VIETNAM - SWEDEN RURAL ENERGY PROGRAMME
IMPLEMENTATION PHASE (2005 – 2008)

MOIT

Area 1

Strengthening the Implementation Capacity of Renewable Energy Policies

TOOLS AND METHOD FOR THE PREPARATION OF DISTRICT RENEWABLE ENERGY OFF-GRID PLANNING

(Final draft)

Prepared by: *Nguyen Van Hanh & Nguyen Kinh Luan, VSRE experts*
Checked by: *Ludovic Lacrosse, VSRE Team Leader*

HANOI, MARCH 2007

Carl Bro Intelligent Solutions

entec Consulting & Engineering

ECC1 ISO 9001

RCEE

INTRODUCTION

District Renewable Energy Off-grid Power Planning (DREOPP) is a part of decentralized rural electrification planning aiming at the micro-region level (remote non-electrified communities, villages, communes, islands etc.). The purpose of DREOPP is to provide the remote and/or mountainous areas with electricity meeting the demand of household, public and productive use. Those areas probably can not be connected to national grids in the near future (even they are located inside of an almost electrified district).

In the framework of national rural electrification program of Vietnam, by the end of December 2005, 100% of provinces and cities, 98% of districts, 95.3% of communes, and 89.7% of rural households have been connected to the national electric network.

At present, there are remaining 10 insular districts, 01 mountainous mainland district among 536 districts in the whole country, and 335/9,024 communes are not electrified by national electric network because they are located in remote uplands or islands that the national electric system could not extend to in the near future (Source: EVN Recapitulative Report for Year 2005 - Hanoi, January 2006). For those non-electrified areas, the renewable energy off-grid electrification is considered as the most appropriate solution. Renewable energy off-grid electrification is considered as an important part of national stratery for rural and agricultural development, improving the rural electricity services, and reducing the socio-economic gap between rural and urban areas.

In Vietnam, there usually exist three levels of power planning, e.g., National, Provincial and district ones. For VSRE, the **district** level is selected. However, because of the status of current rural electrification, the socio-economic, geographic and topographic particularities of the remote mountainous, upland and island districts in Vietnam, the DREOPPpractically should take for consideration of **micro-size,** e.g. **commune, village** and even **household group (communities)** range.

For **supply side**, the planning focuses on **in the site** renewable energy sources whichin the area can be used for electricity generation. Building a power plant outside and transport electricity to these (mostly) isolated areas is in the most cases unreasonable.

For **demand** side, the forecast is also focused on **household groups, villages** and **communes**.

Present status and projection of electricity supply/ demand balance can be established based on the local socio-economic and energy situation (the needs and the availability) that could be identified by in the site investigation and/ or prediction for the planning years.

It is the big limitation of the remote mountainous off-grid areas to integrate fully to other regions even within a district. A lot of obstacles that block their communication with outside, eg. geographical isolation, scattered location of household, road access restriction, etc. Therefore, the district level for DREOPP, is only an administrative notion (in Vietnam, the planning is usually prepared for national level, provincial level, and district level). This notion does not play much important role in our purpose of renewable energy off-grid planning. Instead of whole district integrated energy planning (including traditional and renewable energy), our planning only aims at household groups, villages and communes which can not be able to connect to the national electricity network (up to the year 2015, for instance), though even they are located inside the considered electrified district.

There are several methods for rural energy (incl. renewable energy) planning and for assuming rural energy demand and projections, such as:

(i) Direct survey
(ii) Process analysis
(iii) Trend analysis
(iv) Elasticity approach
(v) Econometric methods, and
(vi) Input, output analysis.

According to the experiences achieved from rural energy studies in several mountainous and remote areas in Vietnam (e.g., Yen Chau district, Co To island etc.) and from the rural electrification practice at district level, the **direct survey** method is proved as the most appropriate methods. Our document will only focus on this method with reference to **trend analysis** method.

Currently, the legal framework for development of renewable energy in Vietnam is still not adequate, especially the documents defining the procedure and/or methodology for preparation of a district renewable energy off-grid planning. The Ministry of Industry has issued Decision No. 30/2006/QĐ-BCN on "Guidelines of procedures and outline of contents for Electricity Planning", where the power planning at national, provincial and district levels had been stipulated and the detailed outlines of contents for each level are separately defined. A district planning of course is much less complexness in comparision with the other levels. The Decision No. 30/2006/QĐ-BCN could be a good reference for our proposing Methodology for District renewable energy off-grid planning.

The essential part of energy planning is the balance between energy supply (electricity in particular) and demand. Based on the finding of demand, a planner has to suggest an appropriate way for meeting the supply with demand. In our case, due to the limitation of using local renewable energy resources for electricity production, the capacity of supply side will be fixed while the demand can flexibly vary. Therefore, in case if the supply is short against the demand, several solutions must be taken, either combining multi-sources of renewable energy, including the creation so called hybrid system with the combination of renewable energy sources with diesel generator(-s) for electricity production or reducing the demand to meet the supply ability. The later should be the last unavoided option in planning. For developmet of individual project, the investor can freely choose the way for balancing between the ability of his/ her project's deficient supply with a dominant demand by restricting number of electricity consumers or their consumption that can be just sufficient for the capacity of his/ her project. In this case, supply ability is prior. On the contrary, the electricity balancing for planning must take priority from the demand side. Development of society and economy of the planned region will be negatively impacted if the shortage of energy/ electricity supply happens, when the ability of energy/ electricity supply can not cover the requirement of demand growth. That why, a good planner must try firstly to find out a way for meeting the demand by suitable solution of energy/ electricity supply. Unreasonable restriction of energy/ electricity needs in demand side should be avoided.

Nowadays, a sound plan is beside a good supply-demand balance still requires a least cost planning. Consequently, the economic and financial analyses is a not less important part of any plan. For a completeness of planning, the positive and/ or negative impacts of the plan implementation on the area socio-economic development, on environment ... should be analysed. Finally, recommendation and suggestion of policies for the plan implementation should also be proposed in the Planning Report.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

A	Amper
AC	Asynchronous circuit
B/C ratio	Benefit/ Cost ratio
CPC	Commune People Committee
DC	Direct circuit
DPC	District People Committee
DREOPP	District Renewable Energy Off-grid Power Planning
EIRR	Economic Internal Rate of Return
EVN	Vietnam Electricity Corporation
FIRR	Financial Internal Rate of Return
GJ	Giga-Joule
HH	Household
kPa	Kilo-Pascal
kVA	Kilo-Volt Ampere
kW	kilowatt
kWh	kiloawtt hour
lps	litres per second
LV	Low Voltage
m	metre
m a.s.l.	Meter above sea level
m/s	metre per second
m2	Square metre
MHP	Micro and Mini Hydro Power (micro 5- 100 kW, mini 100-1000 kW);
MOI	Ministry of Industry, Vietnam
MV	Medium voltage
NGO	Non-governmental Organisation
NPV	Net Present Value
OGB	Off-grid Biomass/ Biogas
OGH	Off-grid Micro and Mini Hydropower
OGS	Off-grid Solar PV
OGW	Off-grid Windpower
O&M	Operation and Maintenance
^{o}C	Degree Celsius
PPC	Provincial People Committe
PV	Photovoltaic panel
RE	Renewable Energy
RRES	Rural Referencial Energy System
V	Volt
VND	Vietnam Dong
VSRE	Vietnam Sweden Rural Energy Project
US$	Dollar of the United State
W	Watt
WB	The World Bank

Chapter 1

OVERALL METHODOLOGY FOR DISTRICT RENEWABLE ENERGY OFF-GRID PLANNING

Tools and methods proposed in this document for renewable energy off-grid planning would be applicable with the consideration of such aspects, e.g.:

(i) **Off-grid small regions (community, village, commune)** with capacity demand varying from 5 to 200 KW are aimed at in the planning. Renewable energy resources used for off-grid power supply are relating to mini and micro- hydro (OGH), solar system (OGS), windpower (OGW) and biomass/ biogas (OGB).

(ii) Due to the particular circumstances of the off-grid areas, which usually are mountainous/ island and remote, sparsely populated, mostly low-income rural and/or ethnic minority communities etc., a combination of on desk study and in site investigation and inventory is a common method for preparation of DREOPP. It will bring out a short and reliable way for identifying the context of the area, the current energy consumption (if any) and electricity demand projections for planning alternatives.

Direct survey would be the most appropriate method for establishing database of socio-economic conditions and energy need of the (small) areas. However, gathering the information by “on desk” study is also not less important, especially for collecting the statistical strings (e.g meteological, hydrological, socio-economic figures) and the natural information (geographical, geological ... features) etc. In some cases, “on desk” study will receive enough basic information for making a plan. In site inventory is then for getting a deeper and supplementary information.

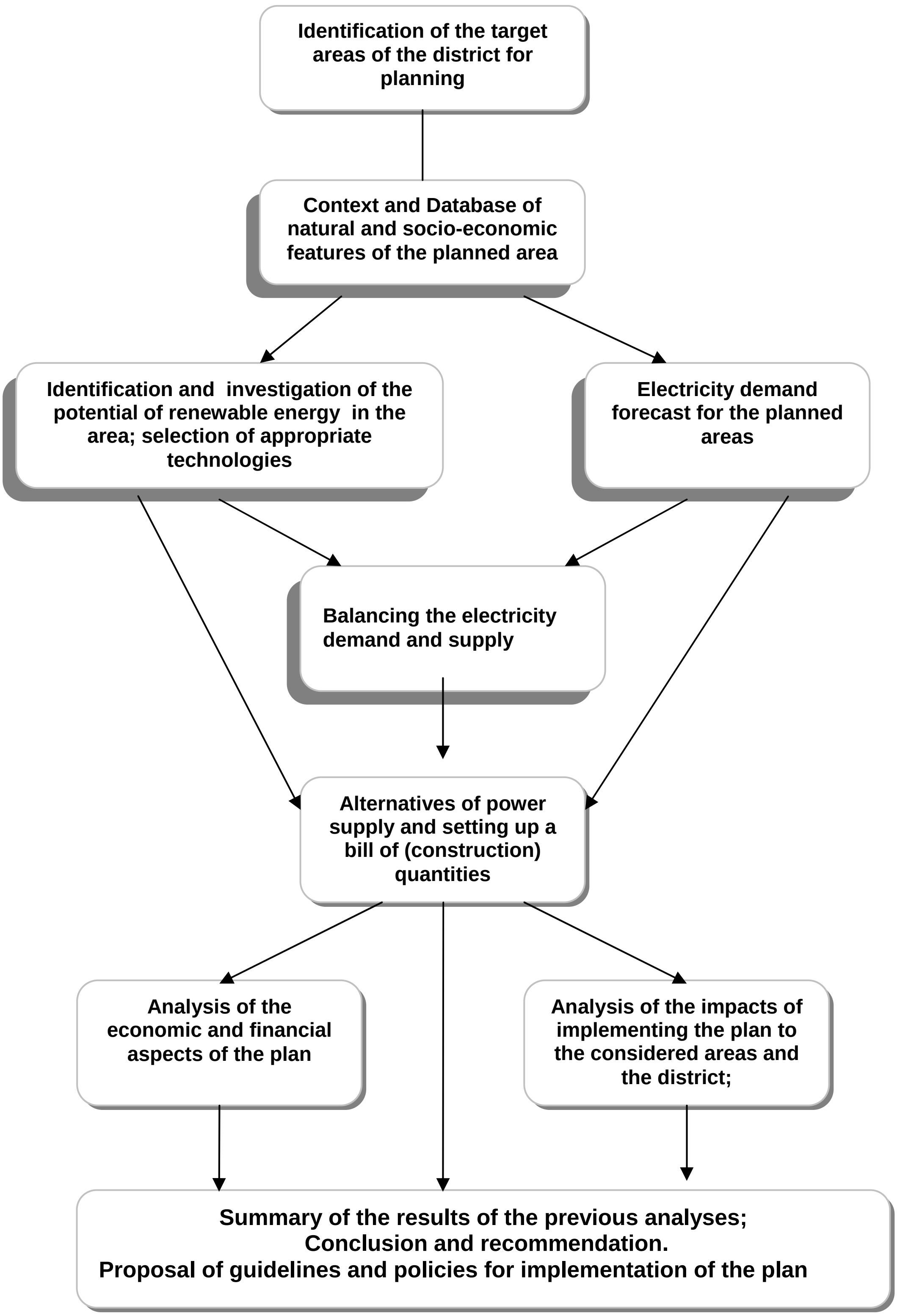
Overall methodology for the preparation of district renewable energy off-grid plan can be illustrated as shown in Table 1.1. The process includes a number of steps closely linked between each other. An output of previous steps can be the input for the following ones as shown in Chart 1.

Analyses of each step ought to be described and itself becomes a Chapter of the Planning Report.

Table 1.1. ***Overall methodology for District Renewable Energy Off Grid Planning***

No	Steps	Instruction
1	**Identification of target areas of the district for planning**	- Clarify the areas based on the existing Provincial Master Power plan; identify in the district map scaled 1/100000 - Aim to the communes/ villages/ groups of households within the selected district that the national electricity grids can not stretch to in the near future (the basic year is 2015).
2	**Context and Database of natural and socio-economic features of the planned area**	- Introducing the context and general aspects of the area(-s); - Natural conditions; - Socio-economic, demographic conditions; - Energy related infrastructures. The information will be taken from the available existing sources (on desk study), in maps or in site surveys
3	**Identification and investigation of the potential of renewable energy in the area and to select appropriate technologies**	- Clarify renewable energy resources available in the target area (identify separately for each group of off-grid communes/ villages/ households to be planned for); - Determine potential (massive amount yearly/ monthly available); - Recommendation of use of the resources to electricity production; - Analysis of available technologies that could be applied (domestic/ foreign/ in the area sources); recommended for projects in the plan; - Estimation of capacity (kW) and electricity (kWh) provided by the potential RE project (-s) - Preliminary analysing the range of costs of selected technologies.
4	**Electricity demand forecast for the planned areas**	- To set up the profiles of the current electricity consumption (if any) and the projections of electricity demand for the planned areas (consumption for households, for public and for expected productive needs must be clarified) - Forecast of electricity demand should be expressed in terms of annual demand, peak load demand and/or daily (annual, if possible) load curve of planned areas.
5	**Balancing the electricity demand and supply**	- Balance between the demand forecast in the step 4 with the available electricity produced from the capacity estimated in the step 3. - Recommendation for solution.
6	**Alternatives of power supply; setting up a bill of (construction) quantities**	- Technology option for power supply to consumers; - Solution for Electric network - Estimation of the bill of quantities for implementing the plan.
7	**Analysis of the economic and financial aspects of the plan**	- Use the recomended analysis model for off grid planning to evaluate economic and financial aspects of the plan implementation;
8	**Analysis of the impacts of implementing the plan to the considered areas and the district;**	- Socio-economic positive/ negative impacts; - Environmental positive/ negative impacts; - Pay attention in the impacts on the population of ethnic groups in the area; - Contribution of the implementing plan to whole district development.
9	**Conclusion and Recommendation. Proposal of guidelines and policies for implementation of the plan**	- Recommendation of policies for the plan implemetation regarding the financial model, institutional model, public participation etc. Recommendation of the priority for plan implementation.

Chart 1. District Renewable Energy off – grid Planning flow chart



Chapter 2

TOOLS AND METHODS FOR THE ESTABLISHMENT OF DATA BASE USED IN DREOPP

GENERAL

Data base development involves: (a) identification of data needed to be collected; (b) data collection; and (c) assembling data collected .

Methods for establishment of data base

a) Identification of data needed to be collected

Data groups needed to be collected are:

1. General information of the area;
2. Geographical, topographical, hydro-meteorological, geological conditions;
3. Socio-economic profile and demographic particularities;
4. Renewable resources available in the planned area/ available from around imported; Technologies applicable for renewable energy power plants in the region;
5. Electricity Demand data;
6. Grid extension/ alternatives of electrification projects.

b) Data collection

- Desk research and direct inventory to collect the socio-economic, geographic, meteo-hydrological information and the data of renewable energy sources.
- Sampling, observations, measurement and direct survey with interviews, using questionnaires installed for typical households, authorities of considered communities, villages, communes and district, as well as, for selected individuals of mass organisations.

c) Assembling data collected

Assembling the data collected is carried out through the statistical tabulation with appropriate statistical and analytical forms, calculating spreadsheets with related formulas. The assembly of collected data (database) is the raw material for analysis and composition of Chapters in Planning Report.

Tools for collecting information of households/ communes/ villages

The **Checklist** is applied in combination with using **formats of questionnaires** for collecting information at district/ commune/ village/ household level. The information could also be withdrawn, for example, from the five year socio-economic/ power development plans prepared by PPC, DPC and CPC for the considered area or from the existing statistical data of relevant organisations.

Part 1. IDENTIFICATION OF THE TARGET AREAS

The purpose of this part is to identify the target areas for the planning.

The identification can be withdrawn from studying the existing Provincial Master Power plan, of which the target districts for our planning will be preliminary determined. In the (geographical/ administrative) district map scaled 1/100000 and by studying the District Electricity Planning, all off-grid communes/ villages/ groups of households that could not connect to the national electricity grids in the near future (the basic year is 2015) will be localized.

The investigation is then carried out on the identified off-grid area(-s). The following checklist will be used.

Checklist for identification of the planned area

Tools and Methods	Instructions for filling the data
Commune (-s) / Village (-s): ……………………………............. ………………………………………………………….............. Province / District (-s): ....………………………………… ....…………………………………………………………	Name of the investigated area(-s), which district/ province belongs to. Maps (geographical/ administrative/ power line) of the district scaled 1/100000, maps of the planned area scaled 1/50000 ought to be collected
Total households: A_{io} = ... HH/village(i); i = 1, 2, 3...n Total households in the planned area... Ao = (A_{10} + ...A_{n0}) Total households have access to electricity at present .... A_{ie} = ... HH/village (i); i = 1, 2, 3...n	Total households in each village (A_{io}) and in the whole planned area (Ao) will be received from CPC and/or from village Heads.
Total households have access to electricity in the planed area $Ae = A_{1e} + A_{2e} + ... A_{ne}$	Total households accessed to electricity (by any source) at present in each village (A_{ie}) and in the whole planned area (Ae)
Which sources of electricity are used? Clarify	Clarify, e.g small diesel, pico hydro, PV etc, and describe how to arrange for use, how much is capacity for a household.
Public/ commercial bases in the planned area. Describe:	Please describe, e.g commune/ village offices, schools, clinic point, shops etc., in the area which will need electricity. Purpose of electricity use?
Which production is currently existed and which will be developed if electricity supply available?	Please describe, e.g handicraft work or agricultural/ forestal product processing, or small industries will be developed etc. Preliminary estimation of maximum electricity capacity needed for each purpose
Population	Population in the investigated area for planning. Average persons/ household.
Main characteristics of the area(-s)	Brief recognition of the area, e.g mountainous/ islandish, average income of population
Contact person (s):……………………………………............. …………………………………………………………..............	Name of local contact person (-s) for each issue and contact details.

Part 2. THE CONTEXT, NATURAL AND SOCIO-ECONOMIC FEATURES OF THE PLANNED AREA

This Chapter and its database latterly given in the Planning Report is very important part regarding the whole logicality of the plan. It will not only provide the input for other chapters e.g. identification of local potential of renewable resources, availability of electricity supply, the needs of electricity use, but it will also be a subject for reasoning out the target of the area development, suggesting policies for plan implementation etc. Taking directly the preliminary gathered natural conditions, the planner will determine the real capability of renewable energy resources available in the erea and by further investigation he/ she can evaluate probable capacity and electricity that could be produced by these resources. The information of organisations existing in the area, the experiences of (if any) enterprises on project management, the willingness of the public participating in project development, willingness and ability of households to pay for electricity, labour source and construction materials available in the area ... will be usefull for the proposal of management scheme of future renewable energy projects, for economic and financial evaluation of the plan, for dicussion on the sustainability of electricity supply by renewable energy resources etc. In this chapter, an overview of general social, economic, demographic context should be provided and analysed.

Checklist for natural and socio-economic database establishment of the planned area

1) Natural conditions of geography, topography, hydrology, meteorology etc. ………………………………………………………………………. ……………………………………………………………………….. Special local conditions: ....…………………….......... …………………………………………………………................	To demonstrate the general natural conditions of the considered area, eg., geographical, topographical, hydro-meteorological, climate data, and specific features (if necessary) such as geological structures needed for cosideration of wind power or hydro power projects proposed in the plan (based on the Section 2 above). Special features of weather, e.g extremely cloudy, rainy etc., that will seriously impact on PV function; or unstability of soil (soil slide), flood ... should be noticed Geographical map scaled 1/100000 for district and 1/50000 for commune/ village area, charts of natural statistical data etc., should be gathered Data will be collected from the existing sources, eg., Map Directorate, Institute of Geography, the nearest Meteorologcal and Hydrological gauges etc.
Name of nearest road head: ....………………………… Walking distance from nearest road head to the border/ center of the planned area: ....…………..km Name of nearest airfield: ....……………………. Walking distance from nearest airfield: ....……………km Notes on route to nearest road head/ airfield (how can manage the transport of equipment and other material to the area? ....………………………………………………………	Describe the general accessibility of the site (how and how long within one year it can be accessed, with focus on fuel availability and transportation of fuel and specific transport means that can access the future project location)
Access year round? Yes☐ No☐, Why not? .... ………………………………… …………………………………………………………………	Comment here if access to the site from the road head is impossible for any reason at any time of year, e.g. landslides, river flooding and lack of bridge etc.
Main out-of-district supply town: ....……………………………………………………	Name the main town from which the site is supplied with imported items (airport, harbour…).
2) Socio-economic conditions + Socio-economic development, current situation and targets for future	The information can be collected from provincial/ district/ commune socio-economic plans or other existing official documents
+ Number of households by ethnic groups living within the planned boundary. Group 1: (name). , number of households: ….. HH Group 2: .. . . , number of households: ….. HH Group 3: .. . . , number of households: ….. HH	List the distribution of the various ethnic groups in the supply area according to number of households. The total number of households should correspond to the number mentioned under section 1 (Ao).
+ Average land area per household in the area: ...... ha/HH.	
+ Potential of biomass resources in the area; Sort 1 (name) .... Sort 2 (name) .... Sort 3 (name) .... Provision of information how to massively collected and estimating their yearly/ mothly/ daily amount	List the distribution of the biomass sources like wood processing residues, agricultural residues, animal manures that can be massively collected and available in year round. This information will be omited if the amount of biomass can be collected is to little, without avail for our purpose of planning
+ Occupations and income sources of households in the	List the distribution of occupations or

planned areas:

Occupation / Income Source	No. of HH	Involved Members	Women Involved
Agriculture			
Army Pension			
Business			
Employee			
Labourer			
Money lending			
Pottering			
Other..............			
Total			

+ Sectors and relevant organizations (NGOs, women's, youth unions, veteran association, others etc.) active in the area:

....

....

How can they assist the RE project and other comments:

....

....

+ Is there any organizations (cooperative, community based or company) in the region that already has the capacity to take over the RE project management/ ownership:

....

Contact details: ....

Proposed ownership (private, company, community, government):

....

....

Entrepreneurial spirit level:............. [high/medium/ low]

Envisaged community participation level: .... [high/medium/low/none]

Comment: ....

....

....

Availability of local skilled people:

- managerial/business skills:..............(good, fair, poor)
- technical/mechanical skills:............. (good, fair, poor)

Comments: ....

....

+ Status of electrification and electricity services in the planned areas:

Electrification and electricity services in identified community, villages and communes	Year 2005	Year 2006
- How many household with private genset connection (% of total)		

income sources across the supply area and include the number of members of the households involved in the occupation and the number of women involved. Note that one household may be involved in more than one occupation/ income source, and one person may also be involved in more than one.

"Employee" means employed by either private company or public / government institutions.

The total households will not be the same as Ao (section 1) because some/ most households will have more than one occupation or income source.

Specify any existing organization with capacity to viably take over management/ ownership of the RE project, and if any, specify contact details.

Specify the ownership structure proposed for the RE project.

Indicate the level of entrepreneurship of the proposed management compared to that of other business people of the area (-s)

Assess the expected level of community participation in the RE project, e.g.: will the community be involved in setting tariff/value rates, how to handle payment defaulters, etc

Assess whether access to RE electricity can be expected to retain and/ or to attract more skilled persons to the area (-s).

Need of training for future project operators, management, technicials etc. should be commented

<table>
<tr><td>- How many household with private diesel/petrol generators (% of total)
- How many household with private renewable energy generators (% of total)
Electricity generation capacity (kW) of the identified community, villages or communes
- Private mini gensets
- Private renewable electricity facilities</td><td>If any</td><td>If any</td><td></td></tr>
<tr><td colspan="3">+ Grid Extension of EVN / other electrification projects:
Current situation of electric network in the area
- EVN grid
Closest EVN grid point:……………………………….
Direct distance:……………. [km]
Plan to extend the grid to the power plant?....... [Yes / No]
- Other local renewable power sources already existing and being exploited in the area:
Type of power unit: ....…………………………
Estimated total installed capacity: ....………kW
Location in the area: …………………………
Main customers: ……………
Portion of electrified households:................... ……… %
The length of the grid .... km
Estimated total load: ....…………… kW
Fuel/ primary energy used: ....……………………
The plan for extension of capacity:
........................…………………………………………………
Current situations of the local grid: ……………..................
.... …………………………………………………
- Other plans to electrify the site (-s) / area (-s)? ………
............……………………………………………………….</td><td>Indicate the end point of the EVN grid and the direct distance to the (center/ border of) planned area.
Indicate any known proposals or plans to bring electricity closer the planned area.</td></tr>
</table>

QUESTIONNAIRE FOR INTERVIEWING TYPICAL HOUSEHOLDS

For gathering information (related to socio-economic aspects) in household level, the questionnaires bellow can be used.

The number of households to be interviewed is as much as possible. For a small community considered in planning, it is not too much difficult to interview even all households. However, for the larger areas (planning for several communes/ villages together) it is better to select a number of representatives from a certain category of households, e.g., rich/ poor or medium in income; commercial/ agricutural/ with or without handicraft professions; high/ low level of education; ethnic groups etc.

The purpose of household investigation is to assist the planner drawing a more detailed picture of the planned area. By processing the gathered data, the planner will evaluate the living conditions of population in the area, the need of energy/ electricity, the ability and willingness to pay for electricity of the households etc.

a) General family particulars and informations

Name of household head	
Sex	Male Female
Ages of household members	20-30 31-40 41-50 51-60 Over 60
Ethnic Group (if any)	Kinh Other (which?) …………………
Education	1. Primary School 2. Secondary school
Number of Children	Boys …… Girls …… (below what age?)
Main Occupation	1. Not working 2. Working (what work?) ....
Number of household members	
Number of Income Earners in Family	

b) Infrastructural facilities related to the renewable electricity requirement

Location of house	Name of Village…………………………… Name of Commune…………………………
Distance to village or commune headquarters	Number of kms………………..
Type of house (circle correct number)	1. Temporary construction house 2. Semi-permanent house with thatched roof 3. Semi-permanent house with tile roof 4. Permanent house with tile roof 5. Permanent house with cement roof
Do you have water handi-pumping currently?	Yes/No. If yes, clarify the purpose of use. For pumping: 1. Surface water (pong, lake, river, stream…) 2. Well 3. Rain 4. Piped 5. Other (specify)……………………………
What fuels do you currently use for lighting in the absence of electricity? (circle correct number) How long is daily lighting time span of your family?	1. Fuel Wood 2. Agricultural waste 3. Kerosene 5. Others (which?)……….. .... hours, from ....(am/pm) to .... (am/pm)

c) Monthly income and expenditure (Optional)

Monthly Income	x1000 Dong	Monthly Expenditure	x 1000 Dong
Family income from agriculture		Agriculture expenses	
Family income from selling vegetables, fruits, etc., from home		Home garden expenses	
		Poultry costs	

garden		Fishery costs	
Family income from selling chicken and eggs		Animal-raising costs	
		Household business expenses	
Family income from selling fish		Taxes	
Family income from selling meat and animal products		Payment to village for duties and obligations	
Family income from own village shop or business		Payment to Commune for duties and obligations	
Salary/Wage earned by yourself in addition to income from the above sources		Food expenses	
		Expenses on clothing	
		Expenses on water supply	
Salary/Wage earned by other family member in the house in addition to income from the above sources		Expenses on house (rent, repair, tax, etc.)	
		Expenses on phones, mail	
Money sent by other family members living outside (in city, town, etc.)		Expenses on transport	
		Occasional expenses (weddings, funeral, entertaiment etc.)	
Other income (e.g., interest from rent on property, savings in bank, pension, etc.): …………………………………. …………………………………. ………………………………….		Medical expenses	
		Education expenses	
		Other expenses	
		Electricity expenses (if any)	
Total income		**Total expenses**	

d) Projections of electricity demand for households

If your house has had electricity, where could you get it from? (circle correct number)	1. Own micro- hydropower system 2. Own diesel (gasoline) generator 3. Own wind generator 4. Own solar PV system 5. Other system (which?)……………………………..
If your house does not have electricity, what do you use for lighting? (circle correct number)	1. Battery 2. Kerosene 3. Candles 4. Other fuels (which?)………………………………
If your house will have electricity, what will be your main uses for it?	1. Lighting (specify type of light and capacity in W) 2.TV sets 3. Electric stoves 4. Electric water heaters 5. Electric water pumps for household water 6. Electric water pumps for agriculture 7. Refrigerators 8. Air-conditioners

	9. Other kitchen electric appliances (specify types of equipment) 10. Recreational appliances (specify types of equipment) 11. Electric equipment used in income-earning activities (specify types of equipment) 12. Other devices and equipments
If your house will have electricity, do you find it difficult to pay for electricity? How do you manage then?	

Note: Pay attention to the differences between urban households and rural ones.

- Urban household: Household living in towns of village, commune (towns people);
- Rural household: Household living out of towns (in country side) of village, commune;

Part 3. IDENTIFICATION OF RENEWABLE ENERGY RESOURCES AND SELECTION OF APPROPRIATE TECHNOLOGIES APPLICABLE IN THE AREA

The first step of resource assessment is identification of the availability of local renewable energy resources by inventory in the communities, villages and communes, which the planning aims at and their adjacent areas located within the maximal allowable length of mini-renewable electricity grid.

Availability of resources implies an adequate quantity for year round production of electricity. For an example, the people in mountaineous areas traditionally have cattle breeding by grazing. Animal manures can be seen every where, however, their collection is not posible. This source of biomass, of course, can not be counted as a resource for electricity production. The situation also will occur even for solar and/ or wind energy resources. Unstable wind speed/ direction during day/ week/ month/ season time; areas shadowed by smok, mist or fog ... are unfavourable condition for wind power or solar PV options. A planner should pay attention and carefully consider such matters for renewable resource planning. Using renewable energy is also tied with the technologies available in the area for extracting, converting and end-use. Imported technologies from outside in some cases are not reasonable.

Input for the analysis of renewable energy resources in the area is directly taken from the previous chapter. Four categories of renewable energy resources would be specially attended, e.g., mini and micro-hydro, solar PV, windpower and biomass/ biogas sources. The planner, by his/ her experiences will preliminarily determine what kind of renewable energy can be taken into consideration for electricity generation based on the information provided from the previous chapter (the natural conditions and biomass amount available in the area). After that, a detailed investigation should be carried out for getting necessary data to evaluate available capacity (kW) and electricity (annual kWh) that could be produced by the renewable energy resource(-s). For each option of renewable energy, a clarification of selected technologies should be provided. Criteria for renewable energy technology evaluation are its *engineering performance, economic performance,* and *social/ environmental implication*. Electricity supply by renewable energy option depends not only on resource availability, but also on technologies/ facilities used by energy supply system. Determining renewable energy resources and their appropriate technologies should be considered together with their cost, and environmental/social implications.

Checklist for evaluation of renewable energy resource capability

Which kind of renewable energy resources is really posible for electricity production in the planned area? Clarify	Take into consideration of four RE resources (if available) in the area: (i) Micro and Mini hydro; (ii) Wind power; (iii) Solar energy and (iv) Biomass/ Biogas. Brief analysis on the exploitation availability and clarify the resources that can be taken into consideration for planning. For relevant RE source, it needs to calculate the usable power/ electric energy

1) If a ***Micro/ Mini Hydro resource*** is clarified, then specify: Source (stream name): ……………………………………… Water intake location: ....……………………… Elevation: ……………… metres above sea level (masl) Headrace route & type: ....……………..…………………….……………..…… Canal length: …………m Power house location:…….……………………… Elevation:.………………. masl Penstock length: ……………m Gross head, **H_{gross}………** m Flow at intake, **Q_i**:………… l/s. Upstream flow abstractions (if any), Q_{up}:………..…… l/s Downstream flow abstractions (if any), Q_{d1}:…………..l/s Will the headrace canal have to accommodate any irrigation demand? Yes☐ No☐ If yes, length of headrace shared with irrigation:…………….m Other demand (specify), Q_{d2}:……….. l/s 80 % exceedance flow based on $Q_i + Q_{up}$ and estimation method, **Q_{80}**:…………l/s 80 % available flow, **Q_{avail}** $= Q_{80} - (Q_{up} + Q_{d1} + Q_{d2})$: ....…………… l/s Estimated maximum available power, **$P_{max} = \eta \times (H_{gross} \times Q_{avail})/100$** = ……………. kW ***Technology selection:*** - Which size of equipments (turbine, generator ...) is more appropriate for the planning? Why? - Selection of technology - What part of the scheme can be domestic/ in the region production or must be imported;	which can be generated from the RE source ($P_{el.}$ and $E_{el.prod}$). Note the source of the water to be used for the MHP project, e.g. name of stream and briefly describe a possible intake and powerhouse locations and the approximate elevations of these locations in metres above sea level (masl). Refer to the respective methods to estimate a duration curve in case of lacking flow data. But make at least one (or better several) runoff measurements during and at the end of the dry season. Note that if flows are abstracted upstream of the intake, these should also be measured and included to determine the 80 % exceedance flow calculations. Similarly, when calculating the 95% available flow for power generation, the upstream abstraction and the downstream demands should be deducted. If there are irrigation diversions close to the intake i.e., within about 6 km (2 hours walking distance), the flow diverted at these locations should also be measured and used to determine the Q_{80} exceedance flow (meaning the flow that is on an average reached or exceeded in 80 % of the time during a year (at 292 out of 365 days). According to Vietnamese regulations, an off-grid hydro power plant have to ensure the continous electricity supply at 80% time rate during a year. Clarify the capacity and number of turbine units and the reason of selection. Clarify turbin type (Francise/ Penton/ etc.), generator and control system; whether it needs a dam, penstock and selection of hydraulic scheme for power station etc.
2) If a ***Wind power resource*** is clarified, then specify: Wind data ...…………………………...................................... ………………………………………………………….................	Specify source, location (-s) and format of data to be used in designing, e.g.: Institute holding data and format (paper, electronic)

Max., min. and average wind speed: Height of measuring and Monthly & daily mean wind speed in m/s .... Additional climate data: .... Wind directions/ speeds are stable during days/ seasons?. No☐ Yes☐ If No☐, clarify whether the unstability of wind directions/ speeds will cause technically unreasonable use of wind energy. In this case, stop further analysis. If Yes☐, further information should be defined. - Calculation of yearly production from a wind turbine: Mean wind speed m/s = U (hup height). Weibull parameter A = U/0.89 Weibull parameter k: Given from wind measurements. If not known, use k=2 for inland, k=3 for sea coast, and k=4 for islands - Calculating production: Power curve P(u): Given by manufacture or test station Mean power **P** = Σ [[(k/A)*(U/A)$^{(k-1)}$ *exp(-(U/A))^{k})]*U*P(u)] (kW) (Σ for each step in the P(u) function) - Annual production **E** = Mean power * 8760* %available (kWh/year). ***Technology selection:*** - Which wind system size is more appropriate for the planning? Why? - What part of the scheme can be domestic/ in the region production or must be imported; - Preliminary estimation of the cost for capacity unit.	Indicate seasonal variation in wind speed. Any extreme wind. Specify source, location (-s) and format of eventual additional climate data relevant in design, e.g.: ambient temperature, cloud cover/ clearness index, precipitation, etc. Due to natural conditions, in some places, direction/ speed of wind changes time by time that causes unstable work of wind turbine. Due to this, the project will not be worth for consideration. Detailed statistical meteorological data can be collected from a nearest gauge station and by in site measurement. Wind roses should be established. To evaluate and select the appropriate size and technology for using wind to produce electricity.
3) If ***Solar resource*** is clarified, then specify: Describe topography: .... Special local conditions:... .... Shadowing:.........:... .... Risks:...	Site/ Area description with focus on being able to establish and keep a free field of insolation for the PV array (-s), e.g.: flat or hilly, threes or other vegetation, open land, ridge or ravine, etc. General local conditions that may affect a PV system, e.g.: salty air (corrosion risk), risk of fog, dusty air, risk of lighting, etc. General risks of shadowing array (-s) e.g.: by trees, bird droppings, high horizon, etc. Assess and describe factors, which may have destructive influence on PV system, e.g.: plants, animals, vandalism, threat of

…………………………………………………………............. The rated power of solar PV modules: General formula $$E = \frac{P_0}{S_0} \times S \times \eta$$ E: Daily solar PV electricity production, Wh/day, P_0: Rated capacity of PV panel system, Wp Po = n * standadized PV module n : Number of solar PV unit of the system Usually standardized module = 50 Wp S_0: Standardized solar radiation (equal to a default of 1000W/m^2) S: Average daily solar radiation around a year. (In the mountainous areas of Vietnam, S = 4.108 k Wh/m^2/day) η: Overall efficiency of solar PV system $\eta = \eta_1 \times \eta_2 \times \eta_3$	loss, landslides, earthquakes, etc. As a rule of thumb in Vietnam: (i) Vietnam has good constant solar radiation in the south and center but substantial seasonal fluctuations in the North. Solar radiation levels (S) in the south and central regions average just below 5kWh/m^2/day and are most constant during the year, ranging from 4.0 to 5.9 kWh/m^2/day. Solar regime in the North exhibits averages around 4KWh/m^2/day (consistent) but it has a wide variation, ranging from 2.4 to 5.6 kWh/m^2/day. (ii) Defaults of η in Vietnam are following: η_1= 0.85; η_2=0.98; η_3=0.90; and η=0.75. (iii) For an example, if we consider a module rated at P_0 = 200 Wp and the amount of sunshine for our site S= 5 KWh/m^2/day (typical value for tropical regions), then our planning alternative will produce: E = (200/1000)* 5*1000*0.75 = 750 Wh/day.
Solar irradiation data [average monthly kWh/m^2/day]: ....………………………………………………………………. Max., min. and average insolation [kWh/m^2/day]: ……..………………………………………………………… Additional climate data [e.g: temperatures, precipitation, etc.]:…………………………….................................. ………………………………………………………….. ………………………………………………………….. Estimated average irradiation: I = ……... [kWh/m^2/day] Estimated average daily load: E = ……… [kWh/day] E = F x I Where F is the area (m^2) of PV system Estimated PV system efficiency: η η = 0,85 for grid connected PV system η = 0,7 for stand alone system with DC load (-s) η = 0,6 for stand alone system with AC load (-s) Estimated PV array size: Pa = E /(I x η) [kWp]	Specify source, location (-s) and format of solar irradiation data to be used in designing the PV system, e.g.: Institute of Meteorology and Hydrology (IMH), average daily global irradiation per month. Indicate seasonal variation in irradiation. Specify source, location (-s) and format of eventual additional climate data relevant in design of PV systems, e.g.: ambient temperature, cloud cover/ clearness index, precipitation, etc.
Technology selection: - Which solar PV electricity system size is more appropriate for the planning? Why? - Suggestion of PV panel manufacturing. - Estimation of preliminary cost.	To evaluate and select the appropriate size and technology for converting the solar energy into electricity. Analyse the suitable scheme for the area (home/ community/ village or larger solar PV scheme)

4) If ***Biomass/ Biogas resource*** is clarified, then specify: Type of fuel (s) available: 1)………………………………………………...................... 2) ………………………………………………...................... 3) ………………………………………………...................... ***Location of fuel (s):*** +) Available at site Ms: ……………….......t/year (For post-harvesting residues: Ms = Mprod = ………………t/year) +) Available within the area, M_{area} = ..………. t/year +) Collected from other places in the commune/village $M_{coll.}$ = …………........... t/year +) Provided by a Long-term contract with supplier(s), M_{contr}. = …………….... t/year.	Specify sources of biomass and biogas available in the commune/village for power production eg., wood wastes, agro-residures, manure production etc.. Specify the biomass or biogas source (s) which is/are available just at the site where the power system is expected to be built Specify the distance from biomass/biogas power plant to the place where the biomass fuel (s) can be exploited. Indicate the means that the additional fuel can be supplied to the site and quantify them. It needs also to analyse: + "Duration of Availability" which means the duration (month or days) in an year when fuel source is available;
+) Total possible availability, $M_{poss.}$ = Ms + Mcoll. +Mcontr. = …………… t/year Self-sufficient fraction: S.F = (M_s + $M_{coll.}$)*100%/(Ms+Mcoll +$M_{contr.}$) = ……… = % Estimate power capacity and yearly electricity production from the Biomass/ Biogas source(-s) ***Technology selection:*** - Technology(-ies) selected for converting biomass substrates into electricity. - Domestic/ in the region production or must be imported - The cost/ capacity unit.	+ Accessible fraction: Ka = …………%. It is the percentage of accessible amount of any biomass compared to total produced amount. For the plant biomass, it can be estimated as the percentage of accessible area compared to the total cultivated area. *(see VSRE document **"Tools and Methods for the preparation of Biomass/ Biogas off grid power project proposal"** – Hanoi 9/2006 and annex .....)* To evaluate and select the appropriate size and technology for converting the biomass and other bio-substrates into electricity. Four technologies could be consided : (i) Direct combustion of biomass; (ii) Anaerobic fermentation (production of biogas), (iii) Biomass gasification and (iv) Pyrolysis, for areal Bm and Bg –fueled electricity generating alternatives ;

Part 4. ELECTRICITY DEMAND FORECAST AND BALANCING SUPPLY-DEMAND FOR THE PLANNED AREAS

Selection of the most suitable method for assuming the current energy demand profiles and projections for DREOPP can face a lot of difficulties, because of the reasions, like insufficiency and unreliability of rural energy data at all energy/electricity planning level; uncertainty of energy consumption of rural population, especially of ethnic minority groups living in mountainous uplands and/or remote island; high poverty and low intellectual standard of local/ mountainous population, especially of poor and marginalized people; rural energy/ electricity source insufficiency within district territory, consequently the forecast of rural energy consumption of DREOPP should be limited in the energy supply capability of local renewable energy sources; expensiveness and inconvenience of some renewable energy types versus high poverty of local rural/ mountainous population etc.

In our document, **direct survey method** is selected and **process analysis** can be used for reference.

Direct survey method

The method could provide a more reliable tool for demand analysis forecasting than other methods. Direct survey method would be useful in providing short to medium term energy demand forecast. The results of interviews at district, commune, village and household level by using a comprehensive system of questionnaires are appropriate for accurately assuming the present demand and projections for DREOPP.

Process analysis methods

This method can be applied by using the so called Rural Referencial Energy System (RRES) at district/ commune/ village level. RRES describes energy flows changing from primary energy sources, coming through a process of trasformation, becoming the useful form of energy for endusers. Process include resource extraction, refining, conversion, transportation, storage, transmission, distribution and end-uses.

Trend analysis method

Trend analysis method has the main advantage of *simplicity* in terms of data and formal requirements. It implies *extrapolation* of past trends by projecting average historical values, of energy-economic activity and per capita energy ratio with assuming that there will be *no considerable change in energy consumption behaviour* in near future. Results of interviews through the system of questionnaires are most important basis for identifying the trend of the change in rural energy demand profiles of the district.

Balancing between supply and demand for the planning alternatives is mainly carried out through the estimated **capacities** (in kW) and **energy** (kWh) of supply side based on the renewable energy sources (MHP, solar PV, wind, biomass/ biogas, diesel/gasoline genset etc…) and electricity demand (domestic, public/ service/ commercial, productive needs) that are forecast for planning alternatives in the peak condition.

There are two approaches can be applied for balancing between supply and demand.

In the *“top-down”* approach, a planner can rely on socio-economic development targets of the planned area and by using so-called elasticity index to canculate a proposed electricity demand for meeting the growth rate of economy. Elasticity index is the ratio between growth rate of energy/ electricity supply and growth rate of economy. In the earlier stage of development, the growth rate of energy/ electricity is always high and usually has to “go a step ahead” in comparision with the growth rate of economy (in some cases the ratio is equal to two or even higher). Gradually, the ratio between two those ones reduces and will reach to below 1, when the energy/ electricity supply systen becomes very strong and supply is redundant compared to demand growth. Currently in Vietnam, the index is around 1.2 to 1.3 for energy supply and around 1.5 “elastic” for electricity. Hence, for matching the target of annual economic growth, for an exemple, around 8%, the growth rate of energy supply should be around 9.6 to 11.2, and for electricity supply is even higher. This approach is, however, not easily applicable for off-grid area planning, where its departure point of electricity supply is almost zero. For these areas, other method will be used, taking into account so-called target stadardized electricity demand for regions established by authorized organisations . For exemple, by the year 2010 and 2015, the standardized electricity consumption of household in the mountainious (recently off-grid) areas, approved by the Minister of Industry, is 350 Wh and 450 Wh respectively. By using these figures, a planner will easily calculate capacity of supply side for a planned area by multiplying the number of households needed to access to electricity by the respected years. Despite the easy application, this method could not promise any precise results for a specific area.

The other approach, that being suggested in this document is a *“bottom up”* approach. This approach is based on the information received from direct investigations by accounting the capacity of devices and equipments used for households (domestic need), for public sector and for productive purposes. The type of end uses, their capacities and expected annual operating time should be determined. Totaling all consumptions, the planner will have a relatively precise picture of demand in an aimed year for planning.

Checklist for evaluation of electricity demand and supply-demand balancing

V.1. Demand forcast

a) <u>Domestic electricity demand</u>

Number of households to be electrified, $\mathbf{A_i}$ = ... HH

Total HHs in area, $\mathbf{A_o}$ = ... HH

Average household population, **D** = ………people / household

Comment:……………..…………………………………….……

…….………....……………………………………………….....

Estimate the number of households to be connected to the project, $\mathbf{A_i}$, and the total number in the area, $\mathbf{A_o}$, i.e. including those not to be connected. Note the average number of people per household in the supply area based on your field visit.

Average subscribed power, **F** =………… Watts/HH

Expected operating time for household lighting:…. (am/pm) to …… (am/pm)

Estimate the average power requirements per household and lighting hours based on discussions with the community.

Total <u>probable</u> ***domestic*** load G = (**F** x $\mathbf{A_i}$**)**/1000 = …… kW

Comment:.……………..……………………………………..…

………………………………………………………….………

b) <u>Public electricity demand</u>

Total load for street lighting = ……….. kW

Total load to be installed in public buildings (community centre etc.) = ...… kW

Total ***public*** load (in use during evening hours)

$\mathbf{G_p}$ =………..kW

Comment: ....…………………………….…….….………

The total probable domestic and public load should be less than the maximum power available calculated earlier in section 2.

Estimated total ***domestic and public*** load

$\mathbf{G_{total}}$ = G + $\mathbf{G_p}$ = ………….kW

Comment: ....…………………………….…….….………

....

c) C<u>ommercial & productive electricity demand</u>

End use development possibilities (e.g. tea processing, fans for improved tobacco drying, mills (maize, rice etc.), carpentry, food processing, etc.

……………………………………….……………..……….

……………………………………….…..…………………

End uses (business loads) that could be connected in the 1st year of the REpower plant operation:

Estimate the number of businesses likely to be connected to the project, (include existing businesses and businesses likely to be established if electricity comes to the area based on the the information received from section 3, i.e. consider local development opportunities). Estimate the power requirements of the businesses as well as the operating time. The maximum power required for business load should be calculated by adding the individual business loads only if the operating hours coincide. Thus the combinations of various loads may have to be calculated to determine the maximum business load. Depending on whether the proposed business is mechanically or electrically operated, fill in the tables accordingly.

Electrically Driven:

No.	Description	Expected Operating Time (am/pm)	Power required (kW)
1			
2			
3			
Maximum power required for business load, J_1 (Add only if operating time coincide)			

<table>
<tr>
<td>

Total power required for business load during peak lighting hours: J_2

Mechanically Driven:

No.	Description	Expected Operating Time (am/pm)	Power required (kW)
1			
2			
3			
Maximum power required for business load, J_3 (Add only if operating time coincide)			

Total <u>probable</u> load on system:

Peak load on the system, $\mathbf{M_p}$ **=** ……………… kW

Comment: ....…………………

....

Design plant capacity of the project, $\mathbf{M_d} = \mathbf{M_p} + \mathbf{0.25M_p}$ (kW)

Comments: ..……………………………………….…….……

....

V.2. Demand – Supply balance

Energy demand compared to supply:

……………………………………………………

Is $\mathbf{M_d}$ less than or equal to estimated maximum power,

($\mathbf{M_d}$ **< or =** $\mathbf{P_{max}}$) Yes☐ No☐

If "no" ($\mathbf{M_d} > \mathbf{P_{max}}$), the solutions:

(i) In the case of renewable **mono-source** alternative, to seek for combining multy sources;

(ii) In the case of renewable electricity **multi-source** planning alternative

P = Pmhp + Pwind + Pspv + Pbio + Pgenset

</td>
<td>

Note that the business loads should operate during the non-lighting hours and the maximum business load should be limited to the probable business load.

The **peak load Mp** should be determined such that it is adequate to meet:

a) the peak lighting load G_{total}

b) Peak end use load if this exceeds the peak lighting load

c) Combination of both lighting and end use loads when these uses coincide.

Design plant capacity should generally be calculated by adding 25% to the peak load. This allows for future increase of household and end use power demands.

Compare $\mathbf{M_d}$ with the available maximum power, $\mathbf{P_{max}}$ calculated earlier (Section 2). If $\mathbf{M_d} > \mathbf{P_{max}}$, the solutions may be: combining multi (available) sources for electricity generation, even with relatively costly possibility by adding a diesel genset as back-up system. Decreasing the number of connections or the specific power subscribed to the connections would be taken for consideration but it is the last solution only in case of no other choice.

Percentages of planned component renewable electricity supply sources (Pmhp,Pwind,Pspv, Pbio and Pgenset) participating in the coverage of electricity demand (Md) should be selected based on **local availability** and **economics** (unit investment, electricity price, pay-back period , IRR of planning alternative, and relevant incentive policies).

</td>
</tr>
</table>

Part 5. ALTERNATIVES OF POWER SUPPLY AND SETTING UP A BILL OF (CONSTRUCTION) QUANTITIES

This section of the planning report presents the configuration of transmission/distribution lines. The technical aspects that would be provided in the report (text) and the corresponding drawings required should be presented that in its basis, an economic analyser is able to quote a price within reasonable limits for the implementation of the plan. Furthermore, the project developers in the future can be able to construct the structures and install equipment with minor modifications to suit site conditions based on the planning report.

A Transmission/ Distribution Diagram of a mini-grid should be developed. This diagram shows an overview of the transmission/ distribution system. This can also be made as a single line diagram and should include:

- Location of Transformers, Switch and Fuses, Earthing points, Lightning Arrestors
- Distances between two nodes (points)
- Size and type of the cables/ wire
- Subscribed load at each node during peak hours
- Name of the village at each load point
- Size of the transformers and Switch/ Fuse unit
- Type of the system (1-phase or 3-phases)

Based on the information taken from the previous chapters, a bill of construction quantity could be prepared for implementation of the plan. This should cover all components of plan implementation, e.g., list of projects (type of technology, capacity) in the plan, electric network equipments, civil works etc. A list of projects disposed in priority should be recommended and attached in the report.

Part 6. ECONOMIC AND FINANCIAL ANALYSIS OF THE PLAN

Analysis of economic and financial aspects of the planning alternative is an important conclusive step to consider and justify their economic-financial viability.

Economic-financial analysis is implemented for considered planning alternatives with taking into account all of costs needed for implementation of the planning alternatives and all benefits (revenues) achieved by this considered alternatives. It should be evaluated on the basis of appropriate economic-financial criteria with the main purpose to draw the line between its economic-financial viability and inviability.

Main criteria usually used in economic-financial analysis for consideration and comparison between planning alternatives are the following:

(i) *Benefit/ Cost Ratio (B/C ratio):* The better alternative, the higher its B/C ratio. B/C ratio of viable alternative should be of upwards.

(ii) *Net present Value (NPV):* The better alternative, the higher its NPV. NPV of viable alternative should be of 0 (zero) upwards.

(iii) Economics-Financial Internal Rate of return (EIRR and FIRR): EIRR and FIRR is the appropriate discount rate, by which the NPV is zero. The better alternative, the higher its EIRR and FIRR.

VII.1. Economic analysis for DREOPP alternatives - Steps of calculation

Select the standardized discount rate:

In the market-oriented economy, the standardized discount rate are defined in each economic development period of the country, usually from 5% to 15%. In Vietnam, there is no official regulation to define the standardized discount rate at national level, therefore, it values could be in the interval of 8% - 10%, commonly 10% for energy sector.

Select the time span in which the economic aspects of planning alternative is analysed:

For planning alternatives of renewable energy development, the renewable energy **plant life** is selected as the time span in which the economic analysis for planning alternatives is done. Usually,

this time span is from 20 to 30 years (MHP, solar, wind and biomass/biogas).

Step of calculations:

(i) *Benefits (revenue) achieved by implementing the alternative in year "t" (B_t) within the plant life.*

$$B_t = g_e \cdot W_t$$

In which:

G_e - Average minimum electricity price that causes the B/C ratio equal to 1 (B/C = 1);

W_t - Electricity sale in year "t";

(ii) Costs for implementing the alternative in year "t" (C_t) within the plant life.

- Investment cost $\left(C_i^t\right)$ needed in year "t";
- Operation and management (O&M) (C_{OM}^t) costs in year "t";

O&M costs consists of cost for maintenance, operating worker salaries, management cost etc…, which are calculated according to the type of renewable energy to be exploided for electricity generation.

- Fuel cost $\left(C_f^t\right)$ for implementing the planning alternative in year "t" that is considered for biomass-based alternative;

Total cost: $C_t = C_i^t + C_{OM}^t + C_f^t$;

(iii) Minimum average electricity price at which the B_t is equal to C_t

- Annual profit achieved by the planning alternative in year "t": $P_t = B_t - C_t$.
- Net present value (NPV) of DREOPP planning alternative:

$$NPV = \sum_{t=1}^{N} P_t (1+i)^{-t} = \sum_{t=1}^{N} (B_t - C_t).(1+i)^{-t}$$

Or:

$$NPV = \sum_{t=1}^{N} (g_e.W_t - C_t).(1+i)^{-t} \qquad (1)$$

In which: N - number of calculating years within the plant life, usually the value of N is equal to the plant life time span (20 - 25 years);

- Minimum average renewable electricity price at which the $B_t = C_t$ (or $P_t = 0$; B/C ratio = 1; NPV = 0):

$$g_e = \frac{\sum_{t=1}^{N} C_t.(1+i)^{-t}}{\sum_{t=1}^{N} W_t.(1+i)^{-t}} \qquad (2)$$

In which:

W_t - Renewable electricity which is generated by considered DREOPP planning alternative;

i - Discount rate;

Tabular form for economic analysis of the DREOPP alternative

Year	t	Discount rate i	$(1+i)^{-t}$	Alternative's electricity sale		Cost					Benefit (Revenue)		Cash flow (Profit)	Discounted cash flow
				W_t	$W_t (1 + i)^{-t}$	Investment capital C_i^t	O&M cost C_{OM}^t	Fuel cost & Tax C_f^t *	Total cost C_t		$B_t = g_e \times W_t$	$B_t (1 + i)^{-t}$	$P_t = B_t - C_t$	$P_t (1 + i)^{-t}$
									C_t	$C_t (1+i)^{-t}$				
1	2	3	4	5	6=5x4	7	8	9	10=7+8+9	11=10x4	12	13=12x4	14=12-10	15=14x4
Starting year														
Closing year														
													EIRR	NPV

VII.2. Financial analysis for DREOPP alternatives - Steps of calculation:

Purposes of financial analysis

(i) Determine the reasonable electricity prices for end users on the basis of different discount rates (for instance 5% - 8% -10% -12%);

(ii) Establish the alternative's balance sheet;

(iii) Recommend financial polices related to DREOPP planning alternatives for ensuring its financial viability;

Steps of financial analysis

Financial analysis is carried out on the basis of the balance sheet of planning alternative.

Steps of financial analysis of DREOPP planning alternative are following:

(i) Revenue gotten by alternative's renewable electricity sold in year "t":

$$B_t = g_e \times W_t$$

In which:

- B_t, W_t : Revenue and electricity sold in year "t";
- g_e : Average renewable electricity sale price;

(ii) Costs needed for implementing the DREOPP planning alternative in year "t", namely:

1/ *Investment capital cost (C_i^t)*

This expense item is calculated as economic analysis;

2/ *Operation and maintenance (C_{OM}^t):*

This expense item is calculated as for the economic analysis;

3/ *Fuel costs (C_f^t):* This expense item is calculated as for the economic analysis in the case of using biomass for renewable electricity generation;

4/ *Basic depreciation cost (C_{bd}^t):* This expense item is calculated for **existing** plants participating in the DREOPP planning alternatives. In the framework of VSRE Program, almost all renewable electricity generating plants considered in the planning alternatives are newly planned, therefore, this basic depreciation expense is considered as zero.

5/ *Taxes*

Taxes levied in renewable electricity cost price are following:

- Tax on capital:2.4% of budgetary investment capital;
- Tax in exploitation of hydropower resources: 2% of revenue got from hydropower generation (output);
- Value added tax (VAT)

6/ *Total cost* is the sum of all of above costs, excluding the investment capital cost (C_i^t);

7/ *Profit before tax*

Revenue got from renewable electricity sale minus total cost;

8/ *Income tax:*

30% of profit before tax;

9/ *Profit after tax:*

Profit before tax minus income tax;

10/ *Loan interest repayment:*

This item is estimated with average common interest rates of 6%, 8.5% and 10%;

11/ *Net profit:*

Profit to be remained after repaying the loan interest;

12/ Annual money availability:

Net profit plus basic depreciation revenue got from **existing** plants participating in the planning alternative;

13/ Discounted cash flow:

Annual money availability minus annual investment capital (C_i^t);

Financial aspects of discounted cash flow is that: The net profit plus basic depreciation revenue (if any) should ensure the internal return for investment capital used by DREOPP planning alternative investor at the appropriate discount rate to be equal to FIRR (financial internal rate of return). Therefore, FIRR is named by the alternative's financial internal rate of return.

Brief guideline for establishment of database for economic and financial analyses is provided in the checklist below.

Checklist for economic and financial analysis

No	RE source type	Maximal available capacity (W)	RE generation (Wh/yr)	Unit investment ($/W)	RE tariff ($/Wh)	%
1	Mini-hydropower	Pmhp	Emhp = Pmhp x t_1	Imhp	Tmhp	Smhp
2	Wind power	Pwp	Ewp = Pwp x t_2	Iwp	Twp	Swp
3	Solar PV power	Pspp	Espp = Pspp x t_3	Ispp	Tspp	Sspp
4	Biomass/ Biogas	Pbio	Ebio = Pbio x t_4	Ibio	Tbio	Sbio
5	Genset	Pgs	Egs = Pgs x t_5	Igs	Tgs	Sgs
	Total	**P**	**E**	**Iaver.**	**Taver.**	**100**

Notes: Calculation formulas

Iaver.=(Pmhp x Imhp + Pwp x Iwp + Pspp x Ispp + Pbio x Ibio + Pgs **x** Igs)/P [$/W];

Taver.=(Emhp x Tmhp + Ewp x Twp + Espp x Tspp + Ebio x Tbio + Egs x Tgs)/E [$/Wh];

* **t** = (Emhp x t1 + Ewp x t2 + Espp x t3 + Ebio x t4 + Egs x t5)/E [hours/year];

* **E** = Emhp + Ewp + Espp + Eore + Egs [Wh/year]

* **P**= Pmhp + Pwp + Pspp + Pore + Pgs [W]

1. <u>Estimation of project investment cost</u>

a) Local price of main materials, equipment, fuel and labour cost:

+ Local rates in the project area:

Description	Unit	VND / unit	Comments
Sand			
Block stone			
Bond stone			
Coarse aggregates			

Note the local rates for **construction materials**, and the units, which apply to the rates, e.g. per cubic metre, per kg. In the case some of these are not available, use the rates applying to other construction sites in the surrounding area, if possible. Comment on the quality of the available building materials if significant.

Note the **labour rates** (per man-day) commonly used in the area. The rate should exclude provision of foods. Comment if other benefits are included in the rate noted. A mason is a skilled worker working on masonry and RCC (reinforce cement concrete) works. A carpenter is a skilled worker working with wood. A

Wood			
Unskilled labour	Md		
Mason	Md		
Carpenter	Md		
Technician	Md		
Transport: - road Mule - easy - difficult Porter - easy - difficult Plane Helicopter	kg		
Kerosene	Litre		
Diesel	Litre		
Other materials			

b) Estimated Project Cost:

Description	VND x 1000	Comment
Mechanical works		
Electrical works		
Civil works		
Spare parts		
Tools		
Transportation		
Training		
Installation		
Testing & commissioning		
End-uses		Include cost if the developer plans to own these.
Preliminary expenses		
Sub-Total		
VAT (non local items)		
Contingencies (10% of subtotal)		
Total Project Cost, W =		

c) Added cost due to multi-purpose project:

VND ....…………………

In case of multipurpose project, the cost contribution (due to, for example, the non hydropower use) should be stated so that appropriate decisions can be made at a later stage.

technician is a worker skilled in electrical and mechanical works.

Note the **transport rate** for a truck or tractor to bring material/ equipment from the nearest major supply town to the road head. Give rates per kg. For mules and porters the rates given should be for transport from the road head to the project site. If possible, rate units should also be per kg basis. Rates for plane/ helicopter transport should only be given if this is the most inexpensive form of transport to site (e.g. because of remoteness). Comment as needed.

Note the local cost of **diesel and kerosene** and comment on how it is transported to the area and on year round availability.

Mechanical costs should take into consideration the size of the equipment (e.g turbine, the length and diameter of the penstock, needed valves, the generator and milling drive systems and the base plates for equipment).

Electrical costs should take into consideration the size of the generator, control and protection systems needed, earthing, the length and complexity of the transmission and distribution systems, the cost of poles and cable support systems and household control/protection devices.

Civil costs should include the cost of the intake system, headrace canal, gravel trap settling basin, penstock support works, powerhouse, overflows and washouts, the tailrace canal, crossings, any landslide protection works and machine foundations etc...

Transportation costs will be significant if transport is by helicopter or plane. Estimates should be based on the total weight required to be airlifted.

Training: management and operator training.

End Uses - costs should include machines (huller, grinder, oil expeller, saw mill etc.), stand and foundation costs, and any special drive requirements.

Preliminary expenses include the cost of surveys and design.

Total all of the above costs to produce a sub-total, and add 10% of the non local items such as electro-mechanical equipment for **VAT**, and a further 10 % for **contingencies** on the subtotal (allows for errors in equipment cost estimation and labour required). Total all component costs to give the total project cost, W.

Note the percentage of the project's total cost, which will be provided through local investment (whether private, company or community), loans through a bank or other lending institution, and through the Government subsidy for the project. Multiply these percentages by the total project cost to give the VND amounts for each category.

2. Estimation of annual O&M (recurrent) cost

a) ***Consumption related costs:***

Fuel/substrate cost: ……………. VND/year

Cost for residue utilisation/disposal:

……………… VND/year

b) Operation related cost

Salary for staff

Salary for manager: ...…… VND/year

Operator/s: …......…………… VND/year

Accounting: ....……………… VND/year

Plant maintenance: ………… VND/year

Network operation: ……....….…. VND/year

Network maintenance: ……….......VND/year

Meter reading and billing: ..…. VND/year

c) Office expenses and Miscellaneous:

……….........VND/year

Total cost ....VND/year

Taking into acount the **added costs** only the parts that invested by the power project investor

List the annual costs of the project:

- The consumption related costs

(In the case of biomass and biogas power systems, these costs include fuel/substrate cost and costs for residue utilisation/disposal. For the cases of other RE –based hybrid power systems, these costs refer to the cost of annually consumed fuels like DO, FO or gasoline, if any).

All salaries of people employed by the Power Plant – manager, operators, accountant etc. To estimate these, the salaries paid to similar employees of other nearby power plants should be compared and an average figure used.

Repair and maintenance – generally 3 to 5% of the total project cost.

Sum all above costs to get annual estimation of operating cost.

3. Estimated income from energy supply

Proposed household electricity tariff

a) T_f:……......VND/watt/month in case of a monthly flat rate **or**

b) T_{em} ..……..VND/kWh in case of installed electricity meters

Probable annual income from ***household*** tariff

a) $\mathbf{S_1} = A_i \times F \times T_f \times 12$ =……….….. VND **or**

b) $\mathbf{S_1} = A_i \times F \times T_{em}$ x hours of use/day x 365 =………... VND

Probable yearly income from ***public*** energy supply: $\mathbf{S_p} = G_p$ x Tariff x hours of use / day x 365 = …… VND

Probable yearly income from sales of electricity to ***productive end uses (S_2)***

End use income estimate from sales of electricity

S. No.	Type	Operating parameters			Power required (kW)	Energy consumption/year (kWh)	End use tariff (VND/ kWh)	Annual income (VND)
		hours /day	days/ month	months /year				
1								
2								
3								
4								
5								
Total							-----------	

Total electrical income from end uses, $\mathbf{S_2}$ =…………..… VND/year

Comment:

……………………………………………………………………………..

Income from agro processing (S_3)

Is milling to be provided in this (in case of MHP) scheme?

Yes☐ No☐

If yes, will the developer install the units? ………………………..…

Or will another entrepreneur install the plant?

…………………………………………………………………………

Annual income from agro-processing operation:

Column	1			2	3	4
Grain	Operating parameters			Annual milling volume	Rate VND / kg	Annual income (VND) 2 x 3
	hrs/ day	days/ month	months/ year			
Rice					$\mathbf{R_r}$=	
Maize					$\mathbf{R_m}$=	
Wheat					$\mathbf{R_w}$=	
Millet					$\mathbf{R_l}$=	
Oilseed					$\mathbf{R_o}$=	
Others ………					$\mathbf{R_x}$=	

Total annual milling income, $\mathbf{S_3}$:………………… VND.

Estimated total income (S_t):

Total probable annual income from MHP; in case of multipurpose project, the additional benefits due to non hydropower use, $\mathbf{S_4}$ = VND ………………

$\mathbf{S_t} = \mathbf{S_1} + \mathbf{S_p} + \mathbf{S_2} + \mathbf{S_4}$= VND…………………, if the milling & other end uses are operated by the entrepreneurs other than the developer

$\mathbf{S_t} = \mathbf{S_1} + \mathbf{S_p} + \mathbf{S_3} + \mathbf{S_4}$= VND. ………………, if the milling & other end uses are operated by the developer

Note that while calculating the total annual income, the sales of electricity to end uses and the income both should not be added.

Calculate the annual income from sales of electricity to the various end uses, $\mathbf{S_2}$**,** from the table.

If milling is to be provided as part of the MHP scheme, either immediately or later, tick the "Yes" box or complete this section. If milling is not planned to be provided, skip this section and go on to the next section.

Estimate the annual milling volume likely to be processed in the MHP (consider local production capacity, processing in other mills of the area and in homes, and usage of this mill when other local mills break down) and enter it in column 2 of the table. Total all the individual grain milling incomes to give a total annual milling income, $\mathbf{S_3}$.

When calculating the total estimated income add the income from sales of electricity to households (S_1), to the public (S_p) and sales of electricity to business loads (S_2) if the businesses are owned by other entrepreneurs and not the developer.
If the developer owns the end uses, then add the income from sales of electricity to households (S_1), to the public (S_p) and the income from the operation of businesses (S_3) but not the sales of electricity to the businesses (S_2) because the developer does not need to pay for the electricity that is consumed from his power plant.
Note that in case of multipurpose projects, the additional annual benefits due to the non-hydro uses such as irrigation should also be estimated.

4. Preliminary assessment of income from RE power system

Total annual income: ....………... VND

Total annual O&M cost …………….. VND

Possible subsidy? …………% of investment

Main output from the pre-feasibility analysis:

Proposed financing:

- Equity: % $\mathbf{W_l}$ = VND .... ……………….
- Loan: % $\mathbf{W_n}$ = VND ....……………………
- Subsidy: % $\mathbf{W_s}$ = VND ..……………………..
- Other: % $\mathbf{W_x}$ = VND . ……….……………..

Pay back: ………. years

IRR: …………….%.

Compare the annual income to the annual recurrent cost. If the income is lower than the costs the project will not be sustainable even with a 100% investment subsidy.

If the income is higher than the O&M cost, then Use the estimated cost and projected income and carry out a financial analysis of the project in accordance with the methodology proposed by VSRE Area 3. (Project approach for the pre-feasibility analysis and corporate projections

EIRR ……………% NPV: …………… VND Interesting to go further on? (Yes/No) Main output from the feasibility analysis: Minimum equity: …….. % of the initial equity Gross margin year 1, 4 and 8: ………………….. Profit margin year 1, 4 and 8: ………………….. Feasible, yes or no? ……………………………..	for the feasibility).

Tabular form for financial analysis of the DREOPP alternatives

Year	t	Discount rate i	$(1 + i)^{-t}$	**Alternative's electricity sale**		**Cost** (C_t)						**Revenue** (B_t)		Profit before tax P^t_{bt}	Profit after tax P^t_{at}	Loan repaying& loan interest I^t_{lr}	Net profit P^t_n	Annual money availability A^t_a	Cash flow
				Electricity sale W_t	$W_t (1 + i)^{-t}$	Invest-ment capital C^t_i	O&M costs $C^t_{O\&M}$	Basic deprecia-tion cost, if any C^t_{bd}	Fuel cost C^t_f	Taxes C^t_{tax}	Subtotal cost Cs	$B_t = g_e . W_t$	$B_t (1+i)^{-t}$						
1	*2*	*3*	*4*	*5*	*6=5x4*	*7*	*8*	*9*	*10*	*11*	*12=8+9+10*	*13=g_e x5*	*14=13 x4*	*15=13-12*	*16=15-11*	*17*	*18=16-17*	*19=18+9*	*20=19-7*
Starting																			
Closing																			
																			FIRR

Part 7. ANALYSIS OF THE IMPACTS OF THE PLAN IMPLEMENTATION ON THE CONSIDERED AREAS AND THE DISTRICT

Implementation of the plan will probably cause both positive and negative impacts on socio-economic development and environment of the planned areas as well as of the district. When the rural population has an opportunity to access to electricity, that are reliable, affordable, appropriate, and sustainable, it is undoubtedly the opportunity for the creating new jobs, new productive activities, improving school conditions, opportunity for accessing to information, using new electric appliances, rising living standards etc. Regarding environmental issues of renewable energy off grid projects, it is not only the projects will impact on environment but in some circumstances the nature will also negatively cause troubles to the realisation of the projects. Renewable energy, in principle, is a clean source. However, some negative impacts should also properly analyse. For an example, beside the possibility of improving irrigation system, a MHP scheme will cause the restriction of fish displacement between up stream and down stream. Landslide to the scheme or will the scheme trigger landslides, flood exposure risk to the scheme and other positive/ negative environmental impacts foreseeable should be analysed. For wind power solution, aesthetics and visibility, noise ... should be mentioned. The visibility of a particular wind system will depend on many factors, including tower height, proximity to neighbors and roadways, local terrain, and tree coverage. Some people may object to a wind turbine being in their field of view, and this could be an issue when applying for a zoning permit. The most characteristic sounds of a wind turbine are the "swish...swish...swish" of its turning blades and the whirring of the generator. Improved designs have made wind turbines much quieter over the last decade. Within several tens metres of a machine, these sounds may be distinguishable from the background noise of local traffic or the wind blowing through the trees, but they usually are not disruptive or objectionable. The impact on any particular neighbor will depend on how close they live, whether they are upwind or downwind, and the level of other noise sources such as traffic. Biomass/ biogas technologies will cause particulate, toxic gas emission, chemicals in waste water etc. Used batteries can bring about the impacts of their disposal.

Part 8. CONCLUSION AND RECOMMENDATION. PROPOSAL OF GUIDELINES AND POLICIES FOR IMPLEMENTATION OF THE PLAN

IX.1. In this part, a summary of all previous analysis results and conclusions withdrawn from those ones should be provided.

A list of project priority should also set up. Time framing for project implementation should be established.

Recommendation on the model for implementation of the plan should be provided, e.g., financial sources, competent body in charge of implementation;

Recommendation on the institutional models for project management etc.

IX.2. Policies and strategies proposed in the plan for renewable energy development are aiming at the creation of favourable conditions for the plan implementation. Their categories could include:

- In the supply side

The policies that raising attractiveness of renewable energy-related investment;

The policies that ensure infrastructure for renewable energy-related development, for implementing the renewable energy electrification plans in the identified off-grid communities, villages, and communes;

The policies that promote technology transfer and equipment import and/or manufacturing for planned projects;

Taxing and taxing concession/ exemption for importing and transferring renewable energy technologies and equipment;

Granting renewable energy development-related subsidies.

etc.

- In the demand side

Electricity pricing policies

Giving the financial priorities to renewable electrification plans in the framework of the national program " Hunger eradication and poverty alluviation" in mountainous, remote areas, uplands, and islands.

The policies that promote the creation of new productive activities in the newly electrified areas

Part 9. **ANNEXES**

List below the items annexed to this document Annex 1: …………………………………………………. Annex 2:………………………………………………… Annex 3:………………………………………………… Annex 4:………………………………………………… Annex 5:………………………………………………… Annex 6:………………………………………………… Annex 7:………………………………………………… Annex 8 :………………………………………………… Annex 9 :…………………………………………………	List all documents annexed to the present document. If possible, include photos of sites and areas as an annex. The technical drawings of main components of project power plants should be available before starting on preparation of the "investment Opportunity Report". It would be useful if the plan of site investigations is included.

Chapter 3.

SUPPORTING MATERIALS

I. TOOLS AND METHODS FOR SELECTING THE POTENTIAL RENEWABLE OFF - GRID POWER PROJECTS/ SITES

The following tools and methods can be refered to for setting the list of project priority.

Based on the identification and investigation results of some potential projects and sites, it always appear the most appropriate project/ site for implementing the plan and the other ones are less attractiveness.

This report proposes six following project/ site selection criteria for renewable energy-based off-grid power project.

7. Technical attractiveness
8. Economical attractiveness
9. Institutional issue
10. Local electric demand /Load profile
11. Environment impact
12. Site specific criteria

2.1. Technical attractiveness

Renewable off-grid power project is considered technically attractive if the following conditions could be seen from the site investigation:

- Availability of RE source: the availability of energy/fuel source should be assessed in some aspects:
  - Annual locally available amount and possible supply
  - Seasonable availability
  - Local concentration of source.

The site with higher possible annual RE/ fuel supply will be more attractive. For two or sevaral sites, with the same possible annual supply, the priority in selection should be made for the site having a more stable and higher portion of locally available amount of RE/ fuel.

- The distance to the consumers: the suitable distance from the power plant to the center of the commune or cluster of consumers should depend on the capacity of the power plant. In general, for the same plant capacity, the case with less distance is more attractive.

- Concentration of electric consumers: The number of consumers connected in 1 km of electric distribution line in case of off - grid rural areas should be at least 30 households. The higher this number, the more attractiveness for the power plant investor.

2.2. Economical attractiveness

In general, economical aspect within the same range of plant capacity is depending on the objective of investors, the more attractive may be the renewable power plant which has one or more of following specifications:

- Less specific initial investment cost;
- Avoidance of "overlapping" projects
- Less electricity tariff;
- Shorter Pay- back time;
- Higher Internal Rate of Return; or:
- Higher annual profitability.

Planning or even implementation of an RE-based off-grid power project can become a fully mistaken investment in case that either during planning or after a few years of operation, the area is connected to the national grid and the RE-based off-grid power project is given up. Therefore, in selection of site for building any power plant, it should be foreseen that the plant will operate at maximum load factor and there will not be any reason to make it stop operating before the end of its possible lifetime. It should be also analysed whether an attractive site could be developed nevertheless in order to first supply electricity to an isolated system and subsequently connect the RE-based power plant to the national grid to feed in electricity, based on a power purchase agreement.

In addition to the above issues, for each type of RE may be proposed some specific selection criteria.

2.3. Institutional issue

Main factors in institutional aspect that could attract the power plant investor are the plant management structure, competitiveness of the plant owner and the expected participation of rural community in project implementation and management.

Management structure: the project, which will be managed by a financially capable organization/ personality having good experiences in rural electrification by renewable energy, especially in projects of relevant RE type, will be firstly ranked.

Competitiveness of the ownership personalities: High competitiveness of the organization or personalities which will take the role of plant owner will bring a positive mark for the project.

Community participation: The active participation of rural community in RE power project will be always a favorable condition for getting the success that makes the project more attractive.

2.4. Local electric demand /Load profile

Similarly for all type of off - grid rural electrification projects, a RE power project will also be attractive when, beside the households consuming electricity only for indoor devices, there are exist or will exist other productive electric consumers, e.g small scale agro-processing units, commercial service etc. .. which consume electricity during the days.

2.5. Environment impacts

The common environmental effect of renewable power projects is in the potential substitution for and reducing the dependence on fossil fuels; reducing pollution, green-house effect etc. In addition, other impacts of RE power projects may be positive in some cases and negative in other ones. Best project should have, of cause, higher and more evident impacts on improving environment in rural areas.

The specific environment impacts were mentioned in Chapter 2, part VIII of this report.

2.6. Site specific criteria

Depending on the specific conditions, there will be other criteria to be considered when selecting the suitable project site. These might be some targeted priority for the concrete project, for example poverty reduction, improving spiritual life of minority ethics in very remote area, enhancing local capacity in management and locally equipment manufacturing for reducing initial investment cost, l*ocation easily accessible by interested parties,* demonstration objectives, conservation zone etc. . . .

2.7. Tools for selection of site/ project

In concrete cases, the project developers and investors can set up their own norms for quantitative consideration of site/ projects. This report, however, assumes some tools, which are described in the following example and may be applied for consideration (see Table 3.1):

Table 3.1 Example for quantitative assessment of project proposal

Criteria	Parameters /specific aspects	Percentage weight of parameter	Score for the site (*)	Evaluation results for the parameter	Percentage weight of criteria (**)	Evaluation results for the criteria
Technical attractiveness	RE source availability (Possible supply; Annual available amount; seasonable availability; Local concentration).	60%	5	3.0	30%	
	The distance to the consumers	20%	4	0.8		
	Concentration of electric consumers	20%	2	0.4		
	Sub-total	**100%**		**4.2**	***Sub-total***	**1.26**
Economical attractiveness	Specific initial investment cost;	20%	2	0.4	20%	
	Electricity tariff	40%	5	2		
	Pay – back time	20%	3	0.6		
	Internal Rate of Return	20%	4	0.8		
	Sub-total	**100%**		**3.8**	***Sub-total***	**0.76**
Institutional issue	Management structure	30%	4	1.2	15%	
	Competitiveness of the ownership personalities	30%	3	0.9		
	Community participation	40%	4	1.6		
	Sub-total	**100%**		**3.7**	***Sub-total***	**0.55**
Local electric demand / Load	Other productive electric consumers exist already	60%	4	2.4		

profile	There will exist other productive electric consumers	40%	5	2	15%	
	Sub-total	**100%**		**4.4**		**0.66**
Environment impacts	Improving hygiene in rural villages	50%	4	2	10%	
	Measures taken to avoid the emission of toxic gases from the power plant	50%	3	1.5		
	Sub-total	**100%**		**3.5**	***Sub-total***	**0.35**
Site specific criteria	Poverty reduction	40%	3	1.2	10%	
	Enhancing local management capacity.	30%	5	1.5		
	Priority for local minority ethnics	30%	4	1.2		
	Sub-total			**3.9**	***Sub-total***	**0.39**
					Total	**3.97**

Note: (*) for example the scores are ranking from 0 to 5.

(**) These weights could be little bit changed according to the objectives of investor, however, it should not be change upsettingly.

The project with the mark lower 2.0 should not be selected for further assessment.

II. EXAMPLES OF TECHNICAL/ ECONOMIC EVALUATION

1. Tabulation for assessing the rated power of a solar PV alternatives

Item	Unit	Estimate	Note
Site conditions			
Altern. name	-	Site name	
Alternative location	-	V&C name	
Nearest station for weather data	-	Station name	
Latitude of altern.location	^oN	Station data	
Annual solar radiation(tilted surface)	Wh/m2	Station data	
Annual average temperature	^oC	St.data	
System characteristics			
Application type	-	Off-grid	Stand-alone
PV energy absorption rate	%	100.0	Ref.
PV Array			
PV module type	-	mono-Si	Ref.
PV module manufacturer/model	-	Manuf. name	-
Nominal PV module efficiency	%	11.7%	Ref.
NOCT	^oC	45	Ref.
PV temperature cefficient	%/ oC	0.4	Ref.
PV array loss	%	5	Ref.
Nominal PV array power	Wp	n (number of modules)*50 Wp	n: sized number of modules
PV array area	m 2	n*Po/ So	

Power conditioning Average inverter efficiency Suggested inverter DC/AC (if any) capacity Power conditioning loss **Annual solar PV energy production** (12 months analysed)	% W (AC) % Wh/year	90% estimated by forecast AC load 0 Ey=365x E; Where : $E = \frac{P_0}{S_0} \times S \times K$	
Specific yield (So)	Wh/m2	Vietnamese default: 1000 W/m2	Ref.
Overall PV system efficiency	%	Vietnamese default: 75%	Ref.
Solar PV electricity delivered Excess(+) or shortage(-) of solar PV available energy	Wh/year Wh/year	Ey […] on the solar PV planning alternative	For estimating the revenue of solar PV system

2. Example of the economic aspects of the (stand-alone) solar PV off-grid alternatives

Economics of the planning for electricity generating solar PV off-grid (stand-alone) planning alternative	**Notes**
1. Home solar PV system (HSS) HSS Capacity: 50 Wp **a. Investment cost:** *a.1. Materials and equipment cost:*	- In Vietnamese socio-economic context, the unit solar PV system of 1x50Wp is considered as the most appropriate solar PV module size. According to the required sizing of HSS and CSS, it is possible to apply the multi-50 Wp unit solar PV module scheme. - In order to make clear the calculations related to HSS and CSS economics, the tabulations are presented with respective costing figures at current pricing values and VND/USD exchange currency rates for reference.

No.	Name and specification of HSS materials and equipment	Unit	Quantity	Current (2006) Unit price (US$)	Amounting (US$)
1	PV panel - 50Wp - 12V - Silica (imported)	Panel	01	196	196
2	Battery 50Ah-12V	Set	01	16	16
3	Regulator 10A	Set	01	31	31
4	Source cable 2x2.5 mm^2	Meter	25	0.2	5
5	Support	Set	01	51	51
6	Auxiliaries	Set	01	3	3
	Total				**292**

a.2. Man-power: 25 US$* *a.3. Equipment transport: 2% [(a_1) + (a_2)] = 2%(292+25) = 6 US$. **Estimated project investment cost**: totaling (a_1 + a_2 + a_3) = 292+25+6 = 323 US$.	- Following figures are experimental defaults which are used by energy research institutions in Vietnam: * 2% for determining the solar PV equipment tranport fees. * Assembling costs of 25$US for HSS and of 76 $US for CSS.

b. Cost price of solar electricity

$$P_e = \frac{\sum_{t=1}^{T} C_t (1+i)^{-t}}{\sum_{t=1}^{T} E_t (1+i)^{-t}}$$

in which:

C_t: Total cost of HSS in year "t" that consists of investment cost and O & M cost;

E_t: Solar electricity produced in year "t";

T: HSS life;

i: Discount rate.

* O & M cost to be negligible

* Cost of equipment substitution: For regulator (life = 25 years) this cost is equal to0.4 US$/year; For battery (life: 5 years), this cost is equal to 7 US$/year; Total cost of equipment susbstitution is of 7.4 US$/year.

* T = 25 years;

* Discount rate i = 5%;

* Solar electricity produced in year "t":

$$E = \frac{P_0}{S_0} \times S \times K$$

in which:

E: Daily Solar electricity production.

P_0: Rated capacity of PV panel (50 Wp)

S_0: Standardized Solar radiation 1000W/m^2

S: Annually averaged Daily solar radiation in Vietnamese mountainous areas (4,108 Wh/m^2/day)

K: Losses 0.85 (big battery) ×

K = 0.85 (battery) × 0.98 (ambient air) × 0.9 (dust) = 0.75.

$$E_{daily} = \frac{50}{1000} \times 4{,}108 \times 0{,}75 = 154 \text{ Wh/day}$$

Annual solar PV electricity production:

E_t = 154 Wh/daily × 365 days = **56 kWh/year**

Cost price of solar PV electricity:

P_e = 0.412 US$/kWh

* Solar PV O&M costs is negligible.
* Solar PV plant life of 25 years.
* Discount rate of 5% for solar PV electricity project.

And so on.

2. Community solar PV electrification system (CSS)

a. Investment cost

a.1. Materials and equipment cost:

No.	Name and specification of CSS materials and equipment	Unit	Quantity	Current Unit price (US$)	Amounting (US$)
1	PV panel-50Wp-12V-Silica (imported)	Panel	10	196	1,960

2	Battery 135 Ah-12V	Set	4	48	192	
3	Regulator 30A	Set	01	69	69	
4	Source cable 2×4 mm^2	Meter	20	1	20	
5	Support	Set	01	76	76	
6	Adapter DC/AC	Set	01	100	100	
7	Auxiliaries	Set	01	13	13	
	Total				**2,430**	

a.2. Manpower cost for PV assembling: 76 US$;

a.3. Equipment transport: 2% $\times a_1$ = 2% $\times$ 2430 = 49 US$

Totaling $(a_1+a_2+a_3)$ = 2,555 US$

b.Maintenance cost: 6 US$/year

c. Equipment substituting cost:

- Regulator: 4 US$/year
- Battery: 3 US$/year

Totaling: 40 US%/year

Solar PV system life:T = 25 years

Discount rate for PV: i = 5%

$$E_{daily} = \frac{500}{1000} \times 4{,}108 \times 0{,}75 = 1{,}540 \text{ Wh/day}$$

Annual solar electricity production:

E_t = 1,540 $\times$ 365 = **562 kWh/year;**

Cost price of solar PV electricity:

P_e **= 0.378 US$/kWh**

3. Tabulation for assessing the rated power of windpower alternatives

Item	Unit	Estimate	Estimate Total	Note
Site conditions				
- Planning alternative name	-	Off-grid	Off-grid	Off-grid
- Planning alternative location	-	Name	Name	
- Wind data source	-	Wind speed	Wind speed	
- Nearest location for weather data	-	Name	Name	reference
- Annual average wind speed	m/s	Va	Va	
- Height of wind measurement	m	Hm	Hm	
- Wind shear exponent	-	0.16	0.16	
- Wind speed at 10 m	m/s	V10	V10	
- Average asmostpheric pressure	kPa	Pa	Pa	
- Annual average temperature	^oC	Ta	Ta	

System characteristics				
-Application type		Off-grid	Off-grid	
-Wind turbine rated power of planning alternative	kW	*w = 0.625 A v^3*	*W=n*0.625 A v^3*	Above preented
-Number of wind turbines used by alter.	-	1	n	
-Wind alternative capacity	kW	w per turbine	W per n turbines	W=n*w
-Hub height	m	measured	measured	
-Wind speed at hub height	m/s	Vh measured	measured	
-Wind power density at hub height	W/m^2	= 0.625 .(Vh)^ 3	= 0.625 .(Vh)^ 3	
-Array losses	%	3%		reference
-Airfoil soiling losses	%	2%		reference
-Other downtime losses	%	2%		reference
-Micellaneous losses	%	3%		reference
Annual wind energy production				
-Wind planning alternative capacity	kW	kW/turbine	nxkW/altern.	n: turbine number
-Unadjusted energy production	kWh	wo=w*CF*8760	Wo=W*CF*8760	
Pressure adjustment coefficient	-	0.93	0.93	0.59-1.02
Temperature adjustment coefficient	-	0.96	0.96	0.98-1.15
-Gross energy production	kWh	wo*0.93*0.96	Wo*0.93*0.96	-
Losses coefficient	-	0.90	0.90	0.75-1.00
-Specific yield	kWh/m^2	Calculated	Calculated	150-1500
-Wind alternative capacity factor CF	%	CF= 30%	CF= 30%	20%-40%
-Alternative wind energy delivered	kWh/GJ	wo*0.93*0.96* 0.90	Wo*0.93*0.96* 0.90	-
-Excess(+)or shortage(-) of alternative's available wind energy	kWh/GJ and/or kW	Matched with forecast electricity demand (production and/or capacity)	matched with forecast electricity demand (production and/or capacity)	-See the forecast electricity demand in chapter […]