km²)	99,916	70,868	40,473	2,435	220	20	1
Area percentage (%)	45.7	33.8	19.3	1.2	0.1	0.01	<0.01
Potentiality (MW)	956,161	708,678	404,732	24,351	2,202	200	10

). The project has measured wind speed at 10 sites in the Central Highland and Central Coastal provinces at altitudes of 80m, 60m and 40m. The project is designed to produce wind data representative of Vietnam's areas that have wind resources for the development of wind power in the future. After project completion, the project's reports on its procedure and standards for the installation of wind measuring poles will serve as helpful reference for wind power developers.

Table 2 Vietnam's wind resources at the elevation of 80 m above the ground (2012, GiZ)

Average wind speed	<4m/s	4-5m/s	5-6m/s	6-7m/s	7-8m/s	8-9m/s	>9m/s
Area (km²)	99,916	70,868	40,473	2,435	220	20	1
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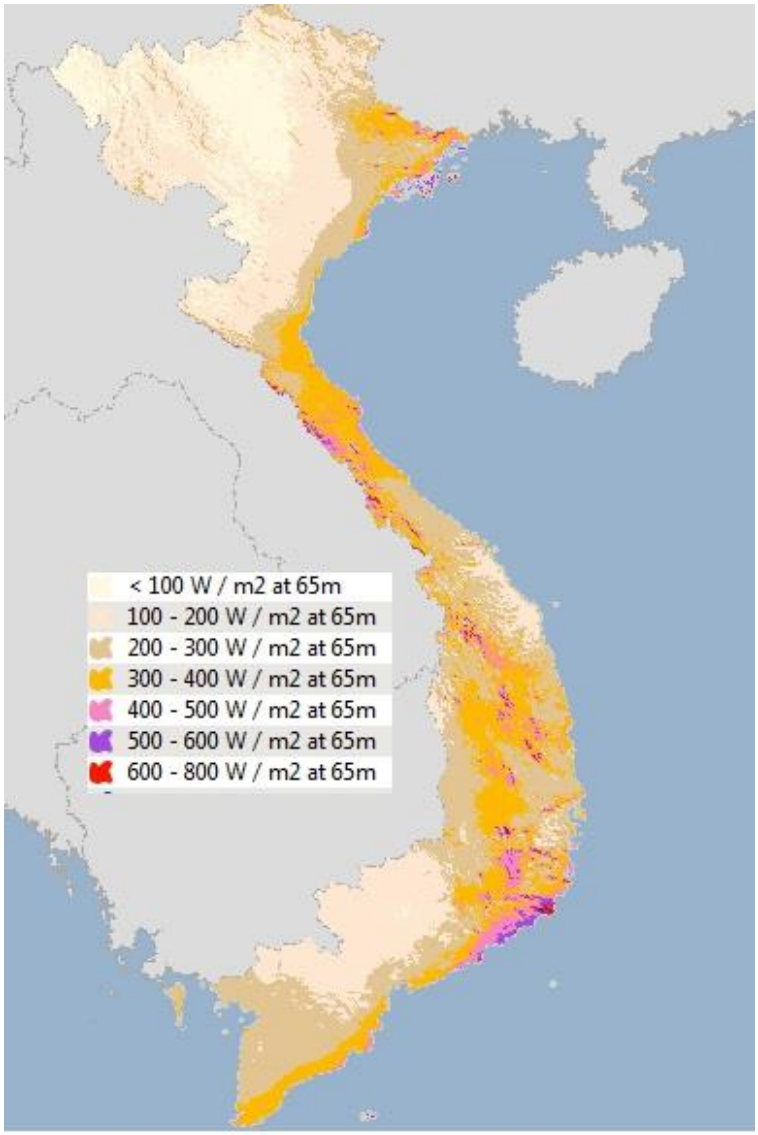
Figure 5 Wind Resources in Vietnam (NREL, 2012)



3.1.2 Current wind use

The wind has been used for energy purposes for many years already in Vietnam, initially for water pumping, later also to generate power in the remote areas. Since 1990s, stand-alone wind turbines with a capacity of 50 to 500 W were manufactures and sold by Institute of Energy (model IE1700).

Many national and foreign supported projects on especially the production and implementation of nationally made small scale wind power equipment as well as the introduction of foreign technologies to Vietnam have been implemented (IE, 2012).

Beside standalone wind solutions there are also hybrid solutions available where project developers combine (often) diesel generators with wind turbines. The range of capacities of such turbines is between 30 kW and 2000 kW (2MW) which is selected based on the assessment of energy demand-side and wind power potential of the locations.

Application	Capacity	Quantity of wind turbine	Operation start	Areas of installation
Household wind turbine	100 – 500W	>1000*	Since 1999	Central coastal areas

Off-grid wind power plants	1-50 kW	about 11	Since 2009 - 2012	Offshore islands
Wind-diesel hybrid	30kW	1	1999	HaiThinh, HaiHau, Nam Dinh Province
Wind-diesel hybrid	30 kW wind + 10 kW diesel	1	2002	Thinh Long, Nam Dinh
Wind-solar hybrid	2 MW	1	2000	Dac Ha, Kon Tum Province
Bach Long Vi wind-diesel **	800 kW	1	2004	Bach Long Vi island
PV Power Corporation Wind-diesel hybrid	9MW (6MW wind + 3MW diesel)	3	2012	Phu Quy

Table 3 Off-grid / stand-alone Vietnam Wind Projects (IE, 2012)(Thong, 2009)

* not all in operation any more ** not in operation any more, see below.

There were many technical issues during operation of these projects. Several projects have stopped due to the lack of skilled personal, maintenance and spare part. The hybrid wind-diesel system in Back Long Vy island stopped working since 2006 due to technical issue. It appears that household scale wind turbines (100 -500W installations) operate better because of regular maintenance as the households feel responsible, this is an additional stimulant towards these solutions for off-grid areas.

It can be concluded that wind power application in Vietnam is still limited; most of the projects are small scale, low quality and un-sustainable.

3.1.3 Off-grid solutions and investments

When it comes to (smaller scale) wind solutions there are already a few providers in Vietnam. Several International wind turbine manufacturers including GE, Vestas, Gamesa, Nordex, Fuhrlaender, IMPSA, Avantis and Sany have shown interest in Vietnam's wind power market. However, they are all interest in large scale wind power project development.

Chinese wind turbine manufacturers have recently shown special interest in Vietnam's wind power market. Sany Group (1.5 and 2.0 MW installations) and Shanghai Electric (1.25 – 2 and 3.6 MW turbines) have sequentially opened their representative offices in Vietnam to study the market. Chinese manufacturers offer very competitive price wind turbines, and they guarantee power output that is equivalent to or better than those of western suppliers. With the current tariff policy issued by Vietnamese Government, Chinese wind turbines have the potential to dominate Vietnam's wind power market.

Table 4 Vietnam's Wind Power manufacturers and/or implementers

Organisation	Capacities	Track record
The Research Centre for Thermal Equipment and Renewable Energy (RECTERE) HCMC University of Technology	200 - 300W for household wind turbine.	Manufactured and installed more than 900 wind turbines in Vietnam.
Institute of Energy MOIT	150 W units (developed and installed one 3.2 kW unit)	Manufactured and installed so far 30 units for households in remote mountainous areas,

The Renewable Energy Centre, Hanoi University of Technology (HUT) the RE&EE JSC established since 2011, its original precursor is RE Centre of HUT)	150 W - 500 W.	Installed 25 units of 150 W and 5 units of 500 W.
Viet Tan Joint Stock Company	1 - 15 kW	Developed wind power projects for island: Hon Me, Phu Quoc and Con Dao
Viet Linh Manufacturing and Trading electricity limited company	500 W	Viet Linh has more than 20 years of experience on design, manufacture power equipment. Wind turbine with 500W capacity is one of their main product which has been installed in Hue as hybrid solar-wind power for a riverside resort.

The off-grid potentials are estimated to be significant (Phong, 2008). On the islands it is estimated at 800-1400 kWh/sqm/year, for the coastal areas in the Central Region at 500-1000 kWh/sqm/year and in the highlands and other regions at less than 500 kWh/m^2/year.

The Master Power Plan 7 (MOIT, 2011) indicates a focus on the off-grid islands and coastal areas that have suitable wind for turbines with a capacity of 150-300W. In the below table the Government has summarized the districts and communes with the highest expected potential for wind power.

Table 5 Government focus of decentralized wind power solutions (MOIT, 2011)

No	Commune	District	Province	Number of households	Estimated capacity (kW)
1	-	Phu Quoc	Kien Giang		5,000
2	-	Bach Long Vi	Hai Phong		800
3	Big island	Ly Son	Quang Ngai		1,500
4	Quan Lan	Van Don	Quang Ninh		1,600
5	-	Co To	Quang Ninh		1,600
6	-	Phu Quy	Binh Thuan		7,000
7	-	Con Dao	Ba Ria – Vung Tau		1,600
Total				**18,232**	**19,100**

The wind power technology has production cost at the range at 10-11 US cents/kWh. The electricity production from wind energy has become more costly over the last few years due to the rapid increase in material costs for wind turbine manufacture. Furthermore there is an imbalance between wind turbine demand and supply.

The initial investment cost for wind solutions is relative high, for larger scale turbines the investment costs fall in the range of 1,800 – 2,000 USD per kW (GiZ/MOIT, 2011). The Institute of Energy (2012) indicated that the hybrid wind-diesel power system mostly used on commune levels- requires investments around 2,400 USD/kW, in which, equipment and installation cost is account for 1560 USD/kW and 840USD/kW, respectively, the O&M cost is about 72 USD/kW. For smaller scale (home solutions) the investment cost is about 250-300 USD for a typical small size wind turbine (150W), exclusive of installation and auxiliary costs. This investment cost is still too high for rural households (Nguyen, 2006).

Box 2. An example of a hybrid solution on Phu Quy Island, Wind Power combines with Diesel Power

The example of Phu Quy Island (EVN PECC3, 2010)

Phu Quy is an isolated district island, located in BinhThuan province, about 120km from southeast of PhanThiet city. There are 3,293 household with about 27,000 people living in this island. The main economic activities are fishing and agriculture. The island has potential wind energy for electricity generation with an average wind speed at 60m high is > 9.2 m/s.

Previously, power for the island was generated solely by the diesel plant.

- Total capacity 3MW - 6 diesel generator units, capacity 500kW each
- Operating time: 16 hours per day (from 7:30 am to 11:30 pm),
- Production cost: 24 cents/kWh.

The production and daily activities were interrupted because of non-continuous power supply; therefore, over 30 individual diesel generators with a total capacity of an additional 1,000kW of electricity. Very expensive, and not available for all residents.

To solve the problem, a hybrid system (Wind-Diesel) was installed for better service. The project was funded by the Petro Vietnam Power Corporation (PV Power ER) and started construction in 2010 and was finalized in Sept 2012.

Total Capacity:

- The existing diesel generators 3MW is remained, expected to cover 20% of power load demand for island.
- Additionally 6 MW of wind power was installed (3 units @ 2MW), expected to cover 80% of power load demand for island.
- The power plant will provide annual output of 25.39 GWh

Total Investment:

- estimated at $ 17,000,000 USD (VND335 billion):
- investment in the wind power component was 2,833 USD per KW
- Project lifetime 25 years

Monitoring and evaluation in 2013 have shown the following results (ThanhNien Online, 2013):

- The poor households are paying 1,863 VND/kWh for domestic use (for the first 50 kWh/month)
- Business users paying at the price of 2,329- 3,105 VND/Kwh;
- The production cost reaches a high value of 6,647 VND/Kwh (excl. VAT).

Due to the high electricity prices, local people have cut down the demand from total consumption of 8GWh in 2011 to 7.2 GWh in 2012 (is estimated), and it is expected to be lower in 2013. Therefore the full capacity of the turbine is not utilized.

The electricity price applied for island currently is not stipulated by EVN and Government; it has been issued by Electricity Regulation Authority and BinhThuan People committee. An incentive for tariff to encourage local household having more demand is necessary to recover full load operation and maintenance for power plant.

Electricity generated by wind is the only renewable electricity that has an approved feed-in-tariff higher than the normal tariffs. More on this can be found in the policy chapter.

3.2 General Assessment of Solar Power

3.2.1 Solar potential

Vietnam lies from 23° to 8° North latitude and has good constant solar radius. The areas with the highest potential for solar energy are the Central and the South of Vietnam, where the sun shines almost throughout the whole year with an average total solar radiation of 5kW/h/m2. The solar intensity in the North varies between 2.4 to 5.6 kWh/m^2/day. The potential of solar energy per region is shown in Table 6.

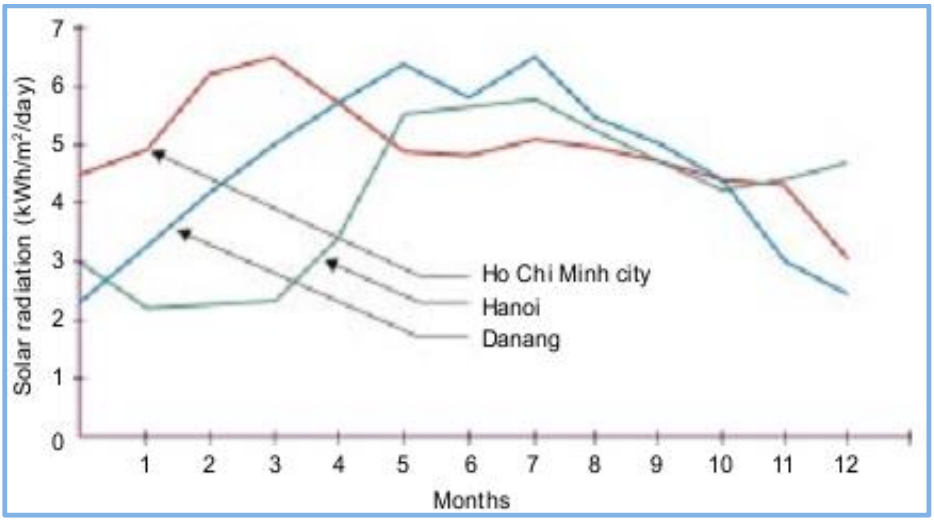
Table 6 Data on radiation intensity in Vietnam (VUSTA, 2007)

Region	Provinces	When	Average radiation intensity (Wh/m^2/day)	Hours of sunshine/yr	Radiation Kcal/cm^2/yr	Application possibility & Comments
North-East	Cao Bang, BacKan, Lang Son,	May – October	3,600	1500 – 1700	100 – 125	Low

	TuyenQuang, Thai Nguyen, VinhPhuc, Bac Giang, BacNinh, QuangNinh					In some mountainous areas the total average radiation intensity is lower due to fog and clouds.
North-West	Lai Chau, Son La, Lao Cai, Ha Giang, Yen Bai, Phu Tho, HoaBinh	March - May	3,500 (Max 5,831)	1750 - 1900	125 – 150	Low Under 1500m
		August - May	3,600			Medium Above 1500m
Red River Delta	Hanoi, Hai Phong, Ha Tay, Hai Duong, Hung Yen, Ha Nam, Nam Dinh, Thai Binh, NinhBinh	May-October	3,900 – 4100			Good
Northern Central	ThanhHoa to Hue	April - October	4,200	1700 – 2000	140 – 160	Good increase of radiation intensity when going south
Central Highlands	Gia Lai, Kontum, DacLak, Dang Nong, Lam Dong	July-September	4,500	2000 – 2600	150 - 175	Very good
Southern Central	Da Nang, Quang Nam, QuangNgai, Binh Dinh, Phu Yen, KhanhHoa	March - October	4,500 – 6,500	2000 – 2600	150 - 175	Very good
South of Vietnam		Whole year	4,500	2200 – 2500	130 - 150	Very good
Total Range			3,500 – 6,500	1500 - 2600	100 - 175	Good

The figure below (Figure 6) gives a good overview of how radiations per day vary in the different regions per day, during the year.

Figure 6 Example of solar radiation in the North, Middle and South of Vietnam (Dung, 2009)



Solar PV testing is standardized worldwide and all solar panel capacities are tested with the same conditions of an insolation of exactly 1000 Watt per m^2 (a measurement of solar radiation received on a certain surface) and at 25°C.Therefore a 200 Watt-peak system will generate 200Watt with these exact conditions. As shown in Table 6 and Figure 7 the insolation varies per region, the average insolation nevertheless in most areas is about 4 - 5 kWh/m^2/day. This means on a clear day 4 - 5 kWh of electricity will be generated. However, this describes an ideal situation, not including losses from temperature, shading of the module or incorrect installation. During the darkest month of the year, the energy losses can amount to 50 %, which implies a system efficiency of 50%, at which, 2 kWh of electricity will be generated per day instead of 4kWh. It is safe to design the system based on the average daily insolation in the month with the lowest insolation.

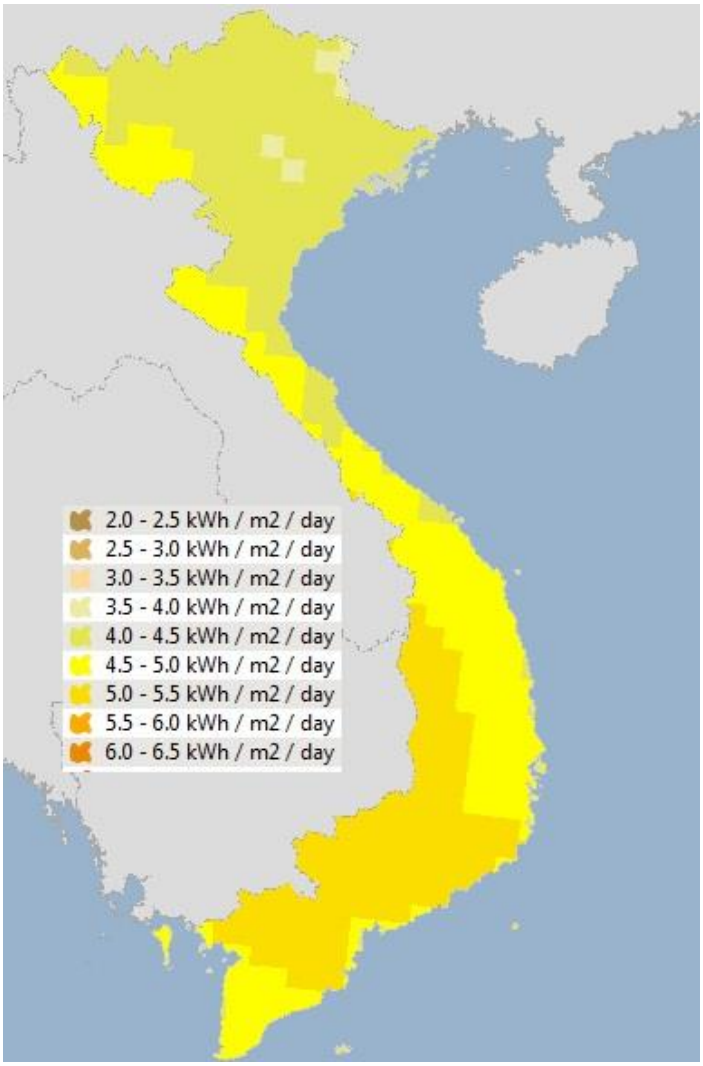


Figure 7 Solar Resources in Vietnam (NREL, 2012)

Solar water heaters are already widely available and used in Vietnam, a large directory of SWH retailers and producers is available. These transactions are fully commercial and no donor interactions are involved in this market. The Government did have a promotional tool under

the National Target Program on Energy Saving and Energy Efficiency for SWH in the past. Therefore this section focuses only on Solar Electricity.

3.2.2 Current Solar Power use

So far, more than 6,000 small solar power stations with total capacity of 750kW have been installed in the mountains and islands, half of which is used for telecommunication, 30% is used for public power for the community centers, schools, clinics and the rest is for household use. Most of these installations are found in the southern provinces of Vietnam because of the high solar radiation. There are two kind of PV system that are being used for off-grid areas in Vietnam, the stand-alone solar PV system and stand-alone hybrid system of solar PV with other energy resource such as wind, hydropower and diesel.

Table 7 Development of solar energy application in Vietnam (Dung, 2009)

Year	Solar energy application	Number	Average Installed capacity (Wp)	Total capacity (KWp)
1989-2008	Solar home system	4000	22-100	314,010
1989-2008	Public systems	152	100-300	30,394
1989-2008	Medical center	24	150-300	3,450
1990-2008	Telecommunication systems	2000	500-3,000	1,000,000
1996-2000	Radio telephone	2	75-100	0.175
1995-2008	Forest guard station	90	100-1,000	32,000
1989-2008	Cultural & battery charging center	80	300-3,200	52,000
1990-2008	Navigation beacon	1300	50-150	45,000
1995-2008	Satellite receiver	50	500-4,000	100,000
2000-2003	Solar boat	2	250-640	0.89
2002-2006	Solar power plant	2	100-154	254,000
2005-2008	Solar villa/house roof	7	1,000-4,000	11,200

There are hybrid systems implemented as well.

- Hybrid system of: PV(28kW) & diesel (20kW) for Bai Huong village, Cu Lao Cham island, Quang Nam
- Hybrid system of: PV (100kW) & mini-hydro (24kW) at Mang Yang, Gia Lai Province (Central Highlands)
- Furthermore Golden Bridge Co Ltd has developed feasibility studies for several island applications including Wind-Solar Hybrid installation (searching for the necessary funds at the moment).

3.2.3 Off-grid solutions and investments

As already indicated in the above paragraphs there is a large potential for (off-grid) solar electrification, with average solar radiation of 3 - 4.5 kWh/m2/day in winter and around 4.5 - 6.5 kWh/m2/day in summer, and with 1,800 to 2,700 hours of sunshine per year. The theoretical energy potential for Vietnam is 43.9 billion TOE/year (Phong, 2008). Solar energy in

the Southern and Central regions can be used on average 300 days per year. Whereas, in the Northeast and Northwest region, the insolation is a bit lower during winter time, however, still having high potential and can be used around 250 - 280 days per year. In off-grid areas solar PV off-grid system is considered to be one of the most feasible options to bring electricity to local people.

In Vietnam most solar panels are imported as well as the batteries. The invertor, controller and other side equipment can be manufactured locally. There are only two producers of solar panels in Vietnam, and a third one is planning to start soon.

1) SolarLab - Institute of Physics in Ho Chi Minh City under the Vietnamese Academy of Science and Technology (VAST), is one of the producers, who designed the first prototype that was in line with international standards, in Vietnam in 2000. Their focus is on hybrid systems, solar combined with hydro (in mountainous areas), diesel or the national grid. This is Solarlab's Hybrid Technology of Renewable Energy sources (Madicub). Solarlab was also able to export to some of the neighboring countries. A follow-up product; the Madicub Intelligent Energy Power, is an integrated solar-local grid managing system suitable for expanding PV power. This model is being further developed for rural electrification, as a "mini solar power plant". Madicub is available from 1 kVA to 10 kVA basic for a solar array of a variable power range between 500 Wp and 10 kWp.
2) SolarBK also successfully developed their own PV equipment production. Both the panels and the inverters are made in Vietnam. They also still provide imported models. The capacities delivered can vary for the solar solutions from 200 – 250 Wp per unit (can be placed in parallel).

Planned or ongoing projects from international investors are:

3) A solar panels production factory invested by Indochina Energy located at Chu Lai Economic zone, Quang Nam province was ground breaking on 14 May, 2011. The investment capital of 390 million USD and was for a total capacity of 120 MW/yr.
4) First Solar (a US based company) postponed recently its plants to kick off a project on making thin-film technology solar panels in Ho Chi Minh City, with an investment of 300 million USD. Their solar panels with the size of 60X120 cm are capable of producing 80-85 watts per hour and have a guarantee period of 25 years.
5) Another solar panel production factory recently ground broken in January 2013 at Phong Dien industrial zone, Phong Dien district, Hue province. The project investors are World tech Transfer Investment and Global Sphere, total investment for the first phase is expected at 300 million USD.

However, due to limited market demand, finance constrains and technology issues, all three factories are put on hold. With the pullout of United Arab Emirates (UAE) investor in the Global sphere project, the local partner Worldtech is looking for another investor to replace the UAE. Meanwhile, Chu Lai Open Economic Zone in Quang Ngai announced that Indochina Energy had sought permission to delay a US$390-million solar panel project in the zone. First Solar also decided to indefinitely put on hold the project in Cu Chi District, they appointed the consulting firm Cushman & Wakefield to transfer parts of the whole of workshops covering 11.3 hectares in Dong Nam IP in Cu Chi District, but till now, the consultant has not found a buyer.

Some larger retailers in the solar market in Vietnam are:

1. Tan Viet Joint stock company established in 1997, a leading company in providing equipment and service for RE development in Vietnam. Tan Viet has implemented quite a number of solar power projects for extremely poor communes in Ca Mau, Quang Binh, Bac Lieu and subcontracted for NAPS SYSTEMS on implementing solar power solution for 300 poor communes in the mountainous areas within the framework of Program 135 funded by Finnish government.
2. Selco Vietnam Co., Ltd is a subsidiary of SELCO-Inc based in U.S.A. Specially in the design, assembly and installation solar home system (SHS), officially put into operation in Vietnam at the end of 1997. SelcoVietnamhas installed solar energy up to 100 stations for 30 National Parks, Natural conservation zones etc nationwide. They installed solar energy capacity up to 1000Wp for more than 50 army border stations and islands; Supplied more than 150kWp solar photovoltaic to the telecom companies and rural post offices; Installed over 500 kit of solar signaling for waterway, airway each kit was around 50Wp.
3. SolarV is the registered Trademark of Vu Phong Co., Ltd has worked in Vietnam since 2009 on Design, Supply and Install Solar Power System for gridded or off-grid purposes.
4. Viet Linh Manufacturing and Trading Electric – Electronic Limited Company was established in 1986 from a small production workshop in HCM City with the AST brand name. AST has a distribution network throughout the country.

Currently, about 80% of PV equipment items such as solar panel, inverter up to 10 kVA and charger controller with 10-12 channels have been manufactured in Vietnam. Most of them still follow analog technology, and the production is limited.

The Vietnam Master Power Plan 7 (MOIT, 2011) also indicates a focus on solar solutions for off-grid areas, with a focus on systems with capacities between 120-150Wp. Solar power requires a significant initial investment. A price / investment cost estimation is provided based on the separate components of such a system (Thong, 2011).

Table 8 Price indications for solar solutions in Vietnam

Key Component	Price	Unit
PV System	8,000 – 9,000	USD / kWp
PV Module	4,000 – 5,000	USD / KW
Battery	65 – 75	USD / kWh
Charge controller (SolarV - source)	30 – 200	USD (depend on the size)
Inverter (SolarV)	100 - 1000	USD (depend on the size)

Based on the electricity standard demands, some models of mini SHS have been developed as a set for easy installation by Viet Linh. The table below indicates a range of prices for the different systems they provide as an example.

Table 9 Example Mini Solar systems provided by Viet Linh Company in Vietnam

Mini-Solar Systems	Daily power demand (Wh)	Daily power supply (Wh)	Solar panel	Battery	Solar charger	DC-AC Inverter	Total investment
160Wp	~ 500	450 – 750	2 x 80Wp 6,004,800	3,231,750	583,800	3,669,600	**13,500,000 (650 USD)**
360Wp	~ 1120	1000 – 1500	2 x 180 Wp 13,510,800	6,255,000	834,000	3,669,600	**24,269,400 (1200 USD)**
480Wp	~ 1720	1800 – 2200	6 x 80 Wp 18,014,400	8,340,000	1,563,750	5,045,700	**32,964,000 (1600 USD)**
1080Wp	~ 3,564	3000 – 5000	6 x 180 Wp 40,532,400	11,467,500	1,563,750	7,714,500	**61,278,000 (3000 USD)**

Based on existing projects in Vietnam it is known that on average an off-grid household will install 2 panels with around 160 – 360 Wp in total. Therefore assuming an installed capacity of 360 Wp, the total investment would be 650 – 1,200 USD for one rural household.

Box 3 A hybrid system for Solar and diesel generator for Bai Huong village, Cu Lao Cham island

The hybrid power system of solar and diesel for BaiHuong village example

The village BaiHuong is located in a narrow stretch of the south-west coast side of Cu Lao Cham island, that belongs Tan Hiep commune in Cu Lao Cham island, Quang Nam province. BaiHuong village has 95 households, their main occupation is fishing with an average income about 300,000 VND/month.

Current power supply is through diesel generators:

- Total capacity: 29KW (12KW-15KVA and 17KW-20KVA generators) were too old
- The operation cost: 8,000 VND/kWh
- The electricity price: 4,000 VND/kWh

Like in "Box 2. An example of a hybrid solution on Phu Quy Island, Wind Power combines with Diesel Power" also here many households invested in their own personal generators (2-3 kW) for their business like tea shop, karaoke or otherwise. Partly also because the existing (out of date) diesel generator was not able to supply electricity for the whole village causing a shortage of electricity and extremely high electricity prices.

To solve the problem, a hybrid solar-diesel has been designed based on the total electricity demand in 2008 and the expectations of the average electricity demand for the period of 2008-2028 for Bai Huong village. The annual consumption in 2008 was about 27,804 kWh distributed of which 19,152 kWh for domestic use (69%); 2,892 kWh for public and service use (10%) and 5,760 kWh for productive use (21%). The expectation on annual demand for 2028 is 36,500 kWh/yr.

The hybrid solar-diesel power system that was installed since 2009:

- Solar PV system capacity: 28kW
- Back up diesel generator capacity: 20 kW (5 + 15)
- Number of household : 100
- Total investment cost: 412,098 USD
- Investors: SIDA – Sweden (80%) &Quang Nam province budget (20%)
- Cost per installed capacity: 8,585 USD/kW
- Cost per connected household: 3,924 USD/hh
- Annual operation cost: 5,067.3 USD/yr
- Capacity output: 27,804 kWh/year

The equipment that was installed:

- 165 solar panels using Sharp – Japan products with capacity 175Wp/module (total capacity 28,8 KW)
- 5 controllers SM600 and 7 inverters SI5048 using SMA – German products
- 145 battery 12V-100Ah using Voltatech - Korea

The electricity price of the system:

- For domestic, public and service users: 2,500 VND/kWh (0.156$)
- For productive: 3,000 VND/kWh (0.19$)
- Average process: 2,600 VND/kWh (0.163$)

The hybrid of PV and diesel power system has been put in operation since 2011 but currently it is working under installed capacity and therefore inefficiently. The electricity is supplied a few hours per day only. 50 batteries are in place but not operational due to a lack of spare parts for replacement and repair. (Source)

3.3 General Assessment for Geothermal Energy

Geothermal heat includes the direct use of heat from the earth, like for example geothermal baths and swimming facilities, but it can also be directly used for heat pumps or electricity generations. Direct use of geothermal heating is site specific and may not be an option for any remote communities.

Geothermal energy has been on the radar of the government for many years. Several institutes have studied the potentials of the country or specific regions since early '80s (with international and high level national support). This has not yet resulted in any geothermal projects for electricity production. Furthermore in the Masterplan (MOIT, 2011) it is only briefly mentioned as an off-grid solution and has no priority.

According to recent interviews with VAST (in public newspapers) there are more than 300 natural geothermal sources recorded identified in Vietnam in six geothermal regions of which the Northwest is the most potential area. Even though publications show that there is some interest in (commercial) development of geothermal electricity generation, no real movement has been identified in the Vietnamese market and no local organizations – other than research institutes and/or universities have shown commercial interest in the development of geothermal projects.

One of the leading geothermal power technology companies worldwide is ORMAT Technologies, has a long history in Vietnam, some of their local activities included:

- R&D in Vietnam in the '90s and planned a geothermal power plant project of 20 MW in the country. At that time the lack of supporting policies for project development of power purchase stopped developments and they withdrew.
- Ormat applied for a license for five geothermal power, with a total capacity of 150-200MW plants in 2008. It is unknown why these plans were not implemented.
- Regional news reported early 2012 that Ormat might be supplying the technology for two newly developed geothermal power projects in Quang Ngai province (designed capacity of each 18.7 MW). No recent news on these developments.

Geothermal electricity systems require large upfront investments, these include large site selection costs as the identification and analysis of the geothermal resource is a lengthy process (RETD, 2012) (Kyoto Energy). Geothermal Electricity could be a solution for Remote Areas in Vietnam, but developments in the local markets, policies in place and the knowledge levels seem not yet ready. MOIT has contracted, funded by EEP Mekong, Kyoto Energy to develop the strategy and roadmap that can feed into the National Power Plan and national strategy. This research started in July and will end by the end of 2013. Existing data (which is all outdated, from the '90s) will be used to better estimate the potentials (initially estimated at 400MW only for Vietnam, while some reports like (Phong, 2008) indicate as low as 200MW) and policies will be analyzed locally, as well as internationally (the US is furthest developed, and has good views on how policies can support the further development of this sector. This report will not focus on Geothermal Energy, it is advised to continue the discussion after the work done by Kyoto Energy and its partners, in cooperation with MOIT.

3.4 General Assessment for Hydropower

3.4.1 Hydropower potential

Vietnam has a great potential of hydro power with 2360 rivers and streams of ≥ 10km long. In general the hydropower opportunities can be divided in several different sizes. Please note that as far as known there is no official definition set by the Vietnamese Government on the right terminology to be used. The below sizes are based on common understanding in the market.

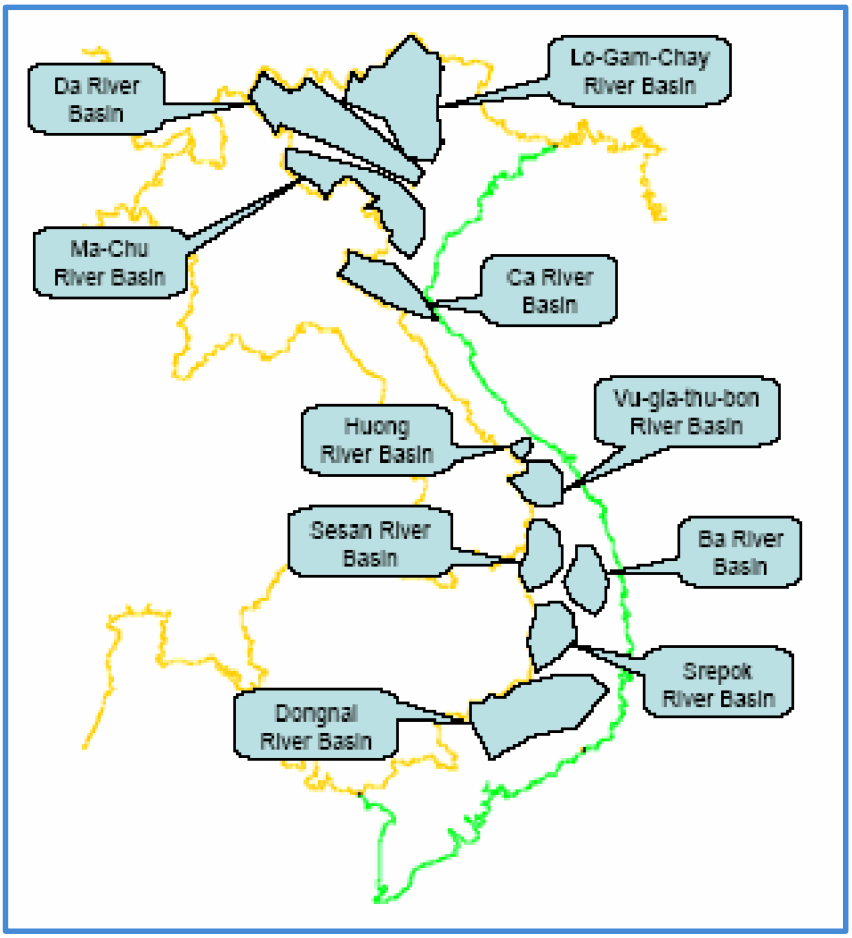
Table 10 Scaling Hydropower

Name	Size	Example usage
Pico Hydro	< 5kW	two fluorescent light bulbs & a TV / radio in about 50 off-grid households
Micro Hydro	<100kW	One household (assuming demand growth) or a small community/hamlet.
Mini Hydro	<1000 kW (1MW)	Mini off-grid aim to supply electricity for a group of households, hamlet or village.
Small Hydro	<10MW	Grid connected or mini off-grid supply electricity to village or commune.
Hydropower	>10MW	Grid connected

Small and larger hydropower (sometimes mini) are based on the larger basin's in Vietnam, and are all located around the 9 basin in Vietnam that cover areas of ≥ 10,000 km2and are rich of water resources.

Figure 8 Locations of the main river basins in Vietnam

- The Red river system in the North, including the Da and Lo - Gam - Chay rivers.
- The Mekong river delta in the South being among the largest rivers in the world.
- In the central, there are the Ma river and the Ca river of the northern part,
- The Vu Gia - Thu Bon river of the central part
- The Se San river and the Srepok river of the Central Highlands,
- The Ba river of the Coastal Area
- The Dong Nai river of the southern part.



Vietnam's gross theoretical potential of hydropower is 34,674 MW equal to 300 TWh/year, and its economically feasible potential is 18.6-20 GW or 82-100 TWh/year (see also Table 11). Vietnam's technical/economical hydro power potential is estimated to 80 to 100 TWh/year, representing about 17,700 MW. Of the total potential 51 TWh/year are in the North, 19 TWh/year in the Central regions and 10 TWh/year in the South. The hydropower potential is mainly concentrated on three rivers: 6,250 MW on the Da river in the north. 1,500 MW on the Sesan river in central Vietnam, and 2,500 MW on the Dong Nai river in the south. In

addition to the above the potential for small- and medium-size hydropower stations is estimated at 1,600 to 2,000 MW. These numbers include the total potential for all sizes.

Table 11 The Vietnam hydropower potentials (PECC1, date unknown)

River basins	Areas, km^2	Number of dams	Total capacity, MW	Power amount (GWh)
Da River	17,200	8	6,800	27,700
Lo-Gam_chay	52,500	11	1,600	6,000
Ma-Chu	28,400	7	760	2,700
Ca	27,200	3	470	1,800
H-ong	2,800	2	234	990
Vu Gia – Thu Bon	10,500	8	1,502	4,500
Se San	11,450	8	2,000	9,100
Srepok	12,200	5	730	3,300
Ba	13,800	6	550	2,400
Dong Nai	17,600	17	3,000	12,000
Micro hydropower			1,000 – 3,000	4,000 – 12,000
Total			**19,000 – 21,000**	**80,000 – 84,000**

3.4.2 Current use of hydropower

The pico, micro and mini hydropower has been the most effective technology applied popularly in Vietnam for off-grid areas. The potential stream energy is mainly in the North and Central parts of Vietnam, particularly in Lao Cai, Son La, Thai Nguyen, Nghe An, Thanh Hoa etc.

Water resources in Vietnam are very unevenly distributed geographically. Vietnam has an annual river flow estimation of about 830 billion cubic meter. The average run-off per sq. km is 2.66 million cm, about 10 -90 liter/s.km^2. The amount of power that can be obtained from a river or steam depends much on the flow rate of river or stream and the height of water falls (head). The required water flow rate and head for small hydropower plants operating at 50% efficiency is summarized in Table 12.

Table 12 Required water flow and head for small hydropower plants (NREAS)

Capacity output (kW)	**Head** (the height of water falls), m				
	3.05	6.1	15.25	30.5	61.0
	Water flow rate required (m^3/s)				
0.5	0.034	0.017	0.007	0.003	0.0017
1	0.068	0.034	0.014	0.007	0.0034
2	0.133	0.068	0.025	0.014	0.0068
5	0.334	0.167	0.068	0.034	0.0170
10	0.668	0.334	0.133	0.068	0.0340

According to the Institute of Energy (Phong, 2008), so far, about 120,000 pico and micro hydropower household plants have been installed with capacities ranging from 0.2 to 5kW with a total capacity approximately 30 – 60 MW, giving annually electricity generation output of 8 – 20 million kWh, about 50% plants located in the North of Vietnam. About 60 MW aggregate capacity of grid-connected mini-hydropower is being exploited in 48 sites through-out of Vietnam with capacity sizes ranging from 100 to 7500 kW. The installation of these systems were either directly financed by the government or through international aid (Ulfsby, 2004).

Vietnam has a large number of large scale hydropower plants, often foreign investments or Government owned. This has also resulted in 223 hydropower projects registered with the UNFCCC; created an average annual 15,574,462 tCO_2 credit (IGES, 2013). At the same time Vietnam's Government is becoming more aware of the natural hazards of larger scale hydro, which resulted in the cancellation of a large amount of already planned hydro systems (VietnamNet, 2013).

3.4.3 Off-grid solutions and investment

The Master Power Plan (MOIT, 2011) indicates a list of off-grid priority areas for hydro power for which feasibility studies have already been developed, see table below.

Table 13 Planned off-grid solutions by the Government of Vietnam (MOIT, 2011)

No	Name of project	Construction Location	Capacity (MW)	Total investment (billion VND)			Number of households access to electricity
				Total	Loan	Counterpart	
1	Thac Bay	Dien Bien	4.5	55.94	40.28	15.66	80
2	SuoiLum 3	Son La	7.5	222.22	160.00	62.22	130
3	So Vin	Son La	2.1	62.22	44.80	17.42	60
4	Nam Sai	Lao Cai	7.5	224.71	161.79	62.92	456
5	Nam Nghe	Lai Chau	2.8	121.08	87.18	33.90	265
6	A Roang	T.T. Hue	7.2	177.78	128.00	49.78	379
7	DakPring	Quang Nam	7.5	200.00	144.00	56.00	425
8	Cha Van	Quang Nam	5.6	133.33	96.00	37.33	357
9	Song Bung 3	Quang Nam	7.5	266.67	192.00	74.67	450
	Total		**52.2**	**1,464.00**	**1,054.00**	**410.00**	**2,602**

Based on these calculations the average investment for small hydro is estimated at 28 billion VND per MW (or 1.3 Million USD/MW).

Other studies also show the importance of smaller scale hydropower to electrify the off-grid areas. Hydro power stations with capacities between 0,5 and 10 MW play an important role especially in the midland and mountainous areas. The potential for small, mini hydroelectric power is estimated to 7 - 10% of the total economic hydropower potential in Vietnam, which are mostly situated in the North and Central Vietnam. The small hydropower potential (<10 MW per site) in the country is estimated to be around 800-1400 MW. This consists of the following:

1. 400 – 600 MW for grid connected mini-hydro;

2. 300 – 600 MW for decentralized, independent mini-grids and;
3. 90 – 150 MW for decentralized, independent pico-hydro systems.

Local institutions and companies have already shown their capability to manufacture a large number of systems of various types, Francis, Kaplan, Pelton and Cross flow in the capacity range from 5 to 1500 kW. However, the investors have shown some reluctance to purchase Vietnamese equipment; they have more favors in purchasing Chinese (or other foreign) equipment.

The Hydro Power Center (HPC) is the most active organization in providing consultancy for grid connecting mini hydro plants. The center has a manufacturing capacity for around 30 mini hydro plants of 20 to 400 kW annually (2004).

The investment cost for small and mini hydropower electricity is very much depending on the adopted technology, location of installation and hydropower plant scale. Therefore the investment range is really large between 950 to 2700 USD/kW (Ky, 2003). See for an example investment the box below.

Box 4 Cao Bien pico-hydropower plant, a sustainable solution for Off-grid electrification

The Cao Bien micro-hydropower plant example

Cao Bien is the poorest hamlet without electricity connection in Phu Thuong commune, Vo Nhai district, Thai Nguyen. There are 30 households with about 150 people with Dao as the main ethnic minority in this hamlet. The main income source is from agriculture activities and the hamlet is mainly self-sufficient.

The Cao Bien micro-hydro was designed based on the actual electricity demand and the possibility of increased demand in the future.

- Capacity: 18kW
- Annual capacity output: 57,600 kWh./yr
- Investment capital sources are ETC – Netherlands and Vo Nha district budget
- Construction took place in 2006
- Number of beneficiary: 30 households, 1 school, 1 culture building and 1 mechanical workshop.
- Investment cost: 35,000 USD
- Operation cost: 400 VND/kWh

A management model had been set up for Cao Bien micro hydropower, which aimed to provide a full package service for local people. An operation and management team with 2 technicians has been well trained. The local people contributed initial amount of 200,000 VND to "operation and maintenance fund" and paying annual small amounts as a using fee to maintain operation and maintenance activities. This model has worked successfully and very appropriated to apply for off-grid rural and mountainous areas.

3.5 General Assessment of Biomass

Biomass is an important source of energy in Vietnam and one that the country is well endowed in. It is estimated that approximately 90% of domestic energy consumption in rural areas is derived from biomass such as fuel wood, agricultural residues (e.g. rice straw and husks) and charcoal. Moreover, biomass fuel is also an important source of energy for small industries located mainly in rural areas.

Vietnam has a large variety of agricultural residues and woody biomass, as well as waste materials from the processing sector. The most important sectors in Vietnam are grouped below (SNV, 2012).

Figure 9 Selected residues for further research

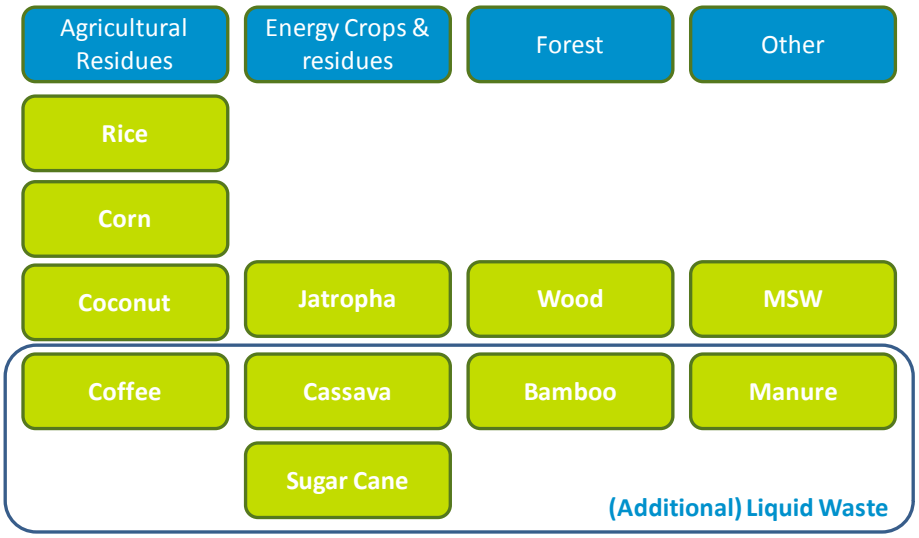


Table 14 Biomass Availability in Vietnam per crop

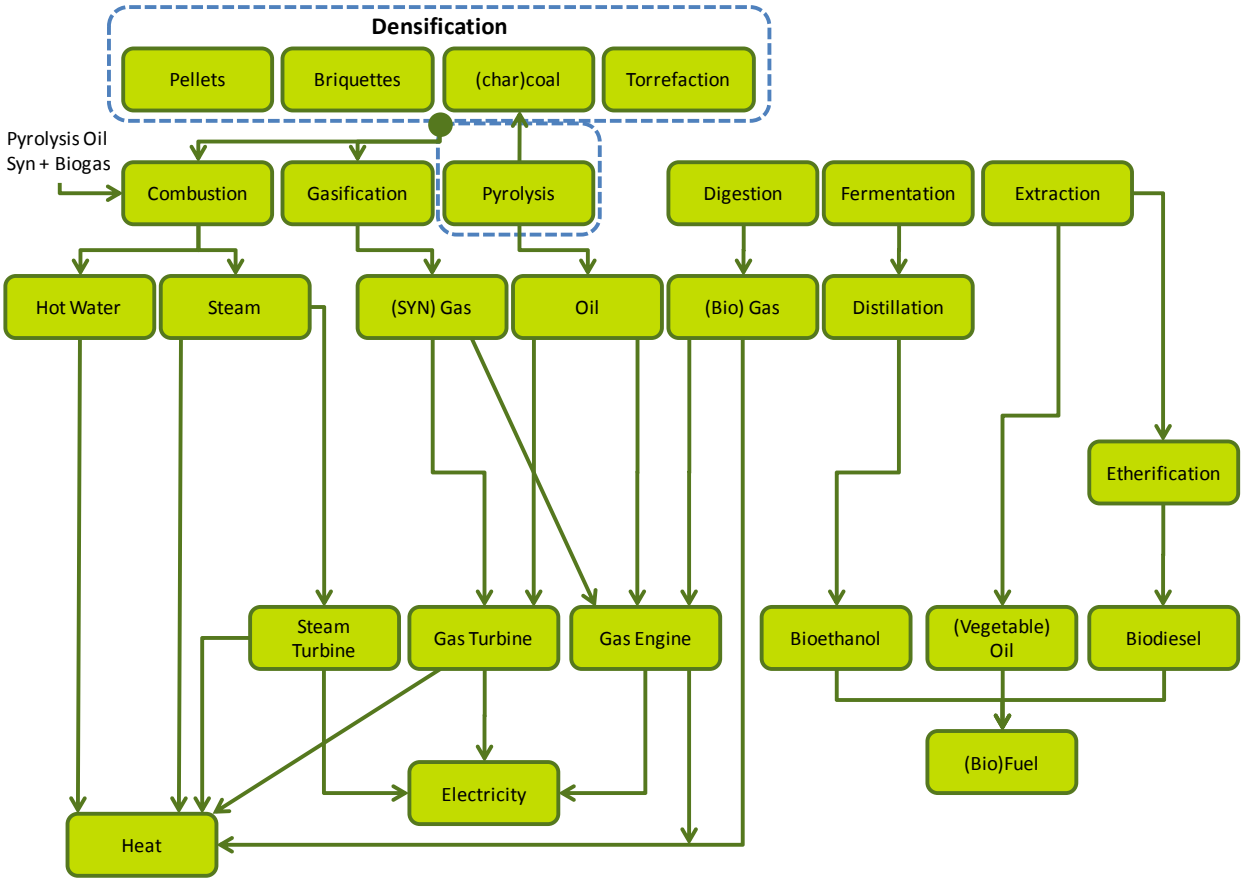
	#Ha	Yield/Ha	Location	% of resource is residue or waste	Current practices	Theoretical Availability (ton)	Practical Availability
Bamboo	800,000 plus 600,000 mixed forest	10 - 13 t/ha	Northwest and east (33%). Mostly: Lam Dong (6.2% bamboo plantations and 16% mixed forest). Tuyen Quang, Son La, Bac Can, Yen Bai (7% BP and 43% MF)	50 - 70%	1) floor manufacturing: Combustion for primary energy 2) charcoal 3) used for paper and pulp production (50 - 80%) 4) domestic fuel	Around 7 million ton/year	unknown
Cassava	560,400	17 t/ha	Central, North East, Mekong	Stem is 30% of the cassava harvest The peel: 3% The cassava root: 40% (moisture 50%) Waste water: 31%	1) Agricultural waste after harvesting: cassava stem and agro-industries' residues - fertilizer and as seedling for next harvest (not collected) 2) Waste of tapioca starch processing can be used for raw fodder and/or fodder processing 3) Waste water for biogas production	3 million tons of cassava stem	unknown
Coconut	130,000	13 t/ha	84% in Mekong Delta (Ben Tre 30%)	30% weight is husk, plus leaves and bark it is 6.5 tons/ha of fuel wood	100% shell: activated carbon or domestic fuel or industrial thermal. 96% husks: processed into coir	975 tons only husk + 1.6 million tons fuel wood + 1 million tons pith	80,000 ton of fine pith
Coffee	500,000 (7% Arabica, 93% Robusta)	1.8 t/ha	Robusta in the Central Highlands Arabica in the North	15% of the dried cherry weight	Combusted, fertilizer, dumped	135,000 tons	unknown
Corn Cobb	1,125,000 ha	4.0 t/ha	50% Northeast and 10% in south east	20-50%	animal feed, cooking, fertilizer production, export (mainly)	1,066,500 tons	unknown
Corn Stob				200%	animal feed, cooking	9 million tons	unknown

Manure	-	±30.000 million heads, manure 2kg/head	Nation wide	n.a.	biogas, dumped, fertilizer	almost 1 million ton	almost 1 million ton
Rice husk	7,500,000 ha	5.32 t/ha	20% in Red river delta and 50% in Mekong river delta	20%	Cooking (15%), brick kiln (40-45%), power plant, briquette (10%), left over (20-25%)	8 million ton	2 million ton
Rice straw				85% (on average)	Mushroom, cooking, burning in field, fertilizer, animal feed, bonsai, fruit bed (58%), burning (42%)	23 million ton	17 million ton
Sugar Cane	266,000 ha	51.7 t/ha	Mekong River Delta, North Middle and Coastal Plain, and East South	Top: 30%, Leaves: 10%, Bagasse: 9%, Fructose: 1.8%, Others: 1.2%	50-60% bagasse: combustion in Furnace; bagasse: fertilization	Top: 4,110,150t; Leaves: 1,370,050t; Fructose: 246,609t; Others: 164,406t	Leaves: 2.1 mill t; Molasses: 0.4 - 0.8 mill t; Bagasse: 2.4 - 5mil t
Wood residues	13 million (*)	residues: 5 million tons/year (**)	Central Highlands, Central North and Northeast (40%), Southeast (20%)	40% Logging, Saw-milling (38% solid, 12% sawdust)	wood chip export, particle boards, burning in kilns, domestic cooking	11 million ton residues. 4million m3 wood production	unknown

(*) 13 million ha in total, 10 ha natural forest and 3 ha planted forest
(**) 2 mil. tons from logged timber, 2.5 mil. tons from sawmills, 500,000tons from scattered trees

Different biomass sources can be converted into several energy carriers (like oil, gas, pellets, or charcoal) or can be converted into energy directly (through combustion). The different conversion routes are shown below, where in this report interest goes to electricity generation.

Figure 10 Typical routes from biomass to energy



In the table below these conversion routes are linked to the different relevant sources of biomass. Other organic material is potentially available like energy crops, jatropha or organic solid waste, but they will not be further considered here. Furthermore several conversion routes that are not applicable for the focus on off-grid situations (too complex, or in early stages of development) have also been removed. The figure above and table below are for indicative reasons; to indicate what options has been explored to come to the conclusions in the next chapter on opportunities.

Table 15 Conversion Technologies linked to the biomass sources

3.5.1	Pellets	Briquettes	Charcoal	Combustion	(An)aerobic (co-) digestion
Bamboo			X	X	
Cassava					
Coconut (Coil and Pith)	X	X	X	X	
Coffee Pith	X	X		X	
Corn (Cobb and Stob)		X		X	?
Manure					X
Manure (poultry)				X	X
Rice Straw				X	X*
Rice Husk				X	X
Sugar Cane Bagasse				X	
Wood	X	X	X	X	

Note: Energy efficient fermentation particularly of straw and leaves could make a substantial contribution to power supply.

Currently an in-depth study is executed by the Institute of Energy on the usage of Bagasse, and a follow-up study by SNV will be done on woody biomass availability, both under the framework of the Vietnam Clean Energy Program. Therefore more in-depth information will be given in later stages and reports.

Biomass for electricity generation is minimally applied in Vietnam, due to a lack of support systems, the business plans are not bankable, pay back times and IRR's are not sufficient to be able to obtain the financial support necessary. The only biomass source that is used for electricity generation on both a small and large scale is biogas. Nevertheless for this report it was requested by Winrock not to include biogas potentials and solutions for Vietnam, only solid and liquid biomass solutions.

There are nevertheless examples of large scale power projects in Vietnam fed with biomass. Like for example the six 10MW rice husk-fired power plants in the provinces of Tien Giang, An Giang, Kien Giang, and Dong Thap (TPO, 2010). Each 10MW rice husk power plant consumes 85,000 tons of rice husks per year.

Another example is from the sugar cane sector. It is estimated that about two million tons of bagasse are used annually by sugar plants for burning in steam boilers to produce at least 4 million tons of steam and 560 million kWh of power (Cuong, 2011), (Tho, 2011). Most of this is used onsite for processing and at present, only 3 power plants are selling their surplus electricity to the national power grid. The highest feed-in tariff received by these plants is 4US cents/kWh. All three plants are located in Tay Ninh province and the biggest power plant is 24MW capacity. There are 38 sugar factories that are producing heat and power from bagasse.

For off-grid communities biomass is often linked to heat production and not electricity production. Solutions like cookstoves, biomass (wood, rice husks, etc) replacing coal or other

sources in the processing industry (like brick making for example), gasifiers – in Cambodia used for electricity generation due to the high electricity prices, but not in Vietnam (and not off-grid). Biomass for electricity production plays worldwide almost no role. This is also reflected in the Master Power Plan, where biomass is only briefly mentioned when talking about biogas only. Nevertheless for heat production the potentials are large, both from biomass availability perspective as well as technology wise.

4. Policy Framework

4.1 National Policy Framework

RE is considered to play a significant role in providing electricity services to rural and poor people in Vietnam. Policy frameworks having great influence on the development and implementation of the off-grid rural electrification program, Vietnamese Government has built a clear policy framework with a set of principles, long-term goals, and national commitments to the program as below:

In the Master Power Plan, the strategy to develop and create rural power supply is indicated. Government will stimulate EVN to develop the national power grid to supply power to 100% households by 2020. The aims are (MOIT, 2011):

- To further develop the national power system to supply efficiently and with highly quality sufficient electricity to meet the power demand for production and residential purpose in rural areas. In case areas cannot meet conditions to access to national power grid, the Government provides investment and support policies for development of local power resource to ensure that by 2020 the ratio of electricity available households is 100%.
- Government provides support policies to help developing socio-economic situations, including developing power supply system for provinces and poor households in remote areas, especially if it concerns ethnic minorities, in order to strengthen ethnic's solidarity, maintain defense security, ensure the living and production of people, and improve physical and mental living.
- To have a Government program to development investment and power supply to every hamlets and minority ethnics of Tay Nguyen.
- Upgrade rural power grid to increase supply capability and electricity quality; reduce power loss in power lines.

The rural electrification (REII) project is expected to fund such developments. The objective of the REII, which became effective in 2005, is to improve access to good, affordable electricity services to rural communities in an efficient and sustainable manner. Financed with a US$200 million IDA credit and US$5.25 million GEF grant, would be achieved through:

- A major upgrading and expansion of rural power networks in about 1,200 communes.
- Conversion of the existing ad hoc local electricity management systems to LDUs as legal entities recognized under Vietnamese law, to improve management of power distribution in rural areas, ensure financial sustainability, and enable future mobilization of private funds.
- Capacity building assistance for the LDUs, provincial authorities, participating regional PCs, and national authorities involved in the planning and regulation of rural electrification.

Additional financing for the Second Rural Electrification Project (US$200 million IDA credit, approved in May 2009). Which increased the outcome to 1,500 communes (1.5 million households) instead of 1,200 as indicated above.

Table 16 Vietnam Policies that stimulate off-grid electrification

Legal document	Time approval	Main contents related to rural electrification
Electricity Law No. 28/2004/QH11, by the National Assembly	3/11/2004	Title: **Electricity law – 2004** **Related contents:** **Chapter VIII: Electricity in services of rural and mountainous areas, Islands.** **Article 60:** Policies on development of rural, mountainous, island electricity to attract al resources and encourage organization, individual to invest in building electricity infrastructure, to accelerate the process of rural electrification. **Article 61:** Investment in development of rural electrification. The state shall adopt policies to provide support in investment capitals, interest rates, capital loans and tax preferences for building, renovating, upgrading off-grid electrification for rural, mountainous area, islands.
Decision No.110/2007/QĐ-TTg by Prime Minister	18/07/2007	Title: **Approval of the Master Plan for National Power Development in period 2006-2015 with view to 2025.** Related content: **Article 1:** to approve the Master plan for National Power Development for the period 2006 - 2015 with the vision to 2025. Continue to implement program on rural electrification which have approved by Prime Minister set target to provide electricity to 95% and 100% of the communes in 2010 and 2015, respectively.
Decision No. 1855/Qd-TTg, by Prime Minister	27/12/2007	Title: **Approving Vietnam's National energy development strategy up to 2020 with 2050 vision.** Related content: **Article 1:** To approve Vietnam's national energy development strategy op to 2020, with 2050 vision • To complete the program on rural and mountainous energy: By 2010, 95% of rural households will be supplied with electricity and by 2020, almost all rural households will be supplied with electricity. • To integrate the use of new and renewable energies into the energy conservation program and other national target programs such as those on rural electrification, afforestation, hunger

		eradication and poverty alleviation, clean water, integrated fish pond-livestock pen-home garden model, etc. • To increase investment from the state budget for energy projects in rural and mountainous areas and islands so as to contribute to economic development and hunger eradication and poverty alleviation in these areas.
Circular No. 97/2008/TT-BTC, by Ministry of Finance	28/10/2008	Title: **Circular on implementing state support policies for investment, development of electricity in rural, mountainous and island areas**. **Related contents:** **Article 1**: Scope of regulation • This Circular guides the implementation of Article 61 of the Electricity Law - 2004 on the State's support policies for electricity development investment in areas in which electricity investment and activities would bring no economic benefits; and for building off-grid for rural or mountainous areas or islands. • The project owners can borrow a portion of investment capital, and enjoy preferential conditions, terms, loan interest rates, payback period and risk treatment. **Article 2:** Subjects of application • Project owners who are enterprises, organizations investing all type of power development projects for rural areas.
Decision 1208/QD-TTg, by Prime Minister	21/07/2011	Title: **Approval of the National Master plan for Power Development Plan period 2011-2030 (Master Plan VII):** **Related contents:** **Article 1:** Approve the National Master Plan for power development for the period of 2011 – 2020 with the vision to 2030. (3) The national master plan for power development. (d) The power supply to rural and mountainous areas and islands: • The development perspective of electrification in rural, mountainous areas and islands:

		- Promote rural electrification in order to help accelerate industrialization and modernization of agriculture and rural areas. - Using the sources of new and RE to supply electricity to the remote, border and island areas. Develop favorable mechanisms for management and investment to maintain and develop power sources in the regions. • Master plan for electricity supply in rural areas: - The period of 2011 to 2015: Invest for expansion of the national grid to supply electricity for 500 thousand households in rural areas. Provide electricity from RE sources to about 377 thousand rural households. - The period of 2016 – 2020: Invest in new power supply from the national grid to 200 thousand rural households. Supply electricity from RE sources to about 231 thousand rural households.
Decision No. 2409/QD-TTG, by Prime Minister	19/12/2011	Title: **Decision on the electricity subsidy for poor people.** **Related contents:** **Article 1:** Providing an expense of 930 billion VND in 2011 to support poor households on payment for electricity bills. **Article 2:** Targeted additional supports taken from social security expenditure of central budget for local budgets in 2012 to support electricity bills for poor households under national poverty line at 30.000 VND/household/month.
	20/11/2012	Title: **Amending and supplementing a number of articles of the Electricity Law.** **Related contents:** **Article 1:** To amend and supplement a number of article of the electricity law as below: • 2. Supplement to the item 1a. Priority is given to develop the rural electrification for rural, mountainous areas, islands; particularly for areas having extremely difficulty in economic-social condition. • 4. Enhance the new and RE exploitation and use; preferences policies toward development and investment projects on utilizing new and RE. **Article 8a**. Power development plan contents

		• 1d. National power development plan includes the detail program on power source development, grid development, connection of the national grid to regional countries, rural electrification, new and RE development and other related contents. • 2d. Assessment of local capable power supply status; particularly for the areas having extremely difficulty in economic-social condition. **Article 62.** The power tariff for rural, mountainous areas and islands. • 2. The power tariff for rural, mountainous areas, islands where having no access to the national grid is stipulated as below: - With regard retail electricity prices for domestic consumption, People Committee will approved the appropriate prices built by local power Unit based on the electricity subsidy approved by Prime Minister.
Decision No. 8217/QD-BCT	28/12/2012	Title: **Approval of Renewable Energy Development Plan for Delta, midland area up to 2020 and 2030 vision.** **Related contents:** **Article 1.4.** Renewable energy development plan for Delta, midland area. 1.1. Development plan for period 2013 - 2020: • Development of RE serving rural electrification in remote area, far from national grid areas. Targeted to provide electricity for 22,899 household based on potential RE available at local areas with capacity of 7801 kWp. • Development of off-grid areas: Targeted to self-provide electricity for medium cattle farms. Develop and apply about 2,421,000 m^3 biogas digesters for electricity generation. 1.2. Development plan for period 2020 – 2030 • Development of off-grid electrification: electricity self-provide for medium cattle farms; develop and apply about 436,000 m^3 biogas digesters for electricity generation. • RE exploitation program for heat and bio-fuel production: develop and apply 1,158 million m^2 solar water heating; 7.98 million m^3 biogas digesters; 627 thousand biomass improved cook stoves; 543 thousand biomass grassfires; 198 million litter of bio-fuel of ethanol.

National target program	Under reviewing	**National target program on off-grid electrification for rural, mountainous areas and Islands period 2013 – 2020.** **Related contents:** The program mainly focuses on the electricity demands and investment activities to build off-grids electrification for hamlets, villages where having no access to the national grid.

Table 17 Other supporting policies in place

Legal document	Time approval	Main contents related to rural electrification
Law No.52/2005/QH11 endorsed by the National Assembly 11	29/11/2005	Title: **Environmental Law – 2005** **Related contents:** **Article 6:** Environmental protection actions which encourage development, use of clean energy, RE, GHG emission reduction, reduction of ozone layer destruction. **Article 33:** Development of clean energy, RE and environmental friendly products. Organizations or individuals who invest in the development and utilization of clean and RE for producing environmentally friendly products, will enjoy tax incentives, investment capital support and land use for the construction of production facilities.
Investment Law No.59/2005/QH11 endorsed by the National Assembly and Decree No.108/2006/ND-CP , by Government	29/11/2005 22/09/2006	Title: **Investment law 2005** **And Detailing and guiding the implementation of a number of articles of the Investment law**. **Related contents:** **Chapter IV.** Domains and Geographical areas entitled preferences, investment preferences and support. Decree stipulated for special investment in the construction of establishments using solar energy, wind energy, biogas, geothermic and tidal energy. • Incentives for tax rates, corporate tax, equipment imported tax and income tax from technology transfer.

		• Terms of land use and land rent exemption. • Loss transfer. • Fast depreciation
Decision No.130/2007/QD-TTg by Prime Minister	02/08/2007	Title: **Decision on several financial mechanism and policies applied to Investment Project on Clean Development Mechanism**. **Related content:** **Article 3.** Potential fields to be invested and carried out CDM project (b) Harvest an apply RE source CDM projects and their products will be granted the following incentives: • Tax exemption: for goods imported as fixed assets, materials, and supplies or semi-finished products which cannot yet be domestically produced and are imported for production activities; preferential enterprises income tax rates. • Land use fee: entitlement to land use levies or rent exemption or reduction under current legal provisions. • Price subsidy: products might be subsidized by the Vietnam Environmental Protection Fund.
Decision No. 177/2007/QD-TTg, by the Prime Minister.	20/11/2007	Title: **Approving the scheme on development of bio-energy up to 2015, vision to 2025.** **Related contents:** **General objective:** To develop biofuel, a new and RE, for use as an alternative to partially replace conventional fossil fuels, contributing to assuring energy security and environmental protection. **Specific objectives for each period:** • 2015: production of ethanol and vegetable oil will reach 250 thousand tons, accounting for 1% of whole country's gasoline, oil demand; • 2025: production of ethanol and vegetable oil reaches 1.8 million tons, accounting for 5% of whole country's gasoline, oil demand.

Joint Circular No. 58/2008/TTLT-BTC- BTN&MT	04/7/2008	Title: **Guiding on implementation of some articles of Decision No.130/2007/QD-TTg.** **Related contents:** Stipulating on price subsidy for products of CDM projects, including: • Electricity produced from wind energy, solar energy, geothermal energy and tidal energy. • Electricity produced from covered methane gas (solid wastes, coal mines) (Subsidy/kWh = cost/kWh + reasonable profit/kWh – selling price/kWh –CDM selling price)
Decree No. 04/2009/ND-CP, by the Government	14/01/2009	Title: **Decree on incentives and support on Environmental protection activities.** **Related contents:** Renewable energy projects might receive the following incentives: • Regulation on incentives, support on land, capital; • Preferential corporate tax. • Exemption from import tax on machines, equipment, facilities and materials imported for production activities. • Exemption from environmental protection fees. • Be allowed to depreciate fixed assets 1.5 times faster than the normal depreciation levels under current regulations. *For example: Solid waste treatment project gets 50% investment capital from the Government.*
Decree No. 87/2010/ND-CP, by the Government	13/08/2010	Title: **Detailing a number of articles of the Law on Import Duty and export duty.** **Related contents:** **Appendix 1:** List of sectors eligible for import duty incentives includes (3) the Investment in the building of power source projects operated by solar energy, wind energy, biogas, geothermal energy and tide. **Article 12. Duty exemption** Import tax exemption is applied to goods imported as fixed assets of RE projects.

Decision No. 37/2011/QD-TTg, by Prime Minister	29/06/2011	Title: **Decision on the Mechanism supporting the development of wind power project in Vietnam.** **Related contents:** **Article 4.** Make, approve and announce of planning of wind power development: People's Committee of centrally-affiliated cities and provinces make plan of wind power development at provincial level, submit the Minister of Industry and Trade for approving. **Article 12.** Preferential of capital, tax and charge: Priority given to investment capital, tax, fees, land use.
Decision No. 50/2011/QD-TTg, by Prime Minister	05/09/2011	Title: **Stipulating functions, tasks, powers and organizational structure of the General Department of Energy directly under the Ministry of Industry and Trade.** **Related contents:** **Article 2:** Duties and power of General Department of Energy. (8) New energy and RE: • Develop and submit to the Minister of Industry and Trade for approval of master plans for provincial development of RE; mechanisms and policies to encourage development of new energy, RE, national target programs on new energy, RE; • Manage and supervise the implementation of national target programs and projects in developing new energy, renewable energy.
Circular No. 06/2013/TT-BCT, by Ministry of Industry and Trade	08/03/2013	Title: **Regulation on the Content, Process and Procedures for Preparation, Validation and Approval of Wind Power Development Planning.** **Related contents:** **Article 7.** Provincial wind power development planning. Wind power development planning of provinces and cities of first category (hereinafter referred to as provincial wind power development plan) is a Planning Project designed to identify the overall theoretical and technical wind power potential and distribution of wind potential across an individual province.

		Article 9. Process, procedure for preparation and appraisal of provincial wind power development planning. The provincial Department of Industry and Trade shall develop a Planning Project including project outline, cost estimation and submit to the provincial People's Committee for approval; **Article 10.** Appraisal, approval and publication of provincial wind power development planning. The General Directorate of Energy shall appraise the Planning Project.
Decision (under reviewing)	In place 2013	Title: **Decision on supporting development mechanismforthe biomass based power projects in Vietnam.** **Related contents:** **Article 15.** Preferences and support towards off-grid biomass based powers projects**.** • Off-grid biomass power projects will enjoy the preferences and supports on investment capital, loans, tax and land use, • The off-grid investors propose the electricity prices and determine the total support for the different in avoided cost tariff of biomass power project and the actual price before submit to Ministry of Industry and Trade for appraisal. Then after, report to the Prime Minister for consideration and approval. The fund support for the difference in avoided cost tariff of approved project and the actual price will be covered by Environmental Protection Fund.

4.2 International Cooperation for Off-grid Projects in Vietnam

There is a number of donor projects that have supported the Vietnamese Government in their aim to reach 100% electrification by 2020. The below list gives an indication of the (kind of) projects, but the total list is longer.

Program	Donors	Time	Description and Achievement
Joint UNDP/ World Bank Energy Sector Management Assistance Program (ESMAP)	UNDP World Bank (WB)	Since 2001	The objective of the RE action plan was to provide cost-effective and reliable electricity to help rural people to improve their standard of living and increase their income. The Renewable electricity was to supply isolated household and communities that cannot be reached economically by the grid and argument grid supply in remote areas. The program was focused on potential markets segment for RE and given priority to provide energy service in poor isolated communities and villages.
Vietnam Sweden Rural Energy Program (VSRE)	SIDA	2004	SIDA and MOIT launched the VSRE in order to support the acceleration of electrification in the country's rural and mountainous areas through the use of off-grid RE systems, especially small and medium scale hydropower, solar PV and biogas technology. VSRE conducted numerous assessments of the capacity and RE potential of rural areas across Vietnam to identify the most promising areas for development of indigenous RE sources and built capacity to support of RE policies. VSRE also developed the new technology standard for rural electrification which were formally adopted in 2006 as national standard to replace the localized standard.
The Solar Energy project in Vietnam.	Finish Government - NAPS system Oy – Finland	2005	The Finnish government has funded EUR5.3 million for a project on solar energy application in rural areas and localities inhabited by ethnic minority people in Vietnam. The government of Vietnam will contribute EUR1 million in reciprocal capital for the project worth over EUR6 million in the first phase. At the initial, the project helped on applying solar energy in 17 mountainous communes and localities inhabited by ethnic minority people in Ky Son, Que Phong and Quy Chau districts in the central province of Nghe An. An additional 283 communes in Nghe An province were also in the plan for solar energy development.

Renewable Energy Development and Network Expansion and Rehabilitation for Remote Communes Sector Project.	ADB	2009	The Asian Development Bank (ADB) is extending a US$151 million loan to help Vietnam expand and improve electricity services in poor and remote communities. This project aim to build on the inroad made by VSRE to deploy hydropower in rural areas which will develop 5-10 mini hydropower plants to serve communes in mountainous areas in the north and center of the country. It will also provide financial support to the Government's ongoing rural electrification program, which is seeking to expand power coverage throughout the country, particularly in provinces with large ethnic minority communities
	World Bank	1994 - today	World Bank has supported Vietnam's developments in Rural Electrification for 2 decades. A range of projects, with EVN and in some cases together with IDA. • Power Sector Rehabilitation and Expansion Project • Power Development Project • Rural Energy Project • Second Rural Energy Project • Rural Distribution Project
Sustainable business model to deliver clean energy in rural Vietnam.	Co-funding World vision Australia and REEEP	2013-2014	With total budget of 293,090 EUR co-funded by REEEP and World Vision Australia. Project is to create a business model to deliver clean electricity to off-grid villages in Vietnam, to test and refine the model in two communities to ensure its viability for a wider roll-out. The project expected to provide 100 MWh of renewably sourced electricity per year to two remote villages. Project will construct the actual plants and mini-grids in the test communities, give training to local people on installation, use and maintenance of technology. Besides, project also plan to develop local community awareness and

5. Barriers for Electrification of Off-grid Areas

Off-grid electrification projects in Vietnam have been having a challenging time, many projects including (but not limited to) The World Bank supported Remote Area Rural Electrification (RARE), and the Muong Te scheme (combines new off-grid electrification with rehabilitation of existing hydro schemes) (World Bank, 2011) the low-cost village-level electrification by JICA, the Vietnam Sweden Renewable Energy Project (VSRE) have all suffered many delays and difficulties (IE, 2009). This chapter will explain such challenges and barriers for the application of RE solutions in remote Vietnam.

5.1 Affordability and Financial Barriers

It is widely known, that the main financial barrier for RE projects is the higher initial costs compared to more traditional forms of energy like kerosene or diesel generators. Feasibility studies have shown nevertheless that on the longer term RE solutions are cost-competitive, when looking at the total life cycle (IOREC, 2012). In Vietnam this barrier has been lowered or reduced by the involvement of donors and/or the government. So far, most of the off-grid RE power projects in Vietnam were and are funded by the Government or international organizations with different supporting mechanisms. Off-grid areas are, as indicated previously, mostly remote rural areas, mountainous area or islands with a relatively high percentage of poor people. The local people have low to extremely low incomes, they are not able and/or willing to pay for electricity at high prices.

The difficulty of defining credible revenue models in the context of Vietnam also limits the opportunities to access (low cost) financing, either to support the initial investments, but also in prior stages of feasibility study. More on financial models available in Vietnam will be presented in the final report.

Furthermore the high involvement of Government funds, donor funds and/or EVN investments compete directly with potential private sector investments. Investments might not be encouraged, and –as mentioned- local stakeholders will (rather) wait for public funding with lower costs than take any investment risks themselves. When the aim is to stimulate private sector investment in the RE sector, it needs to be considered how public funds can further stimulate private sector investments instead of limit / discourage. This can be part of future policy development. This could also mean a close public-private cooperation, through cost sharing or leveraging investments, or more ESCO's like arrangements (Energy service companies - pay for service).

The affordability question was grouped in two sections;

5.1.1 Investment costs

The small scale household level. In the mountainous off-grid areas, if there is access to electricity, it is often self-sufficient by local household / entrepreneurs with pico hydropower plants (own investments), SHS's (or diesel generators). However, only few households live close enough to the stream to be able access it for the use of pico-hydro. For households further away from the stream, the installation costs for pico-hydro solutions are too high. For the poorest households it is not feasible to invest in either pico-hydro or SHS for their energy needs.

The medium and larger scale level. Investments for capital intensive RE solutions need to come from the local governments and/or EVN. Local governments get budget allocated yearly that they need to allocate themselves in line with the government priorities and the local priorities. As EVN has indicated that they will extend the grid (100% by 2020), the willingness to allocate

funds to invest in (renewable) energy is very limited. At the same time, RE solutions require larger investments than conventional solutions, so it will not be the highest priority in these often poor areas. Other more basic needs that *RE* have larger priorities. So the ability to invest is also low.

This also means that whatever investment is done on the short term, it should be in RE solutions that continue to be viable after the village or household gains access to the National Grid, through – for example- the sales of (surplus) electricity to the grid. Such viable business cases need to be developed.

5.1.2 Operational costs

This meanly is related to medium and large scale solutions, operation also requires a logistical system to collect fees (for medium and larger scale solutions), and a system that maintains the installation. Local governments and/or EVN also need to allocation budget and organize this system. Furthermore as explained in paragraph 2.3.as well as in the case studies in the Box's, there is a gap between what that households can pay (based on government calculations) and what the real costs of production are. In case of diesel generation each kW produced costs EVN money, which lower the incentive of initial investment and running it continuously.

5.2 Location and Logistics

Especially in the mountainous areas available infrastructure is limited, roads and means of transport are not in place, and at the same time community (or household) density is low. Transportation of the systems to the location is therefore an additional high cost and physical barrier for implementation. Installation in the mountainous areas can take more than a day of transporting with motorbikes and/or horses or horse carriages as more modern transport technologies cannot reach the sites. This is not applicable for off-grid island locations.

Box 5 Example of bottleneck in location

Example of difficulties in location selection (GiZ 2012).

A good example is the wind power project of REVN in Binh Thuan. It was a 2 months effort to transport 5 wind turbines (nominal power 7,5MW in total) from Phu My Seaport to the project location in Binh Thuan on the 300 km stretch of road – and this wasn't even remote or extremely rural area. Additionally the company had to hire a crane from Singapore, as no cranes were available at that time in Vietnam to erect the turbines.

5.3 Technology

5.3.1 Hydropower specific barriers

Unfortunately even for this well-established market there are still a few barriers.

Cheap, out of date and low quality technology imported from China is still dominating in the off-grids areas in Vietnam. There is limited spare part availability in the remote mountainous areas for replacement and repairs. Lack of knowledge on repair (less a problem in Vietnam) and/or spare parts can stop a whole system from working.

Natural hazards heavily influence the lifetime of the smaller installations. It was reported to us by several smaller scale projects that the regular flooding washes away or damages the small pico and micro hydro systems as there is no flow control build in, turbines get swept away without protection (which is often lacking).

There are also safety issues linked to the installation of pico and micro hydro, often household purchase the technology individually and *install systems without any technical support* from

experts, leading to low quality installments, breakages and short lifetimes. Furthermore the un-insulated electric wires used can cause electrical shocks for the installers / operators in case not properly installed.

5.3.2 Wind power specific barriers

The wind energy market in Vietnam is rapidly changing. Due to the introduction of the first feed in tariff in Vietnam-for wind-, a lot of attention has been given to the development of this market, also influencing the off-grid sector. Especially the unit size of the turbines available in Vietnam has increased throughout the last years, from imported low capacity turbines from China and the EU (<250kW) to the now larger capacity units of 1-2 MW. The reliability of the wind data in Vietnam is questioned, even though it is widely available, especially for the rural and remote areas for the wind potentials (GiZ, 2012).

The relatively new FIT is 1,614 VND (7.8 USD cents/kWh) in Vietnam, compared to – for example - 18 USD cents/kWh in Thailand and 23 USD cents/kWh in the Philippines. These FIT already give a good indication of the real production prices. When we extrapolate this to off-grid production we know, also from earlier chapters that the initial investment is relatively high, and therefore production costs are high.

Furthermore, some of the provinces with good wind potentials are also rich in minerals, this could potentially create a conflict in land sourcing (wind parks vs. mines), like for example in Binh Tuan and Ninh Thuan.

5.3.3 Solar specific barriers

As indicated before the solar market has developed quickly over the last few years and most projects are donor driven in Vietnam (PV for electricity production not for hot water). Local producers are in the market but have difficulties competing in quality with imported panels and side equipment from Europe and China The equipment failure rate is high, and therefore the trust in local equipment is low.

Systems lifetimes are at risk due to the limited knowledge levels when it comes to selection and operation of the systems. This often results in compromises on the quality of the charge controllers (for example) which than impacts the overall lifetime of the system and / or its costs.

There are no standard reported for Solar technologies; performance standards, equipment certification and codes of practice for quality control need to be developed and accepted, this is an essential part of creating sustainable solutions.

5.3.4 Biomass specific barriers

Barriers in the biomass sector stem from the scattered locations of the residues throughout the country. Especially rice is a good example of this scatteredness, as it is not always processed in a central, large scale, location; normally the residues are spread over a large area especially in the remote areas. The same is nevertheless true for other residues like corn residues for example. As a result a RE system needs to be developed where residues can be efficiently be collected and transported to - at a central power station or processing location.

This also makes contracting of the biomass sourcing difficult. Transport from inland or remote areas to the commune or hamlet center for decentralized production might be a financial barrier for the farmers, and potentially even a logistical barrier (due to the bad roads). The benefit might not outweight the additional costs, and there is no logistical system in place for

these transports. Biomass is mainly air and water, which is transported, so densification could be a solution for this (pelletizing and/or briquetting). After densification the biomass can be used for either heat production (for industrial use, brick making etc.) or for (co-)generation. The latter does require significant investments. Biomass electricity production gets more interesting at scale, nevertheless heat production can be interesting at any scale.

5.4 Policy Barriers

Major barrier for renewable to establish off-grid (and on-grid) RE business in Vietnam is a lack of favoring policies, a reliable legal framework and the substantial subsidization to encourage developing RE power projects at off-grid areas. There is a lack of strong and comprehensive policy for investment, management and operation RE project both in off-grid remote areas as well – as often reported - for on-grid projects. There was a lack of a focal point in Vietnam, but this was put into place in 2011 with the introduction of the General Directorate of Energy which is the managing body for energy development in Vietnam.

Not directly relevant for off-grid solutions, but a good indicator that shows the lack of supporting policies is the absence of feed-in tariffs (only in place for Wind Power). A feed-in tariff is usually referred to a regulatory guaranteed price per kWh that an electricity utility has to pay to a private, independent producer of electricity fed into the grid, this can be financed with state budget or other with other funds. The independent producer could be a household, a community or an investor. This can be of interest – as indicated RE solutions that are introduced in off-grid areas should be designed in a way that they can be connected to the grid if/when the grid is extended to the rural areas so that the investment doesn't become a waste after the grid is extended but it can continue to contribute to pay back the investment. This is when FIT do play an important role for off-grid projects.

With a policy of 100% electricity access by 2020, the Government of Vietnam has set itself a very ambitious and almost impossible goal. The last mile, in other words, the last households to be connected will be expensive solutions for the Government and/or EVN. If this goal of 100% by 2020 is not supported by sufficient budget's to reach this – which is the case at the moment. It will be difficult to reach the remote areas not yet connected. Also this policy gives local governments an excuse to not invest their state budget allocated, as expectations are in place that either EVN or National State budget will cover in the nearby future the grid extension.

Incentives for RE project development are not only in the form of subsidies or FIT, the government can also further develop its tax policies (current tax exemption has shown not to be sufficient), create access to green loans, develop favorable loan mechanisms (grace periods, longer timelines, favorable interest rates, etc), mobilize capital (through ODA and/or bilateral foreign loans).

5.5 Local Capacities

Almost every survey done on rural electrification, specifically in Vietnam (IE, 2009) (GiZ, 2012) (World Bank, 2011) or more general (IOREC, 2012) indicates that there is a large need for proper training and knowledge transfer. This refers to knowledge on many levels:

- At present the R&D efforts and RE developments in Vietnam take place very scattered over the country. Vietnam has a large number of research institutes and universities developing RE solutions, there is limited to no coordination between the organisations which results in overlapping results instead of further development of the total market.

There is no coordinating body for learning institutes (on all levels universities, colleges and vocational schools) that supports knowledge exchange between them. The human resource availability in clean tech solutions is only developing at the moment, resulting in a relatively young and inexperienced group of RE experts, and a limited number of senior RE experts with sufficient experience. This is an obstacle for the development of the sector.

- Enterprises interested in developing energy projects often have limited skills in the development of bankable business plans to attract sufficient financing for the projects (either through loans and/or grants). Support is given by organizations like the Nexus Group, or CIF PFAN, but his is not for all available.
- Local enterprises sometimes also have limited information or access to information about what technologies are available abroad and this leads to low quality import for example, or not available spare parts.
- Provincial, or other local governments have limited knowledge on the wide variety of the opportunities of RE technologies. Solar, wind, biomass, hybrid solutions are not known or understood by the local governments and can therefore not be stimulated. Nor will it receive more priority for the local government budget allocation.

In the field, the capacity necessary also relates to operation and maintenance. Depending on the technology used maintenance will play an important role. It has been acknowledge by local enterprises in Vietnam, that this is the main barrier for RE solutions after installation. The operation and maintenance can be seen as a challenge and an opportunity at the same time. Operation and maintenance will create new jobs in the rural areas, (the same can be said about fee collection). The challenge is however the availability of capable and trained maintenance technicians. Given the geographic isolation of off-grid areas and the comparatively small opportunity of replication of the RE systems in the area (low density of communities), it is challenging for project developers to create capacity building and training programs in a cost-effective manner that are sustainable (sources: own experience writer in previous projects, interviews with local entrepreneurs) (IOREC, 2012). Local government may not have the resources to finance such expertise, or to coordinate or set-up such systems.

The local RE entrepreneurs interviewed also indicated that often spare parts are not available in the Vietnam mountainous areas, and knowledge levels are not up to the levels needed for the technical support. It is often seen therefore on project sites that after (ODA) projects leave the sites, 3 to 5 years later the installations are not operational anymore.

From a logistical point of view it is therefore more interesting to look at off-grid areas that do have a diesel system in place and which can be replaced. Nevertheless this is also an additional barrier; for local governments this could potentially mean double investments (if they invested themselves in the diesel generation) or it will not be a priority to invest the scare financial resources in a RE project as they already have access to electricity (in case EVN invested); even when relatively fuel savings benefits can be demonstrated through the feasibility study.

Furthermore, it has been reported by several project developers that the equipment implemented in the rural and remote areas is regularly used for other purposes (like the batteries or other parts) and not returned, especially when there is no clear ownership of the installation or if it is community based.

6. Financial Opportunities for RE Projects in Vietnam

Access to finances continues to be a struggle in Vietnam according to the Renewable Enterprises interviewed. At the same time the financial institutions present in Vietnam indicate that accessing strong, high quality (commercial) projects in Vietnam is challenging. This suggests a gap between the financial institutions and the project developers. Financial support can be provided in multiple different ways.

- Equity / Co-investing
- Loans (senior/subordinate) - potentially (if available) with more favorable conditions through grace periods, guarantees or other support
- Grants / subsidies
- Grants for investment
- Or combinations of the above

The following financial institutions and their support mechanisms that are specifically focusing on (Renewable) energy are identified4. Funds that were identified, without energy specific opportunities are Mekong Capital, Finnfund, Viet Capital, VietinBank Capital. Furthermore Vina Capital's closed-end fund Vietnam Infrastructure Limited ('VNI') has energy as one of the 4 focus areas, but investments are of a size and scale, and require returns that are more likely to be linked to large scale (grid-connected) energy projects like for example their windfarm joint venture with Electricity of Vietnam (EVN). The opportunity of ADB's ASEAN Infrastructure Fund (AIF) was also explored, but didn't seem to have direct potential for the private sector.

6.1 Dragon Capital

The Mekong Brahmaputra Clean Development Fund L.P. (MBCDF) was launched on 6 July 2010 and is focusing on Clean Technology in the Mekong River Region and the Brahmaputra River Region. The fund size is 100 million USD in total, but is aiming for project sizes of 1 – 5 million USD per investment. Energy is one of the main topics. Expected returns are >15%, with a timeline of maximum 10 years. Funders of this program are among others FMO (see below), Asian Development Bank, Finnfund and BIO. The fund will make investments that meet the "Triple Bottom Line" principles of "People, Planet and Profit".

MBCDF's first investment in a Vietnamese project was announced in June 2012, which is a 29MW hydropower project developed by Tam Long Power Joint Stock Company. Upon completion, the project will generate 135 million kWh of clean energy each year to feed the Vietnamese national grid. The project started construction in 2012 and will commence operations in 2014. Current interests are mainly in industrial scale biomass and biogas, as well as other solutions that can reach scale, and are on a commercial basis. Solar –for industrial purposes

6.2 Indochina Capital

Indochina Capital Corporation (Indochina Capital) launched the Mekong Renewable Resources Fund (MRRF) in June 2011. The initial US$50 million fund from the US Oversea Private Investment Corporation (OPIC) will invest in renewable resource opportunities in the Lower Mekong region. MRRF is sponsored by Indochina Capital, a Vietnam-focused fund management group, whole core platform of MRRF will focus on environmental services and infrastructure investments, including waste-to-energy, recycling, solid waste management, sustainable forestry

[4] This list does not include non-energy focussed grants, loans or other financial products.

projects, wastewater treatment and clean-water initiatives. Its renewable energy investments may include wind, small hydro, solar, biogas and biomass, while energy efficiency investments may entail renovations to existing power plants, agricultural processing, and industrial facilities.

The MRRF is now raising an additional US$100 million from institutional investors. In addition, Indochina Renewable Resources was contracted by the World Bank to advise the Vietnamese Government on Public Private Partnership program for infrastructure.

MRRF is looking for companies/projects that can deliver IRR's of 13%-18%. The holding period would be from 7-10 years. Investment size can be varied from $3-$15 million, would be higher depend on the project type, in return for a significant minority stake (30%-45%) in the company.

6.3 FMO – Dutch Development Bank

FMO supports sustainable private sector growth in developing and emerging markets by investing in companies, the energy sector is one of their focus areas and they offer several products for enterprises active in this sector. Many of their projects have an off-grid focus. More information can be found at: http://www.fmo.nl/energy.

There are several types of financial products that FMO can offer, varying from a size of 500.000 Euro to 20 million Euro as part of their "Access to Energy Fund", their "Infrastructure Development Fund (IDF)" or their standard funding schemes. Directly investment is an option, and/or a wider range of investor can be attracted through cooperation with FMO. Local currency financing (to reduce risks) is a potential option. Funding possibilities include, but are not limited to equity, senior loans, subordinated debt, longer grace periods and tenors often necessary to get such projects started, grants for providing project development. FMO is also interested and exploring opportunities to develop Micro Finance schemes for biogas (and potential other RE technologies) in Vietnam.

6.4 Vietnam Environmental Protection Fund (VEPF)

Since it established, the VEPF has disbursed about US$50M of loans, for 156 environment projects in Vietnam. The renewable energy projects that received financial support were mostly small hydro power projects, biogas generation and use (wastewater & waste treatment, landfill gas) and energy efficiency projects (unfired bricks) with the aim of developing them as under the UNFCCC acknowledged CDM projects. VEPF is funded through state budget, but also through (as regulated by the law):

- Environmental protection fees for wastewater, exhaust gas, solid waste, mineral exploitation and other environmental fees
- Compensation for environmental damages
- Penalties paid for administrative breaches within the area of environmental protection
- CERs sale charges
- The funds, support and contributions of local and international organizations

VEPF provides loans with an interest rate at 5.4%/year fixed, with 7-8 years crediting period and a grace period of 1-2 years. VEPF has indicated publically that it is currently searching for technical assistances and other funding sources to support and implement a potential biomass renewable energy projects (rice husk / woody biomass).

6.5 World Bank's RE Development Program (REDP)

The Renewable Energy Development Project has been launched in May 2009 for Vietnam which aims to increase the supply of electricity to the national grid from renewable energy sources on a commercially, environmentally and socially sustainable basis. The project has three components with total credit of US$202 million, 40 years of maturity, and grace for 10 years. Most relevant component is that they provide credit re-financing facility to participating commercial banks (PBs) for loans to eligible renewable-based projects less than 30MW developed by private sponsors. And it also supports activities to facilitate the development of further renewable energy projects contributing directly to building a pipeline of renewable energy projects.

World Bank provided credit through five domestic banks including Bank for Investment and Development of Vietnam (BIDV), Joint Stock Commercial Bank for Foreign Trade of Vietnam (Vietcombank), Saigon Commercial Bank (Sacombank), Asia Commercial Bank (ACB) and Vietnam Technological and Commercial Joint-stock Bank (Techcombank) for renewable energy projects to re-borrow (GiZ, 2012). The maximum borrowing does not exceed 80% of loan value from participating commercial banks, in a minimum period of 12 years, the period of grace/extension is not more than 3 years during the period of 2009-2014.

6.6 Clean Technology Fund

The objective of CTF is to provide financing to demonstrate energy efficiency and renewable energy investments to create an enabling environment for scaled-up private sector investment and reduce GHG emissions, to support direct finance for 2,000 MW of private sector energy efficiency and renewable energy projects.

Initial projects of Vietnam were focused on the transport sector and energy efficiency in the industry, but a new program with as title "Sustainable Energy Finance Program" with a timeline of 15 years and the aim to reduce 4.5 Mt CO2eq in those years has been approved (Nov 2011)(as well as a distribution project) and are implemented in cooperation with IFC. Nevertheless this project is put on hold "given the market environment in Vietnam" (CTF, 2013). It is very likely that the money reserved will be channeled into other projects.

Furthermore the government of Vietnam has developed an investment plan in coordination with the ADB, members of the World Bank Group (IBRD, IFC), and key Vietnamese stakeholders to tap US$250 million from the Clean Technology Fund (CTF) for targeted Renewable Energy and low carbon investments in the power, transport, and industrial sectors. Vietnam's CTF investment plan will support energy efficiency investments in industrial and energy service companies; the initial capitalization for energy conservation and renewable energy funds; direct investment into a private sector renewable energy. A recent CFT semi-annual report of October 2013 (CFT, 2013) indicates nevertheless that it [the reserved funds] is "*unlikely to be used given the current investment climate, including (i) low feed in tariff to make wind and solar power projects bankable; and (ii) technical and commercial capacity of local developers in the RE sector. IFC has conducted scoping studies, met with a number of stakeholders to ensure*

alignment with Government policies. Moreover, IFC has conducted a number of exploratory discussions with potential credible and capable RE developers particularly related to wind energy, biomass and solar projects. As a result, IFC does not foresee any investment opportunities in the near future and will make these funds available to other MDB priority projects, as determined by the government of Vietnam. This reallocation will be reflected in the country investment plan update that will be submitted for the TFC approval."

This gives quite a strong signal of the barriers for investment in the RE sector in Vietnam.

6.7 Green Growth Strategy Facility

Vietnam and Belgium have signed an agreement for a six-year project to develop a "Green Growth Strategy Facility" worth 5.5 million EUR (7.3 million USD). The facility will promote green initiatives including energy efficiency, transferring clean technology and managing waste and waste water to attract investments from the private sector in green growth projects. The Strategy was adopted in September 2012 as on of the main tasks the promotion of the use of clean and renewable energy which aim to reduce the carbon emissions and greening existing production processes.

As part of this facility a fund for green growth initiatives will be developed which will allow Vietnam, through the Ministry of Planning and Investment to attract more investments in green growth initiatives.

6.8 Vietnam Business Challenge Fund

The Vietnam Business Challenge Fund (VBCF) is capitalized by the UK Department for International Development (DFID) and the implementing partner is SNV Netherlands Development Organisation. VBCF is designed to support the private sector in Vietnam in developing innovative inclusive Business models that deliver both commercial benefits for the company and social impact for the low income population. One of the three main focus sectors is low carbon growth – which includes clean tech and renewable energy technologies.

VBCF provide advisory services, mentoring and non-reimbursable funding of up to 49% of the total investment to selected Inclusive Business projects in Vietnam through competitive open calls. The VBCF will last from September 2012 until December 2015 and provide fund in the rage of 100,000 – 800,000US$/project. At the time of writing this final report the last round of calls for business was just closed, a hand full of RE projects have ben accepted and are supported through VBCF.

6.9 The Armstrong S.E. Asia Clean Energy Fund

Vietnam is one of the focus countries of the Armstrong S.E. Asia Clean Energy Fund; a private equity fund that invests in small-scale renewable energy (wind, solar, hydro, biomass, waste to energy) and resource efficiency (clean water supply, waste recycling, energy efficiency) projects in Southeast Asia. Projects can be in the different stages of development namely in a pre-permitting development stage, in a greenfield stage (Post-Permitting) or for Operating Assets. This strategy is driven by the high energy demand and strong market fundamentals in the region. Armstrong Asset Management will seek to provide investors with a gross return in excess of 20% per annum.

The Global Energy Efficiency and Renewable Energy Fund (GEEREF) is one of the funders of this Armstrong Fund, and has committed Euro 10 million.

Armstrong Asset Management is currently open for proposals: business plans can be submitted through their website.

6.10 Financial Service Providers

There are a large number of financial service providers in Vietnam, they can support strong renewable energy projects with finding financial means to support the projects. Below are just two examples of such service providers, but there are many more active in the Vietnamese market.

6.10.1 The NEXUS Group

Nexus Group specialises in in Investment Consultancy, Investor Relations Consultancy and Stock Media in Vietnam. Nexus helps corporate build and operate an effective investor relations policy to increase stock valuation, create liquidity and access capital markets. NEXUS has already supported a number of Renewable Energy projects in Vietnam.

The Nexus Group is also the local representative of the CTI-Private Financing Advisory Network (CTI-PFAN). PFAN is a multilateral, public-private partnership initiated by the Climate Technology Initiative (CTI) in cooperation with the UNFCCC Expert Group on Technology Transfer. PFAN operates to bridge the gap between investments and clean energy businesses. PFAN has supported 3 RE projects in Vietnam ncluding a biofuel, biogas and a wind project.

6.10.2 Green-Asia Capital Advisors Ltd

GreenAsia Capital Advisors Ltd is an independent investment advisory firm focusing on the renewable energy and environmental sectors in the Asian markets.After successfully working in both China and Thailand since 2005, GreenAsia's Management extended its working area to Vietnam and is currently based in Ho Chi Minh City, Vietnam.

The advisory service focuses on providing strategic, commercial and financial advice to clients on renewable energy investment. Services package including market entry advisory, project financing modeling and fund raising. Its strong track record on solar PV, wind projects, biomass-to-energy, wastewater treatment and desalination projects.

7. In-depth Case Studies

7.1 Selection of Communities

As indicated in the introduction of this report, Vietnam already has a grid connection outreach to 97.6% of the country. With such high electrification numbers it is easy to understand that the grid has not expanded *only* to the inaccessible areas and/or the areas where connections are economically not interesting. These off-grid areas are mainly mountainous communes and islands. It is the responsibility of the Provinces to establish local generation solutions in these communes in the form of diesel, small hydro power, solar power, or other solutions.

These off-grid areas are often the poorest areas in Vietnam, as also shown in paragraph 2.1. These provinces have limited resources to divide among their projects and focus areas in their area. Therefore investments in (often more expensive) RE solutions, instead of the standard diesel connection or no electricity access, is not the highest priority.

Furthermore interviews with RE technology suppliers, especially the RE entrepreneurs, have indicated that the mountainous areas that are off grid are often difficult to reach. No good roads lead up to these areas, and it is challenging to transport (expensive) equipment to these areas. From a business perspective these areas seem to be less interesting, also because the communities are small, and the density of the communities is small. So there is also limited opportunities to sell several systems in the same areas.

Furthermore as indicated in the barriers Chapter 5, there is the challenge of operation and maintenance in the remote mountainous areas. With a future focus of this program to increase public and private investment in and piloting of RE technologies, it might be challenging to work with commercial enterprises in these areas.

EVN supports and finances grid extension, which is something that needs to be financed by the provinces in case they 'extend' the grid on their own with diesel or RE solutions. This includes both the initial investment costs as well as the operation, maintenance and fee collection costs. Therefore provincial offices prefer to trust on the grid extension by EVN, instead of making long term high investments themselves in local solutions for off-grid areas. EVN has indicated to the provinces that the grid will be extended to them in the next 8 years, the government has committed to 100% access to electricity for households (on-grid and off-grid) by 2020. This is an additional reason that there is limited interest from the local provinces to invest themselves in electrification solutions, they prefer to wait for EVN to make the investment.

7.2 Sites Selection

Through in-depth discussions between the project partners, it was decided that the two types of off-grid areas will be selected for field studies; one island location and one mountainous location. By designing the selection this way, the different situations in off-grid areas can be analyzed for the further development of the Vietnam Clean Energy Program and the second (pilot) phase.

Based on a general analysis of the off-grid household list (see for clarifications paragraph 2.2), a sorted list was developed on district level for both mainland and island. The sorted list supported in the identification of 29 provinces and 13 district islands which still have in total 76,076 un-electrified households. A set of selection criteria for each type of commune (island & mainland) was developed (see paragraph 7.2.1 and 7.2.2), which was used to select the most suitable island and mountainous area for off-grid field surveys.

7.2.1 Island site selection

There are 13 district islands that have been identified to be considered in this screening process. A next selection process was executed, based on the criteria below and shown in the table.

- The island is not connected to the national grid and there is no plan to connect to the National Grid in the nearby future (next ten years).
- The island must hold potential for RE Solutions (wind, solar or biomass), making it possible to supply electricity from RE as the main source.
- Local Government is interested in RE solutions and willing to look into the different options available for this site. Local Government or other local stakeholders are willing to invest in RE solutions for electricity purposes.
- The island is easily access by waterway and not too far away from mainland.

Table 18 Screening process for island selection

No	Island	Characteristics	Justification	Selected
1	Co To (Quang Ninh)	A tourism island, 30km from the mainland, 1500 households, 6,000 people. Existing 21diesel generators sets with total capacity of 1300 kVA for domestic consumption and 53 solar PV stations serving public activities. Co To island is planned to connect with national grid by end 2013. The project with a new power station and transmission lines from Van Don district to Quan Lan and from Quan Lan to Co To with total length of 65km has been approved and financed by Vinacom in and Quang Ninh province PC.	Having plan for grid connection in near future. (Source)	NO
2	Quan Lan (Quang Ninh)	A tourism commune island, 15km from mainland, belong to Van Don district. Several power investors already executed surveys, and have been exploring the opportunities. Van Do is planning to connect this island with the national grid (see also Co To Island plans) (Source)	Having plan for grid connection in near future.	NO
3	Bach Long Vi (Hai Phong)	A small society, long distance from the mainland (110km) with only a few inhabitants. Have a hybrid power system of diesel and a wind turbine with high capacity relative to the demand (800kW wind + 2 x 0.4MW diesels) and central power supply.	Not easy to access. Almost sufficient power supply by the hybrid system.	NO
4	Con Co (Quang Tri)	A new established district island since 2004, 2.2 km^2 with 150 households, 500 people, 28km from mainland, Limited access to electricity with a centralized diesel based power station (132KVA / 112.2kW / 0.4kV) comprising of two units of 66kVA each to meet electricity demand on the island. Existing few small solar PV panels supply electricity for administration (almost 10 years operated). No survey has been conducted for the power demand and consumption for island so far.		**YES**

		Quang Tri has published a request for donors/project developers for RE solutions for the island on the Decision 1936/QD-UBND dated on 16 Oct, 2012.		
5	Cu Lao Cham (Quang Nam)	A tourism island, 18km from the mainland with 900 households. There are 3 diesel generators with total capacity of 75kVA, a central electricity supply. In 2009 VSRE piloted a hybrid system of solar and diesel in Bai Huong islet with capacity of 28kW, voltage 220V to provide the electricity for about 90 households. New hybrid wind/diesel power project 1MW (planning for 2MW in near future) is under feasibility study to electrify the entire Cu Lao Cham island, implemented by EAB Company.	Quite a number of power projects have been implemented and sufficient power supply in nearby future.	NO
6	Ly Son (QuangNgai)	Typical island society, 30km from mainland, 4747 household, 21,000 people with perspectives for economic development. Good potential for wind and solar energy. Currently, only 50% of electricity demand has been provided by existing diesel generators total capacity of 3MW. A grid extension project with 30km submarine cable has been approved and expected to be finished by end of 2014 to provide electricity for whole island.	Plan for grid connection expected to be complete by 2014 (source)	NO
7	Cu Lao Xanh (Van Phi) (Binh Dinh)	Tourism island belong to Quy Nhơn city, 365 ha with 484 household, 2110 people, 9km from mainland. Plan to install 13km submarine cable (22kV grid) to supply electricity for whole island.	Having plan for grid connection in near future (source).	NO
8	Bich Dam (Khanh Hoa)	Belong to Vinh Nguyen district, 10 ha area, 142 households, 900 people living in. Electricity is currently supplied by local EVN 4 hours per day with a central diesel based power station capacity of 165kVA. Aware of the importance on electricity providing to islanders, Khanh Hoa provincial PC is planning to connect the island with grid in nearby future.	Having plan for grid connection in near future (source)	NO
9	Van Ninh (KhanhHoa)	There are still 3 hamlet islands of Ninh Tan (55 HH), Ninh Dao (130 HH) and Diep Son (78 HH)having no access to electricity due to the difficult geographical condition. On 21/03/2012, Khanh Hoa province PC has approved a demonstrated project to provide clean energy solution for all 55 households in Ninh Tan hamlet. The total investment cost of 4 billion VND will provide each household a 350 Wp solar PV system. Once this model implemented successfully, it will be replicated to all other islands within province.	Having plan for providing renewable energy solution for all un-electrified island (source)	NO
10	Phu Quy (Binh Thuan)	Big island with 16km^2 area, 3,293 household and about 27,000 people They have a well developed central power supply system including a central diesel based power station with a total capacity of 3 MW, additionally 6 MW of wind power (3 units of 2MW) and a 22 kV power	Having sufficient power supply system.	NO

		distribution system. The combined power system expected to cover 100% energy consumption for whole island.		
11	Con Dao (Vung Tau)	Tourism and fishing island, 100 km from mainland, 51 km^2area, 4,500 households and about 20,000 people. Having a developed central power supply system including a diesel power station with a total capacity of 3 MW and a 22 kV power distribution system. There is ongoing wind measurement by EVN and a private investor is preparing a wind farm project for Con Dao. The proposed project includes 6 MW wind power, 3 MW additional diesel power (in addition to the existing 3 MW), and a 1 MW fly-wheel unit.	Expected to have sufficient power supply system in nearby future.	NO
12	Phu Quoc (Kien Giang)	A tourism and fishing island, 45 km from mainland, 589 km^2, 62687 people living in. Centralized power station with diesel electric generators total capacity of 12MW. Planned to be power connected to the mainland. The construction of a 55.8-kilometer cable line with a capacity to transmit 131 MVA has been budgeted with USD114 million (VND2.4 trillion) and is targeted for completion early 2014.	Having plan for grid connection in near future. (Source)	NO
13	Kien Hai (Kien Giang)	Group of very small societies. Do have plan on building a sea-crossing overhead transmission line to bring power to Hon Tre island commune- the district's administrative centre. The 13 km-long line will be built in 2014 and 2015. Another commune, Lai Son island, will have power supply from a solar power plant invested by the Hanoi-based Europe Distribution Joint Stock Company. Depending on the success of this plant, the model may be replicated in An Son and Nam Du island communes.	Having plan for grid connection in near future. (source)	NO

The above screening process indicates that most of the island in Vietnam have a central power system based on diesel generation, which is owned and operated by EVN. However, those central power systems are limited in both time and capacity – supplying power. Research has shown that almost all islands are planning to be soon connected with national grid (plan for 2014 – 2015) or to invested in RE solution of wind/solar.

Con Co Island is found to be the only island that satisfies all the criteria. Con Co originally known as a military island, it was newly established in 2004 as an island district belonging to *Quang Tri province*. Con Co has very favorable conditions to focus the first pilot study on: Renewable energy source availability (wind/solar), limited access to electricity, no power development plan for future yet, energy demand is increasing for economic development, strong supports from local Government.

Moreover, by experience, good relationship with the local governments and strong support from local people are key drivers for successful project implementation. Con Co island is considered a good choice for off-grid site study, especially as key staff of the project (VCEP's

DCOP and RE Senior Advisor) have long term relationships with the local authorities during the implementation of solar PV systems for the island in 2004-2005.

Therefore, Con Co island has been selected as the most appropriate island for site study.

7.2.2 Mountainous site selection

The criteria in the table below have been applied one by one to gradually eliminate from the un-electrified list of 29 provinces and finally select the most appropriate province to be considered for site survey analysis.

The districts selected are indicated in this screening process. In cooperation and in discussion with the provincial representatives other districts might be more preferable to the local authorities so SNV wants to approach to province in a flexible matter.

Table 19 Criteria for mountainous sites screening

No	Criteria	Standard	Justification
1	Number of households without access to electricity.	Over 2,623 households	Number of un-electrified households of selected province must excess the average number per province.
2	Renewable energy potential source are available	Y/N	The site must hold potential for RE Solutions (wind, solar, hydro and especially biomass source), making it possible to supply electricity from RE as the main source.
3	Ethnic minority	Y/N	High priority is given to the mountainous off-grid areas where having high rate of ethnic minority people.
4	Accessibility	Accessible (Y/N)	To avoid the locations where is impossible to access or costly for traveling and implementing pilots afterwards.
5	Poverty rate	Over 20%	To classify the low and high income province, this is highly related to the shortage of electricity.
6	Coordinate with VFD project location in implementation.	Y/N	The VFD project will be implemented in ThanhHoa, Nghe An, Nam Dinh and Long An. It would be beneficial for both VCEP and VFD projects if implemented in the same location on sharing the network and information.

The first screening step is based on the available information of un-electrified list; there are 29 provinces with a total of 76,076 households without electricity. The provinces of Ha Giang (8805 HHs), Quang Ngai (5806 HHs), Nghe An (5277 HHs), Son La (3674 HHs), Dak Lak (3133 HHs), Yen Bai (3099 HHs), Thanh Hoa (3013 HHs) and Lang Son (2648 HHs) have been sorted as having the highest rate of un-electrified households.

The following screening steps would give preferences to the provinces having:

- Ethnic minorities,
- Accessible
- High poverty rate
- Available renewable energy source

All filtered provinces (except Dak Lak) are almost similar in their qualification based on the selection criteria.

It has also been taken into account that there is a strong interest from all parties, including USAID, to integrate VCEP's work as much as possible with VFD (Vietnam Forest and Delta's Program) focus, which is on Thanh Hoa and Nghe An. Based on all the above criteria and selection procedures both Thanh Hoa and Nghe An province were compared for economic viability and Nghe An showed more potential. Because of a larger number un-electrified household rate and higher density of un-electrified households at commune level. This would bring a greater impact to local people and allow for scaling-up and pilot models across province in future.

Based upon justification, Nghe An Province has been selected for site survey under this study.

Within Nghe An a district needs to be selected. Three districts have been screened Quy Chau, Tuong Duong and Ky Son based on the SNV un-electrified list. Quy Chau is identified as the most appropriate district as it located in the province central, easier to access by car and furthermore Tuong Duong and Ky Son are frontier districts sharing the border with Lao – which is politically sensitive and lack suitable accessibility. Nghe An province PC is currently planning to connect some communes in Tuong Duong and Ky Son with the national grid. The 110 kV transmission line through Tuong Duong – Ky Son districts will expected to cover several communes of Thach Giam, Xa Luong, Luu Kien and Hoa Binh town (Tuong Duong), communes of Chieu Luu, Huu Kiem, Ta Ca and Muong Xen town (Ky Son).

As indicated above this selection was done in a preliminary matter, and approval and input was sought from the local authorities. They fully approved the selection as well as the reasons for the selection.

For reasons given, Quy Chau district in Nghe An Province is selected to be the second site for the survey.

7.3 Survey Design and Methodology

The main aim of the surveys as formulated in the Terms of Reference is "to survey for possible demonstration sites" and therefore it is indicated that the survey will at least contain demographic data, socio-economic data, current energy usage by sample of households, energy needs of the community, ability and willingness to pay for electricity, resource assessment, preliminary superficial assessment of RE technology options and costs, analysis of investment in terms of CBA and ROI.

Furthermore, the survey seeks an understanding on the developing trends within RE solution application for electrification of remote mountainous areas and islands, people attitudes and driving factor for change. The survey also targets to assess the potential of RE sources available in the selected areas.

7.3.1 Key survey questions

The following topics will be key to be answered with the survey:

1. What is the current situation of the electricity usage in remote areas and islands?
2. What is the affordability of RE resources from an investment point of view, as well as the household point of view?
3. What is the RE potential for the selected site?

4. What are the lessons learned from existing implemented RE solutions in neighboring communes/districts and how can they be applied at the selected site? (if any)

7.3.2 Data collection methods

Methods used for the study include desk study, semi-structured interviews using questionnaires, and case studies.

Desk study is to review study reports related to clean and RE, off-grid electrification in Vietnam and abroad, energy (the electricity) consumption and practices, and the potentials of RE solutions in Vietnam.

Semi-Structured interviews is a tool to collect primary information on energy, leaving room to go in-depth into selected questions if necessary. As the survey is only a quick scan as little time is allocated data will not represent a proper sample size, and more emphasizes will be on qualitative data. In-person interview using questionnaires will be used to ensure reliability and validity. More information is given in paragraph 7.3.3.

Case study is employed as a qualitative study method to reflect upon representative RE pilot projects. This will include information such as operation situation of existing power system, applied business/financing model, willingness to pay for the electricity of local resident, happiness of local resident with this system, etc. In other words it will focus on the change process, lessons learned and replicability.

7.3.3 Questionnaires – for semi structured interviews

Several questionnaires are designed to gather the required data, (Annex 2 and 3). The questionnaires are split in three levels:

1. Household level - which is aimed to acquire data on consumption and use of the electricity by each household, their willingness to pay for the electricity. This also includes (small) enterprises.
2. Community or village level to collect information on site as social-economic conditions, population, infrastructure (electricity and road access, school, heal care station, etc), general potential of RE sources

Interviews with Provincial governments will be open interviews based on checklists. Furthermore an open interview will be executed in the nearby commune (if applicable) that already has access to a RE pilot technology. The interview structure for this still needs to be developed. A tentative meeting schedule for the two field visits is indicated below.

7.4 Summary of the Survey Results

The field survey in Quy Chau, Nghe An was executed from 28th October to 2nd December 2013, and combined with an official VCEP visit to the local Government representatives of Nghe An and Thanh Hoa. The field survey was executed by Ms. Nguyen Thi Thu Ha (SNV), Mr. Nguyen Thanh Quang (SNV) and Mr. Han The Phong (Winrock). Due to multiple reasons related to the implementation of the Vietnam Clean Energy Program in Vietnam, the second field visit to Con Co Island has not been executed as planned and has been delayed until further notice.

The team had a meeting with Quy Chau district's People's Committee, Bureau of Industry and Trade and the Bureau of Ethnic Minorities on 1st December 2013 to discuss the site for conducting the survey. Among those un-electrified communes and villages, *Thung Khang village – Chau Binh commune* was proposed to be the most appropriated site. According to the district

Unit of Industrial and Trade, this village is located in remote mountainous area with absolutely no access to the national power grid and it is very likely to remain off-grid until 2020. While at the same time it has a high number of un-electrified households compared to other villages. Following the meeting, the team spent two days in Thung Khang village to carry out in-depth survey, conducted interviews with 43 out of total of 125 households in this village to collect information on households's monthly income, current energy use and their willingness to pay for electricity; to survey the renewable energy potential source available at the village.

Detailed survey work and key findings analysis are presented in the "Off-grid survey report in Thung Khang village" (available upon request). This section only provides an overview of the key findings from the report.

7.4.1 General information of selected site

Quy Chau district with total area of 1,057,656 km^2 has in total 12 communes with around 55,200 habitants (10,321 households). The district is one of poorest areas in the province with the highest number of off-grid households. The 2012 data (Peoples Committee Quy Chau, 2012) shows that there are 3 commune centers, 52 villages (belonging to 12 communes) and 1782 households (with 102,571 people) that still don't have access to electricity. Quy Chau' PC is planning to improve this situation by extending the existing grid connection to cover national electricity grid to 100% communes and 90% of households by 2015.

Thung Khang is an un-electrified village, about 30km from the district center of which about 10 km of the road is in bad condition. The village has 125 off-grid households with 510 people (80% Thai, 20% Nung) of which most live along the Nam Khang stream.

The main economic activity in the village is agriculture (corn and rice), animal husbandry and forest exploitation. Income levels are as indicated in the table below.

Table 20 Income levels in the surveyed area

Percentage		Income level
65%	Poor	<1 mln VND/month
26%	Mid-Level	1 – 2 mln VND/month
9%	Better-off	>2 mln VND/month

7.4.2 Households' Energy use

The currently used energy sources in Thung Khang village are pico-hydro, kerosene, wood, batteries, candles. In which, pico-hydropower usage is relatively high. There are 70 pico-hydro units currently running that provide electricity for 100 household. There are still 25 households in the village that do not have access to electricity. The electricity is mainly used for lighting.

The majority of the pico-hydro units in the village are imported from China, with capacities of 300W and 500W and costs between 700,000 to 1,000,000 VND (35-50 USD). All households installed their pico-hydro units by themselves. The villagers lack sufficient capacity in electricity to set up and operate the pico-hydro units properly, therefore most pico-hydro units are working in bad conditions, with low quality cables and long periods of time in which they don't work – these conditions create risky situation possibly even leading to injuries and/or even deaths (one case was reported that happened before the survey took place). A lack of voltage regulator also causes electrical shocks shortening the lifetime of equipment. The households take the pico-hydro units home during rainy season to avoid damage caused by foods. On

average the households are still using other energy sources (candles, kerosene, flashlights) 2 months a year.

The operational costs for maintaining these pico-hydro units found to be quite high, around 100,000VND/month (5USD/month) – which is mainly for replacing ball bearings, electric wires and light bulbs.

Kerosene is the most used energy source for lighting. 84% of the hh use this either as a backup fuel for the flood or dry season (0.8 – 1.5 lit/month) or as their main energy source (1.5 - 4 lit/month). All households receive a state subsidy for 5 liters of kerosene per year for lighting, Kerosene price per liter is 22,000 VND (1,1 USD).

Batteries used in flashlight are the third source of energy for lighting purposes (67% of the hh), either as backup or as a main source.

Firewood is used by 100% of the households for cooking purposes (and space heating in winter). The households consume an average of 320 kg wood per month. Most of firewood used in village is collected (for free) from surrounding *Acacia* forests by the women.

7.4.3 Willingness to pay for electricity

All the interviewed households expressed their desire and willingness to pay for *uninterrupted* and stable power supply, to be used for lighting, cooking, TV, electric fans and in some cases for water pumping and rice milling (for business purposes). The survey showed that the local people are willing to pay a rather high rate for electricity of about 92,000 VND/month on average – this is more or less the current expenses households have for maintenance of their pico-hydro, kerosene or other sources for lighting.

7.4.4 Total energy demand forecast

The electricity demand forecast in the Thung Khang Village is divided into domestic use for household applications, public use and use for services. There was no demand for productive use in this village. The power demand is estimated based on the survey results from current energy use in village, and extrapolated to include all households within the village (125 households), assuming all will be connected in such a case; these numbers are shown in the table below. This demand is considered as a minimum base load demand for the project design. Based on the survey a month use of around 30 kWh is estimated, which is almost double than the survey of Ky (2003) showed. In the table below it is not taken into account that the amount of electricity use will increase after having access to stable power supply. To make a good estimation of this it is recommended to have a more in-depth survey; monitoring energy use over the last few years, and to survey in more depth the interest of households in other electrical equipment.

Table 21 Estimation of total electricity demand for Thung Khang village

Demand	Capacity (kW)	Monthly (kWh)	Annual (kWh)
Domestic use	33.5	3,705	44,455
Public use	2.2	427.84	5,134
Service use	1.4	630	7,560
Total	**37.1**	**4,762**	**57,149**

7.4.5 Potential Renewable energy resource assessment

Biomass resources: The survey showed there is little potential for bio-energy in Thung Khang village. The information of Chau Binh commune indicated that the forestry land area of commune is 11,127.4ha, with an additional 1,109.6ha of agricultural land. About 400-500ha of planted forest is annually exploited with a total volume of 4,000 m^3/year which is mainly sold to a nearby paper factory. The residual wastes from logging of the planted forest are mainly branches and bark which is currently collected by the households or burned out in the open. The first is managed by local afforestation units.

Wind resources: Wind power potential is limited in this region and is not a viable option.

Solar / PV: The monitoring data of sunshine hours published on the website of the General Statistics Office (GSO) shows that Nghe An has quite a good potential for solar energy with an average insolation of 4.2 kW/m^2/day and the average sunshine hours monitored in period from 2006-2012 is up to 1,564 hours.

Hydro source: Nam Khang stream originates from the top of a mountain at 1,000m. The stream flow rate is estimated at 0.5-0.8m^3/s in the dry season (with shallowest water level about 0.5m), the average slope of the stream is from 35% - 40% . An explorative tour showed a 10m drop, 2km out of the village center which could be a potential location for a mini hydro power supply solution. As this solution has the highest potential and economic viability this is further worked out below and in the full report.

7.4.6 Recommendation for selected areas

Nam Khang has a gradient that creates a height difference, providing a good opportunity for hydro power. It is estimated that from the waterfall, a water channel about 200 m long with 10 m height difference could be established. The power house with mini hydropower turbine could be installed at the end of the water channel for power generation. Base on the outcomes of the site survey, including the power demand forecast and the potential of hydropower resource available, the main specification for mini-hydropower solution is presented in table 22 below. Alternatively, the a grid connection option is considered for comparison. The investment cost for this option is summarized in Table 23 below.

Table 22 Main specifications for electrification in thung Khang site

Specifications	Unit	Value	Source
Catchment area	ha	200	Provided by Chau Binh Commune PC
Average annual discharge	m^3/s	0.5-0.8	Estimated
Design discharge	m^3/s	0.7	Estimated
Design head	m	10	Estimated
Design capacity	kW	40	Estimated
Investment unit[5]	USD/kW	2,500	World Bank Report in December 2010
Total investment costs	USD	100,000	Estimated
No. of households	HHs	125	Surveyed data
Investment / HH	USD/HH	4,000	Estimated

Table 23 Investment cost of a grid connection

[5] Referred to Report on Lessons Learned in Renewable Energy Small Power Producers Program (RESPP) funded by the World Bank in December 2010

Specifications	Unit	Value	Source
Investment unit per household	USD/HH	2,000	World Bank Report
Number of households	HHs	125	Surveyed data
Total investment	USD	250,000	Estimated

The technical-economic analysis has been executed (for full calculations refer to the full report) and Net Present Values (calculated based on a quick scan) are show below in Table 24.

Table 24 The comparison of electrification solutions for Thung Khang village

Option	NPV
Installation of a 40kw hydropower plant	-1.5 billion VND
The electricity supplied by the Gird	-139.2 billion VND

Thung Khang village is remote area with limited opportunity to connect with the National Grid, the extension of grid to the village could be seen as a rick during installation and operation. This indicated clearly in the extremely low and negative project NPV as economic analysis for the grid connected solution.

Biomass and wind solutions were found not to be a big potential in this village, and solar power is expected not to be cost effective because of its high investment cost – furthermore other downsides of solar influenced the negative advise of the consultancy team like the negative experiences of the solar companies in Vietnam (as presented above) in combination with the lack of local capacity (low education levels) and therefore low awareness of high-tech. Therefore it is recommended to look further into the mini-hydropower solution for the village as the best option for electricity generation and stable long term supply for the village. It is recommended nevertheless to conduct further (technical) investigations into the specific flow rate of Nam Khang stream and the area topographic features, to ensure a good design and to develop an in-depth and detailed feasible study.

8. Concluding Remarks

The Vietnam Clean Energy Program has the goal *to strengthen the foundation for low emissions energy systems in Vietnam* (Intermediate Results (IR) 2)[6]. The research on "Off-grid Opportunities and Challenges in Vietnam" as presented herewith is part of the Sub-IR 2.3 *Increase public and private investment in and piloting of renewable energy technologies*. This Sub-IR has the aim to create access to financing for renewable energy projects for developers, to improved national and local enabling environments that facilitate increased private sector investment in renewable energy; and to implement renewable energy demonstration projects. This Sub-IR was suggested to result focuses on renewable resources that have received relatively less attention to-date, including solar, biomass and biogas. One of the results defined in the Vietnam Clean Energy Program that will now not continue in 2014 is (result 2.3.3) *Off-grid poor communities gain access to renewable energy.* This was combined with other results (2.3.1 and 2.3.2) focusing on *economically viable renewable energy projects* and the (support of) development of *a policy framework for renewable energy that facilitates private sector investments.*

There is a strong need for an improved enabling environment, existing out of –but not limited to- a further developed policy framework that supports the (commercial) development of access to renewable energy. At the moment renewable energy projects are implemented mainly driven by donor funds and grants, commercial investment is limited to larger scale hydropower, larger scale biogas and low-efficient use of industrial residues on site for boilers. Commercial activity in RE project development is therefore limited and have not been reaching the target group as formulated in the Vietnam Clean Energy Program as men and women in poor and marginalized communities nor has it been reaching any of the other goals as set-out in the VCEP RFP document "should provide energy that powers poverty-alleviating businesses, supports health or educational facilities, reduces female labor in collection and production of household energy, reduces indoor air pollution, reduces pressures on forests, or generates other development co-benefits". Therefore further support through VCEP, and the combination of the 3 aimed for results to the off-grid communities, and the RE sector of Vietnam could make a significant impact.

The electrification rates for off-grid areas are still far from the national target for 2020, a high number of off-grid households are scattered national wide (mostly located in mountainous areas and islands). Vietnam has an abundance of natural resources that are potential energy sources for the off-grid areas. The Government has developed a policy framework with a set of principles, long-term goals, and national commitments to rural electrification and renewable energy, specifically indicated in the Power Master Plan VII which emphasis on energy sector with key directions on development of rural electrification program in rural, mountainous and island areas and development of power generation from the renewable energy. Nevertheless the Government lacks the funds currently to fully implement its plans, and external support in knowledge exchange, the development of further supporting policies, and demonstration projects is necessary and welcomed by the Government.

[6] When finalizing this report it was already known that the Renewable Energy component (Sub-IR 2.3) of the Vietnam Clean Energy Program would not continue beyond the initial exploration and study phase.

There is a large number of RE project finance opportunities in Vietnam in case the business case is strong. Nevertheless the interviewed financial institutions indicated that there are few strong enough projects that reach their desks, while at the same time project developers indicate there are few financing opportunities for them. There seems to be a gap between the capacity of either the project developers and/or the (commercial) strength of the projects and the offering of the financial institutions.

Also at local level support to the RE sector, for example in capacity building is necessary as many pilot/demonstration or donor funded RE projects are abandoned, or improperly operated and maintained due to low capacities and/or the lack of spare parts. It is also identified that often low quality technology is being used, either imported from China or other countries or locally developed/hand made by local workshops – requiring more efforts on maintenance and repair and potentially even a risk for its users. Demonstration projects, like the one explored in Thung Khang, Nghe An for example need to be developed with a strong capacity building component to it, up to date (international) technology should be demonstrated. The In-depth case study in the off-grid mountainous village of Thung Khang has shown a potential to improve the livelihoods of its inhabitants by gaining access to a mini hydro power installation. There is willingness to pay for stable and reliable power supply, even though their living conditions are low. This could be further explored in a follow-up phase.

References

ADB, (2008).Wind Power Expert Report – Island Wind-Diesel Hybrid Power System. RSC – C80473 (VIE) RERMIC project Renewable Energy for Remote Mountain and Island Commune Vietnam

CTF, (2013). CTF Semi-Annual operational report.

Cuong, N.D. (2011). A study: Rice Residues and Renewable Energy in Vietnam. 2011.

Dung, T.Q., (2009). Photovoltaic technology and solar energy development in Vietnam

EVN PECC 3, (2010).Feasibility study report of Phu Quy district island power plant (Vietnamese only)

GiZ (2012). Status of wind power development and financing of these projects in Vietnam. Tung, P.T., Mai, V.C., Wasielke, A.

GiZ/MOIT, (2011). Information on Wind Energy in Vietnam

IE (2009). Renewable Energy Development in Vietnam Current Status and Outlook

IE, (2012). Wind Energy Market - developments in Vietnam - potentials and Status Quo. Forum on Wind Energy Development between Germany and Vietnam. Dr. Nguyen Anh Tuan

IE, (2012).Renewable energy development plan for Red river Delta and North midland to 2020 vision to 2030. (Vietnamese only)

IGES, (2013). IGES CDM Monitoring And Issuance Database. Version "Database | 2013/07"

IOREC (2012). International Off-grid Renewable Energy Conference, Key Findings and Recommendations

Ky, T.H. (2003). A model for sustainable development of grid connected renewable energy in Vietnam

MOIT (2011).The National Master Plan for Power Development Plan period 2011-2020 with the vision to 2030. Decision 1208/QD-TTg, approved by the Prime Minister on 21/07/2011. The document was written in 2009. Chapter 10; the electrification development for rural mountainous areas and islands

Nguyen, K.Q., (2006). Wind energy in Vietnam Resource assessment, development status and future implications. In Energy Policy 35 (2007) 1405–1413.

NREAS. Small hydroelectric plants, EPP-13, on FS 13. The Northeast Regional Agricultural Engineering Service

NREL.(2012). Geospatial Toolkit Vietnam. www.nrel.gov/international/geospatial_toolkits.html

Peoples Committee Quy Chau (2012). Socio-economic development master plan for Quy Chau district, Nghe An province to 2020.

Phong, L.T. (2008). Renewable energy potential, status of renewable energy use for off-grid rural electrification and policy for rural electrification. Presentation at the Rural renewable energy week. MOIT

Phuong, K. (2013). Power price goes up by 5%. Online newspaper of the government of the socialist republic of Vietnam. Last accessed on 13 August 2013, website was down in December 2013. Similar articels can be found here: Toui Tre News.

Power Engineering Consulting JSC1 (PECC1).Vietnam Hydropower Current Situation and Development Plan. Presenter Dr. Nguyen Huy Hoach.

RETD, (2012). Renewable Energy Technologies for Remote Areas and islands.

SNV, (2012).Biomass Business Opportunities Vietnam. Supported by AgencyNL.

Thanh Nien Online, (2013). Bất hợp lý giá điện trên đảo Phú Quý. Last accessed on 12th of December 2013.

Tho, N. (2011). http://www.tietkiemnangluong.vn. Last accessed on 21st of August 2013.

Thong, D.D., (2011). Solar PV Technology in Vietnam Application status & problems and future

Ulfsby, O. (2004). Sector report, Hydropower

Thong, D.D., (2009).Renewable Energy activities in Vietnam. Presentation.

TPO, (2010). Rice husk power plants in Vietnam. Last accessed on the 21st of August 2013.

VietnamNet (2013). The end of the small scale hydropower plants. Last accessed on 23th of December 2013.

VUSTA (2007).Assessment of Vietnam Power Development Plan.Vietnam union of science and technology associations (VUSTA).

World Bank, (2001). Wind energy resource atlas of Southeast Asia

World Bank, (2011). State and People, Central and Local, Working Together: The Vietnam Rural Electrification Experience

ANNEX 1 – List of off-grid communities in Vietnam – Province Level

List of un-electrified communities Source: Data collected by Committee of Ethnic Minorities Affairs (CEMA) in Sept 2012 updated by SNV RE team in Aug 2013

Last update 21-08-13

	Name of Province/district/commune/village	Number of households	Number of inhabitants	Poverty Rate (GSO 2011)	Average income (1000 VND/person/month) (GSO	Climatic conditions**	Natural enevironment***			
							Water	Wind	Solar	Biomass (forest and rice crop residue)
	TOTAL	***74,941***	***355,304***							
	PROVINCES IN NORTH	**41,066**	**209,728**							
I	**LAO CAI PRORVINCE**	**1,587**	**8,551**	**36.6%**	**819**	-Average temperature is from 15-29 degree. -Annual rainfall is from 1400-2000mm.	There are two big rivers flowing the provinces (Hong & Chay) and thousands of small steams and rivers with a length greater than 10km), to be very good hydro potential for small hydro development.	The wind power potential in Lao Cai is quite low. It keeps less than 100W/m2 at 65m. However, somepoints bodering with Lai Chau province shows a quite good potential of wind at 300-400W/m2 at 65m.	The map show Lao Cai average potential for solar energy development with solar radiation intensity from 4-4.5kWh/m2/day.	Forest resources: 307573ha of which 249434ha of natural forest and 58139 ha of cultivated forest area.
II	**YÊN BÁI PROVINCE**	**3,099**	**18,577**	**25.2%**	**884**	-Average temperature is 22-25 degree. -Annual rainfall is from 1500-2200mm. -Average moisture is about 86%.	Water resources: there are two big rivers flowing the provinces (Hong & Chay) and about 200 small rivers and streams. It is very good for small hydro development.	Yen Bai doest not have good potential for wind energy development, except for somepoints bodering with Son La province. It shows 300-400W/m2 at 65m.	The map show Yen Bai average potential for solar energy development with solar radiation intensity from 4-4.5kWh/m2/day.	Forest resources: 406230.9ha of which 231,563.7ha of natural forest and 174,667.1ha of cultivated forest area.
III	**ĐIỆN BIÊN PROVINCE**	**8,167**	**46,664**	**46.4%**	**611**	-Average temperature is 21-23 degree. -Annual rainfall is from 1,700-2,500mm. -Average moisture is about 83-85%.		Dien Bien does not have good potential of wind energy sources.	Dien Bien has good potential for solar energy development with radiation intensity from 4.5-5kWh/m2/day.	Forest resources: 348,049ha.
IV	**PROVINCE LAI CHÂU**	**4,157**	**24,209**	**46.8%**	**567**	-Average temperature in 2011 is 23.6degree. -Annual rainfall in 2011 is 2017.7mm. -Average moisture in 2011 is about 82.3%.	Lai Chau is located upstream of Da river with large rainfall and some big rivers as Nam Na, Nam Ma & Nam Mu flowing across this province create good potential for hydro develoment.	Lai Chau shows a good potential of wind energy at boder with Lao Cai province.	Lai Chau has low potential for solar energy development with radiation intensity from 4.0-4.5kWh/m2/day.	Forest resources: 283,667ha of natural forest area.
V	**PROVINCE SƠN LA**	**3,674**	**19,636**	**34.8%**	**802**	-Average temperature in 2011 is 20.6degree. -Annual rainfall in 2011 is 1093.4mm. -Average moisture in 2011 is about 81.2%.	Water resources: There are two big rivers (Da & Ma rivers) flowing aross the province, 35 large streams and hundreds of small streams create a significant potential for hydro power development.	Son La shows somepoints bodering with Laos and Yen Bai province potential for wind energy development.	Son La has good potential for solar energy development with radiation intensity from 4.5-5kWh/m2/day.	Forest resources: 572,859ha of forest
VI	**PROVINCE HOÀ BÌNH**	**453**	**1,519**	**27.7%**	**829**	-Average temperature is 23degree. -Annual rainfall is about 1,800mm. -Average humidity is about 85%.	Water resources: Hoa Binh has four major river systems: Da River, Ma river, Thuong Tien and Song and and many other small streams giving it a major advantage to develop hydro power projects.	Hoa Binh does not have good potential for wind energy development.	The potential for solar energy application is low.	Forest resources: Hoa Binh has over 200 thousand hectares of forest with rich flora, including many valuable timber species such as ironwood, tau, slug, for-credit study, lat hoa
VII	**PROVINCE PHÚ THỌ**	**2,336**		**17.0%**	**1,126**	-Average temperature is 23degree. -Annual rainfall is about 1,600-1,800mm. -Average humidity is about 85-87%.	Water resources: Phu Tho has three major river systems: Da River, Hong river, and Lo river.	No potential for wind energy development.	It keeps low potential for solar energy development with radiation intensity from 3.5-4.5kwh/m2/day.	Forest resources: Phu Tho has potential for development of forestry industry. It also has very good potential of biomass energy source from rice husk (1.8-6.8million tones/year)
VIII	**PROVINCE HÀ GIANG**	**11,979**	**64,768**	**45.5%**	**610**	-Average temperature is about 21.6-23.9degree. -Annual rainfall is about 2,300-2,400mm. -Average humidity is about 85%. -Number of annual sunshine hours is about 1,427hours.	Ha Giang has three major river systems: Lo River, Chay river, Gam river and smaller rivers such as Nho Que, Mien, Bac, Chung creating a considerable advantage to develop hydro power projects.	Ha Giang shows some potentials for wind energy development at 300-400W/m2.	It keeps average potential for solar energy development.	Forest resources: Ha Giang has about 345,860ha of natural forest.
IX	**PROVINCE CAO BẰNG**	**1,520**	**7,003**	**35.5%**	**749**	-Average temperature is about 23-30degree.	Cao Bang has four major river systems: Bang Giang River, Quay Son river, Gam river and Bac Vong river and small streams system creating a considerable advantage to develop hydro power	Cao Bang shows some potentials for wind energy development at 300-400W/m2 and especially some points having better potential at 400-500W/m2.	It keeps average potential for solar energy development.	Cao Bang has about 10,000ha of forest.
X	**PROVINCE BẮC KẠN**	**459**	**2,556**	**28.6%**	**776**	-Average temperature is about 20-22degree. -Annual average rainfall is about 1,400-1,600mm. -Annual average humidity is about 84%. -Average sunshine hours in province is from 1,400-1,600.	Bac Kan has five major river systems: Lo River, Ky Cung river, Gam river, Bang river and Cau river and small streams system creating a considerable advantage to develop hydro power projects.	Bac Can map shows some potentials for wind energy development at 300-400W/m2.	It keeps average potential for solar energy development.	Forest resources: Bac Kan has a total forest area of 420,990.5ha in which 224,151.4ha of natural forest, and 39,352.5ha of cultivated forest area and others.
XI	**PROVINCE LẠNG SƠN**	**2,648**	**12,205**	**25.0%**	**930**	-Average temperature is about 17-22degree. -Annual average rainfall is about 1,200-1,600mm. -Annual average humidity is about 80-85%.	Water resources: Lang Son has five major river systems: Thuong River, Ky Cung river, Luc Nam river, Tien Yen-Ba Che river and Na Lang river and dense streams network.	Lang Son keeps a good potential of wind energy. Somepoints at boder with China show greater than 800W/m2. On average is 300-400W/m2.	It has low potential for solar energy development with radiation intensity from 3.5-4.5kwh/m2/day.	Forest resources: Lang Son has a total forest area of 172,635.01ha including natural forest and cultivated forest areas.
XII	**PROVINCE QUẢNG NINH**	**987**	**4,040**	**6.5%**	**1,787**	-Average temperature in 2011 is 22.6degree. -Annual rainfall in 2011 is 1823.8mm. -Average moisture in 2011 is about 82.1%.		Quang Ninh shows a good potential of wind energy. Somepoints at boder with China show greater than 800W/m2. On average is 300-400W/m2. Islands in this province also have a good potential to install wind turbines.	The potential for solar development is ranked as average with radiation intensity from 4-4.5kwh/m2/day.	Forest resources: Quang Ninh has about 243,833.5ha of forest in which 80% is area of natural forest.
XIII	**PROVINCE THANH HOÁ**	**3,013**	**15,169**	**22.6%**	**840**	-Average temperature is about 23-24degree. -Annual rainfall is about 1,600-2,300mm. -Average moisture is about 85-87%. -Annual sunshine hours are about 1,600-18,00.	Thanh Hoa has an average potential of wind energ for electricity supply. As mapped it shows wind energy density is from 300-400W/m2.	The potential for solar development in Thanh Hoa is classified as average with radiation intensity from 4-4.5kwh/m2/day.	Forest resources: Thanh Hoa has about 484,246ha of forest with reserve of about 16.64 mill meter cubic wood. Besides, Thanh Hoa shows very good potential of biomass energy source from rice husk (1.8-6.8million tones/year)	
XIV	**PROVINCE NGHỆ AN**	**4,142**	**16,643**	**22.5%**	**920**	-Average temperature in 2011 is 23.3degree. -Annual rainfall in 2011 is 2558.6mm. -Average moisture in 2011 is about 83%.	Nghe An has a dense river and stream network and sloping terrain which facilitaes hydro power development. The estimated hydro potential capacity is up to 1,200MW in province.	Nghe An has wind energy density quite good (300-400W/m2 along with the seacoastal) and somepoints bodering with Laos has wind energy density is upto 500-600W/m2.	Nghe An has good potential for solar energy development with solar radiation intensity reaching to 5kwh/m2/day.	Forest resources: Nghe An has a total forest area of 885,339ha in which 732,741ha of natural forest and 152,867ha of cultivated forest area. Nghe An also has quite good potential of biomass energy source from rice crop residues.
XV	**PROVINCE QUẢNG BÌNH**	**57**	**257**	**23.0%**	**950**	-Average temperature is about 24-25degree. -Annual average rainfall is from 2,000-2,300mm.	Quang Binh has a large system of rivers and streams with the density of 0,8 - 1,1km/km2. 5 main rivers are named Ron, Gianh, Ly Hoa, Dinh and Nhat Le. There are3 160 natural and artificial lakes with expected capacity of 243.3 million m3.	Quang Binh has a good potential of wind energy source. The wind energy density shows 300-400W/m2 and some places bodering Laos keep at 500-600W/m2 and even greater than 800W/m2.	Good potential for solar energy development.	Forest resources: Quang Binh has 486,688 ha of forest including 447,837ha of natural forest and 38,851ha of planted forest.

XVI	**PROVINCE QUANG TRI**	150	500	**21.7%**	**951**	-Average temperature is about 24-25degree. -Annual average rainfall is from 2,200-2,500mm. -Average relative humidity is about 85%. -Average sunshine hour is quite good, about 5-6hours per day.	Quang Tri has three main river systems discharging into sea: Ben Hai river, Thach Han river and O Lau river.	Quang Tri has good potential of wind energy, especially in areas bodering with Laos. The wind energy density is from 300-800W/m2.	Very good potential for solar energy development with radiation intensity to be able to reach 6kwh/m2/day at some sites bodering with Laos.	Forest resources: Quang Tri has 219,638.85ha of forest including 101,631.02ha of productive forest; 62,664.45ha of protective forest and 55,343.38ha of special forest. The potential of utilizing rice residues are moderate.
XVII	**PROVINCE QUẢNG NAM**	**1,066**	**4,291**	**21.7%**	**935**	-Average temperature is about 25.4degree. -Annual average rainfall is from 2,000-2,500mm. -Average relative humidity is about 84%.	Quang Nam has a dense river and stream network with total length of 900km including 9 major rivers such as Thu Bon and thus makes it high potential for hydro power development.	Quang Nam has potential for wind energy development, espcially in western districts of province.	Quang Nam give a good opportunity for solar development with radiation intensity from 5-6kwh/m2/day.	Forest resources: Quang Nam has 425,921ha of forest including 388,803ha of natural forest and 37,118ha of planted forest. Quang Nam also has a quite good potential of biomass energy sources.
XVIII	**PROVINCE QUẢNG NGÃI**	**1,060**	**4,536**	**20.8%**	**909**	-Average temperature is about 25.8degree. -Annual average rainfall is from 2,200-2,500mm. -Average relative humidity is about 85%. -Accumulative sun radation amount is from 130-150kcal/cm2/year.	Quang Ngai has four main rivers including Tra Bong, Tra Khuc, Ve and Tra Cau with catchment areas are respectively 697km2, 3,240km2, 1,260km2 and 442km2. Thus, it has good potential for development of hydro power projects.	The potential for wind energy development in Quang Ngai is not significant.	Quang Ngai also has a good potential for solar development with radiation intensity from 5-6kwh/m2/day.	Moderate potential for utilization of rice crop residues.
XIX	**PROVINCE BÌNH ĐỊNH**	**794**	**3,912**	**15.2%**	**1,150**	-Average temperature is about 20.1-26.1degree. -Annual average rainfall is 1,751mm. -Average relative humidity is about 79-92%.	Binh Dinh has four major rivers Lai Giang, Kon, La Tinh and Ha Thanh. The estimated hydro potential capacity is about 182.4 Million KW.	Binh Dinh show good potential for wind energy development.	Binh Dinh keeps a quite good potential for solar energy development with radiation intensity from 4-5kwh/m2/day.	Binh Dinh has huge potential for utilizing rice husk.
XX	**PROVINCE KHÁNH HOÀ**	**820**	**3,653**	**8.8%**	**1,258**	-Average temperature in 2011 is 26.7degree. -Annual rainfall in 2011 is 1327.6mm. -Average moisture in 2011 is about 77.6%.		The map show Khanh Hoa quite potential for wind energy development. Somepoints has wind energy density is up to 800W/m2.	Khanh Hoa has solar radiation intensity from 4.5-5kwh/m2/day, making it a good potential for solar applications.	Moderate potential for utilization of rice crop residues.
XXI	**PROVINCE ĐẮK LẮK**	**1,814**	**8,476**	**19.6%**	**1,067.7**	-Annual average rainfall is 1,600-1,800mm.	Dak Lak has big potential for hydro development with estimated capacity of 2,636 million Kw, especially small hydro power projects to electrify some remote areas in province.	The map show Dak Lak quite potential for wind energy development with average wind energy density is 300-400W/m2 and up to 800W/2 at somesites.	Dak Lak has a really good opportunity for solar application with radiation intensity from 5-5.5kwh/m2/day.	Dak Lak has quite good potential for utilization of rice crop residues.
XXII	**PROVINCE BÌNH PHƯỚC**	**1,640**	**6,401**	**9.1%**	**1,526**	-Annual average temperature is about 25.8-26.2 degree. -Annual average rainfall is from 2,045-2325mm. -Total sunshine hours in year is quite abundant, about 2,400-2,500. The sunshine time on average is 6.2-6.6hours per day. -Annual average humidity is about 80.8-81.4%.	Binh Phuoc has a dense river and spring system with density of 0.7-0.8km/km2, including Sai Gon river, Song Be river, Dong Nai river, Mang and other small ones.	Binh Phuoc does not have wind energy potential.	Binh Phuoc has a really good opportunity for solar application with radiation intensity from 5-5.5kwh/m2/day.	Forest resources: Binh Phuoc has a total forest area of 165,701ha.
XXIII	**PROVINCE BÌNH THUẬN**	**1,407**	**6,268**	**9.3%**	**1,560**			Binh Thuan has a very goood potential of wind enegy with density on average of 400-500W/m2 and 500-600W/m2 along the sea coast.	Binh Thuan has a really good opportunity for solar application with radiation intensity from 5-5.5kwh/m2/day.	Binh Thuan has potential for utilization of rice husks. As pointed out in NREL map annual rice crop residues are from 550,000-900,000 tones/year.
XXIV	**PROVINCE BA RIA-VUNG TAU**	**1,000**		**4.8%**	**1,695**	-Average temperature in 2011 is 27.5 degree. -Annual rainfall in 2011 is 1382.9mm. -Average moisture in 2011 is about 79.1%. -Sunshine hours in year is quite signfinicant, about 2,400 hours/year.		Vung Tau also shows potential for development of wind energy turbines along the sea coast.	Vung Tau has a quite good potential for solar development with radiation intensity from 4.5-5.5kwh/m2/day.	It has low potential for utilization of rice residues due to insignificant amount (from 80,000-285,000 tones/year)
XXVI	**PROVINCE AN GIANG**	**459**	**2,192**	**8.5%**	**1,319**	-Annual average temperature is about 28 degree. -Average relative humidity is about 80%. -Average daily sunshine hours are from 7-10hours.		No potential for wind enegy development.	It has a really good potential for solar energy development.	An Giang also has huge potential of rice husk amount. As mapped out it is about 1.8-6.8million tones/year.
XXVII	**PROVINCE TRÀ VINH**	**529**	**2,155**	**21.1%**	**1,089**	-Annual average temperature is about 26-27 degree. -Average relative humidity is about 80-85%. -Annual average rainfall is from 1,400-1,600mm.		Tra Vinh has good potential for wind energy development with energy density from 300-500W/m2.	Really potential for solar energy development.	Forest resources: Area of forests and forest land is 24,000 ha and agri- cultural land is about 186,170 ha with annual rice crop residues from 1.8-6.8million tones/year..
XXVIII	**PROVINCE KIÊN GIANG**	**6,634**	**27,748**	**8.1%**	**1,316**			The wind energy potential in Kien Giang is not really clear. Only some sites has average wind potential with energy density from 300-400W/m2.	Quite potential for solar energy development with radiation intensity from 4.5-5.5kwh/m2/day.	Kien Giang also has huge potential of rice husk amount. As mapped out it is about 1.8-6.8million tones/year.
XXIX	**PROVINCE BẠC LIÊU**	**7,745**	**36,921**	**12.9%**	**1,273**	-Average temperature is about 28.5 degree.		Bac Lieu has good potential for wind energy development along the sea coast.	Quite potential for solar energy development with radiation intensity from 4.5-5.5kwh/m2/day.	Amount of rice crop residues in Bac Lieu is 550,000-900,000 tones/year.
XXX	**PROVINCE CÀ MAU**	**1,545**	**6,454**	**10.9%**	**1,251**	-Average temperature in 2011 is 27.5 degree. -Annual rainfall in 2011 is 2445.9mm. -Average moisture in 2011 is about 79.5%.		Ca Mau has good potential for wind energy development along the sea coast.	Quite potential for solar energy development with radiation intensity from 4.5-5.5kwh/m2/day.	Forest resources: Ca Mau has 97,187ha of forest including 9,986ha of protective forest, 11,530ha of special forest and 75,670ha of productive forest. Agricultural land area for cultivating rice is about 248,200ha with annually rice husk amount from 285,000-

ANNEX 2 – Questionnaire for Village Leader

Questionnaire for Village Leader

No	Questions	Answer
I	**General information of respondent**	
1	Name	
2	Sex & age	☐Male ☐Female Age:…….
3	Organization:	
4	Position in Community:	
II	**General infrastructure information**	
1	The distance from district/ commune/village centre to your site?	From district centre : ....km From commune centre : ..... km From village centre : ....km
2	Total population in your commune/village	…….persons
3	Number of households in your commune/village	…….households
4	Number of schools in your commune/village	……schools
5	Number of clinic stations in your commune/village	……stations
6	Is there any road leading directly to your site?	☐ Yes ☐ No
7	How far is it to the closest road from your site?	……..….. km
9	What transport mean(s) can access to this road?	
III	**General information on existing power system information**	
1	Is there any existing power system in your site?	☐ Yes ☐ No If yes, please go to 2-12 If no, please go to 13
2	If yes, what is it?	☐Mini hydropower: ……. kW ☐Wind power: ……..…. kW ☐Solar power : ……...…... kW ☐Diesel power : ……..…... kW ☐Biomass power : ……. kW ☐Biogas power : ……..…….. kW ☐Hybrid wind +diesel: ……..… kW ☐Hybrid Solar + Diesel: ……..… kW
3	What is total capacity?	……. kW
4	Who are investor and operator?	
5	How much time does it operate a day?	

6	How is the electricity quality?	
7	How many household in village do get access to the electricity?	
8	Is it enough for use daily?	☐Yes ☐No
9	Do you have to pay money for it?	☐ Yes ☐No
10	If yes, what is the electricity tariff?	……..VND/kwh
11	What is the payment way for the electricity?	☐ Monthly ☐ Measurement
12	Have household been satisfactory with it yet?	☐ Yes ☐ No If no, please tell us the reason? ……
13	If there is no electricity in the community, what kind of energy do households use to meet their energy demand?	-Lighting -Cooking -Watching -Producing
14	What is the energy price?	☐ Diesel ……VND/L ☐ Gasoline …… VND/L ☐ Coal …… …VND/kg ☐Firewood……..…VND/kg ☐ Battery……VND/charge ☐ Candle……VND/piece ☐ Cell…….…….VND/piece ☐Biogas gas……VND/m^3 ☐ LPG……VND/kg

Date:……..

Interviewer
(Signature and name)

Respondent
(Signature and name)

ANNEX 3 – Questionnaire for the selected households

No	Question	Answer
I	**Respondent information**	
1	Name of respondent	
2	Sex and age	☐ Male ☐ Female Age: ……..
3	Address	
4	Occupation	
II	**Household information**	
1	Category	☐ Poor *(income < 400.000 VND/pers/month)* ☐ Pro-poor *(income 401.000 – 520.000 VND/pers/month)* ☐ Medium *(income 520.000 VND/pers/month)*
2	Occupation	☐ Agriculture ☐ Forestration ☐ Aquaculture ☐ Service (trading…) ☐ Other:
3	How many people in your household?	…… people are within labour age (from 18 up to 60) …… people are out of labour age (under 18 and over 60)
4	Average monthly income of household (VND/month)	Income sources: - Monthly salary: ……VND/month - Labour wages: ……VND/month - Trading: …… VND/month - Sideline:…… VND/month - Cultivation, cattle breeding ……VND/month - Loans …… VND/month - Other (from relatives) ……VND/month
5	Household monthly expenses	☐ Housing: ……..…… VND/month ☐ Food and drinks: ……..…… VND/month ☐ Education:…… VND/month ☐ Electricity (if any): ……..…… VND/month ☐ Water:……...…… VND/month
III. Energy demand information		
1	Do you currently have access to electricity?	☐ Yes → If yes, please go to questions 2 -5

<table>
<tr><td></td><td></td><td>☐ No → If no, please go to questions 6 – 7</td></tr>
<tr><td>2</td><td>What kind of electricity do you use?</td><td>☐ Pico/mini hydro power …… W
☐ Solar power …… W (…… panel)
☐ Wind power …… W
☐ Diesel power …… … W
☐ Biogas power …… W
☐ Biomass power …… W
☐ Other (specify …… W</td></tr>
<tr><td>3</td><td>Is the current electricity supply sufficient and stable?</td><td>☐ Yes
☐ No
Supplying hours……/day</td></tr>
<tr><td>4</td><td>Average monthly consumption</td><td>☐ Power tariff: ……VND/kWh
☐ Electricity use: ……kWh/month
☐ Payment: ……VND/month</td></tr>
<tr><td>5</td><td>Electric equipment and applicances</td><td>
<table>
<tr><th>Equipment</th><th>Q.ty (pieces)</th><th>Capacity (W)</th><th>Use duration (hr/day)</th></tr>
<tr><td>Lighting</td><td></td><td></td><td></td></tr>
<tr><td>TV</td><td></td><td></td><td></td></tr>
<tr><td>Radio</td><td></td><td></td><td></td></tr>
<tr><td>Electric pump</td><td></td><td></td><td></td></tr>
<tr><td>Electric fans</td><td></td><td></td><td></td></tr>
<tr><td>Water boiler</td><td></td><td></td><td></td></tr>
<tr><td>Electric cooker</td><td></td><td></td><td></td></tr>
<tr><td>Air conditioner</td><td></td><td></td><td></td></tr>
<tr><td>Fridge</td><td></td><td></td><td></td></tr>
<tr><td>Electric water heater</td><td></td><td></td><td></td></tr>
<tr><td>Iron</td><td></td><td></td><td></td></tr>
<tr><td>Computer</td><td></td><td></td><td></td></tr>
<tr><td>Washing machine</td><td></td><td></td><td></td></tr>
<tr><td>Food processing</td><td></td><td></td><td></td></tr>
<tr><td>Wood processing</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

		Rice milling Ice making machine Processing other crops Other
6	Energy demand for lighting	☐ Kerosene lamps: …… lit/month …… VND/litter ☐ Candle …… piece (size ……)/month …… VND/piece ☐ Torches ……cell (size……)/month …… VND/piece
7	Energy demand for other purposes	☐ Radio (using cell): …… cell/month (size……). ☐ TV (using battery): ……VND/month (battery charging fee) ☐ Pump: (type……) ……..… VND/month ☐ Fan: (type……)……..… VND/month
8	Energy for cooking	☐ Firewood ……kg/month …… VND/kg ☐ Coal ……kg/month …… VND/kg ☐ Diesel …… littler/month……VND/litter ☐ Biogas …… m3/month……VND/m3 ☐ Liquid gas: …… tank/month ….……VND/tank
9	Energy for production and transportation	☐ Diesel/gas for fishing……litter/month ☐ Gas for transportation ……litter/month ☐ Ploughing machines… …… litter/month ☐ Rice milling …… litter/month ☐ Others. …..…… litter/month
10	Do you use solar energy?	☐ Yes ☐ No Capacity: …… (W)
11	Are you willing to use electricity from renewable energy?	☐ Yes → Answer question 12 ☐ No If no, please share with us your reason: …….
12	How much will you be able to pay for electricity?	…… (VND/month)

Date:……..

Interviewer **Respondent**

(Sign, Name) (Sign, name)