MICRO GRIDS

Introduction

The use of micro-grids has a long history, micro-grids were used to provide electricity to small towns right from the beginning of the electricity era in the late 19th to mid-20th century; in most developing countries micro-grids still play an important role supplying electricity to small towns and villages, and the IEA (International Energy Agency) estimates that micro-grids will play a critical role in the future providing electricity services in developing countries, with a share of electricity supply to about 40% of people presently without electricity.

There have been many positive things said or written about micro-grids, such as “micro-grids are cheaper than large-grids”, “micro-grids are more reliable than large-grids” and “micro-grids are cleaner than large-grids”. The fact is that none of the above is true for every micro-grid. There are a number of factors affecting each case. Practical Action’s experience shows us that in most cases at least one of the above assertions is true but rarely all of them together for every case if these factors are handled appropriately.

A combination of the demand size and distance from the grid determines its economic competitiveness. Most isolated electricity demands can be met using renewable energy sources but not all. The use of appropriate technologies and implementation approaches contribute to the economic competitiveness and sustainability. Good governability of electricity services and proper training for operation and maintenance contribute to their economic competitiveness and sustainability of a scheme. This Technical Brief provides some tips on the basics of implementing micro-grids based on Practical Action’s experience around the world. For this brief “large-grids” are understood to be national or regional grids providing electricity to a number of cities and large towns.

Definition

Literature shows several definitions of micro-grids, most agree that micro-grids have a number interconnected loads and energy sources and clearly defined boundaries, most argue about whether micro-grids can be connected to large grids. Some definitions consider different types of loads and the need for smart operational devices as part of the definition of micro-grids.

Practical Action focuses its attention primarily on isolated systems (not connected to larger grids) and suggests that the definition of micro-grids should be restricted to isolated electrical systems; the main reason being that those connected to larger grids, even if they are managed independently once connected, became dependant on and therefore part of the larger grid. In an attempt to provide a meaningful definition to practitioners and planners, Practical Action proposes the following definition.

> “A micro-grid is an isolated electrical system of interconnected loads and electricity generation plants providing electricity services to villages and/or small towns comprising of demands from 50 to 10000 families, operated and managed independently. In some cases smart monitoring and operating equipment may be necessary to enhance efficiency and/or good governability”.

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The figure of 50 families is chosen because of the financial viability of the micro-grid which requires a minimum number of users, and from field experience, in Latin America, Practical Action has found that, a well-managed and properly implemented micro-grid can be financially viable from 50 families onwards, provided that the implementation cost, or a significant proportion of it, is sunk. The upper limit of a 10000 families is considered because it is frequent to find clusters of isolated villages and small towns that can be served by combining small generation plants (of tens to a few hundred kW of generation capacity) and can be managed locally.

Advantages	Disadvantages
• Can be managed locally, therefore be more inclusive and customer friendly. Local management reduces costs of operation and maintenance • When well managed and operated they can provide energy security and safe from blackouts and energy shortages • Contributes to local employment and self-confidence of villagers • In most cases can be implemented using clean local energy sources (hydro, solar, wind and biomass energy)	• Fast growth of demand could overburden the system in a short time after commissioning the micro-grid • Very small micro-grids (below 500 families or so) have little chance of payback of the up-front investment, and there is none or very little credit for implementation such systems • There is very little credit in the market for the implementation of these systems.

Infrastructure required for micro-grids

In the past, micro-grids were powered either by small diesel sets or Micro-hydro Power Plants (MHPP) generating at “low voltage”, 110V, 220V or 440V. Two sorts of arrangements were used: 1) generation and distribution and, 2) generation, transmission and distribution.

The basic infrastructure for MHHP or Diesel set is typically composed by: civil works, electromechanical equipment, transmission lines (when the system is installed “far” from the village/small town) and distribution lines. Civil works include the engineering works associated with the generation plant. In the case of MHPP these include intake, channels, power house, settling basins, penstock and others; in the case of diesel sets these include foundations for the equipment and power house. Electromechanical equipment includes the electricity generation machinery and ancillary systems such as controls and monitoring systems. Transmission system, commonly known as transmission lines; are used when the generation plant is located “far” from the users, high or medium tension transmission is used to minimise losses in the cables. A transmission system includes a step-up transformer to elevate the voltage from its generation value (110/220/440V) to tens of thousands of volts, a step-down transformer which reduces the voltage from medium/high tension to a useful voltage (110/220/440V) and high/medium tension cables and posts. Distribution system is composed by the cables, posts, meters and others used within the village to provide electricity to the users.

With the introduction of other energy technologies to generate electricity (early 1970s), solar PV, wind generators and biomass systems, the use of battery storage systems and electricity inverters has also become more common in electricity schemes. Solar and wind energy sources are intermittent, hence not necessarily available when users need electricity, a way of coping with this intermittence is by generating electricity energy is available and storing electricity in batteries so it can be used later on when users need it. However batteries only work with DC current and most domestic appliances in the market use alternating (AC). Inverters allow direct current (DC) to be changed into alternating current (AC). Although it is not common, there are a few cases of micro-grids using DC current, especially for very small groups of families, living in houses very close to each other and when the generation plant is very close to the village, in these cases they have to use appliances manufactured for DC current. A disadvantage of using DC appliances is that the appliances are not widely available and can be more expensive than its equivalent using alternating current. Figure 1, below, shows a general arrangement of a micro-grid considering all the basic components (with no storage system and no inverter).

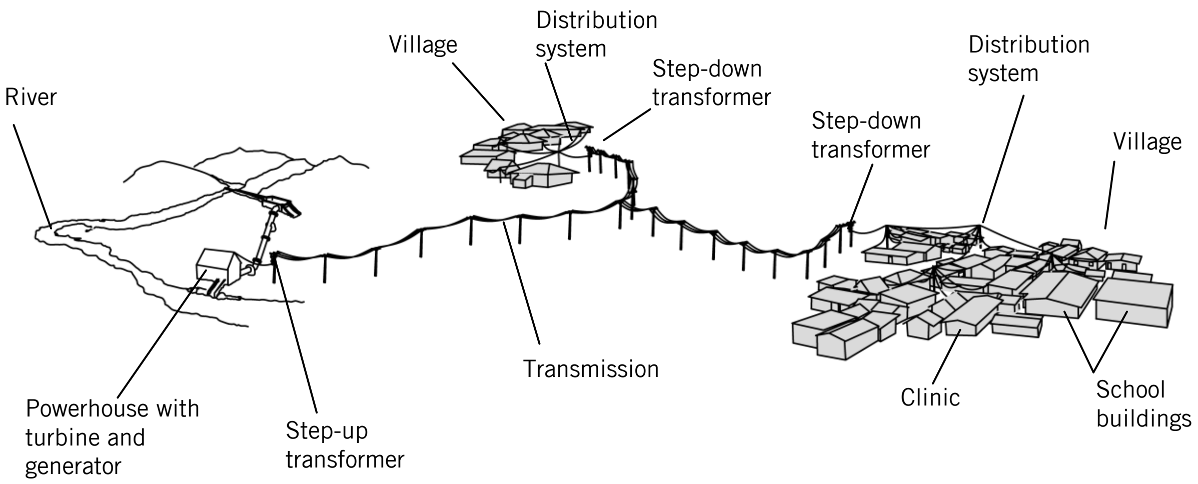

Figure 1: Typical components of a MHPP. Illustration: Neil Noble.

The choice of which components to use for your particular micro-grid will depend on specific conditions related to: location, energy source availability, density and distribution of the houses to be served, electricity supply management. For example if diesel set is installed next to the village, storage system is not needed; but because Diesel sets only operate very few hours a day the families (at least some of them) may feel the need to charge their own small battery at home to have access so that to electricity for some basic needs (radios or lighting) when the Diesel set is switched-off.

Factors affecting the system configuration

Distribution of village population. - Most rural villages in developing countries have been built with no planning, and are formed by tens or by hundreds of houses scattered over large areas; this type of village generally requires medium tension transmission lines to provide good quality electricity to all. Villages with densely concentrated houses generally do not require transmission lines even for several hundreds of houses, provided that the generation scheme is close the village.

Location of the generation scheme. – Villages located “far” from the generation point require medium or high tension lines to reduce voltage losses, but this increases the cost of the scheme considerably, the longer the transmission lines the higher the cost. Most MHPPs, and to some point wind generators, frequently require transmission lines even when the service is for one village or town. For a single village or town, using solar PV systems and/or Diesel sets, these are generally installed very close to the village or town and transmission lines are not necessary. For micro-grids incorporating several villages and/or small towns, transmissions lines are almost always necessary.

Electricity supply management. - MHPP can generate 24 hours a day 365 days a year (when designed with the minimum average flow); Diesel sets and most biomass systems can generate 24 hours a day, but in practice they are only operated when electricity is needed[1]. Solar and wind energy systems operate for a few hours a day (when the energy source is available), these systems require **storage**, which helps with the management of electricity supply to the users. The following table shows the different technologies used and their infrastructure requirements. Hybrid

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[1] Diesel sets are generally operated for a few hours a day, during evening hours, because of the high cost of fuel.

systems can combine energy sources to increase coverage, but can significantly increase cost and complexity.

Infrastructure components required	Technology by source of energy					
	Solar PV Systems	MHPP	Wind generators	Biomass systems	Diesel sets	Hybrid systems
Civil Works	Small works	Large civil works	Small quantity	Relatively small quantity	Small quantity	Depends on the combination of technologies
Electricity storage system (batteries)	Always require large storage systems	Does not require	Large storage systems	Do not require	Does not require	Depends on the combination of technologies
Inverter	Always require an inverter	not require	Require inverter	Do not require	Do not require	Depends on the combination used
Transmission lines	generally do not requires	most require transmission lines	Most cases require TL	Do not require	Generally do not require	Depends of the combination used
• All technologies require a distribution systems • The use of transmission lines is required when the installation of the system is more than 1km distance from the most distant user • All household should have energy meter • Smart controls may be needed when the quantity of energy generated is limited						

Table 1: Requirements of the technology options.

Technology choice

Micro-hydro Power Plants (MHPP) - Micro-hydro power is the small-scale harnessing of energy from falling water. Water is diverted from the river using an intake, conveyed through a channel and finally dropped through a penstock reaching a hydraulic turbine; the turbine spins due to the impact and/or pressure of water and produces mechanical power, this power is then transferred to an electric alternator to convert it into electrical power. Properly designed, built and managed MHPP is reliable and produces 'low unit energy costs'.

In most cases MHPP requires considerable civil works (intake, channel, penstock and other structures) and take a longer period than the other technologies to implement; construction periods for MHPP vary from 6 months to 3 years depending on the size of the river, topography of the site, length of the channel, type of soils, etc.

It is believed that the implementation of MHPP causes little or negligible negative environmental and social impacts, and mitigation measures (if needed) are generally very simple and low cost. For example; the community can implement a watershed conservation plan based on community participation. That will not only preserve the watershed but improve it.
A characteristic of MHPP is that they can run 24 hours a day 90% of the time or more. The availability of electricity 24 hours a day during most of the year, with a good tariff scheme and good management can make the implementation of productive uses and small businesses attractive and in that way contribute to the economic development of the community. See *Micro-Hydro Power* http://practicalaction.org/micro-hydro-power-2.

Solar energy - Solar energy, in the form of solar radiation is the most abundant source of energy in earth. Solar radiation is measured in units of power per square meter (kW/m^2). The intensity of solar radiation varies each hour of the day throughout the year. Information centres provide monthly and yearly average solar radiation data.

There are several technologies to convert solar energy into electricity the most common is Solar Photovoltaic (PV). Solar PV is produced in tiny generation units called cells. Solar PV technology is available commercially as solar PV modulus. A solar PV module is an arrangement of several cells in different ways and numbers to produce various power outputs. Arrangements of 20W to 50 Watts were promoted strongly for rural dispersed populations in developing countries to serve individual homes during the 1980s and 1990s; more recently PV has also been promoted for micro-grids in developed countries, in developed countries solar PV has been promoted as a green alternative mainly to feed the grid.

The most important characteristic for the success of solar PV (so far) has been its modularity, which allows the size of the generation unit to be matched to the size of the demand. In developing countries this characteristic has led to successful businesses models. For example; in Africa there are quite a few companies selling tiny solar PV modules for lighting and mobile charging.

The use of solar PV modules as a source of energy for mini-grids is not new, there have been several experiments in the developing world, solar PV modules have also been promoted in hybrid systems where they are complemented with Diesel sets or wind turbines but this has not yet had a major breakthrough, among other reasons because it is still expensive compared to other options, if present, although the cost is dropping making it viable in more locations.

Solar PV micro-grids in small villages necessarily require a storage system but in most cases can be installed very close to the point of consumption (the village). See *Solar Photovoltaic Energy* http://practicalaction.org/solar-photovoltaic-energy.

Wind generators - Wind generators convert kinetic energy, the wind, to mechanical shaft power using wind turbines. That mechanical power is transferred to a generator to produce electricity. Small and medium size wind generators are used to supply electricity to micro-grids and sometimes to provide electricity to a single load (farm, business, household, etc.). Large wind generators are used to supply electricity to the grid (large grids).

Small wind generators supplying electricity to single loads or mini-grids require storage systems. The electrical generator produces DC electricity, which is stored in a battery or bank of batteries, or it generates AC electricity, which is converted to DC and then stored.

For very small wind generation systems (fractions of a kW), it is easy to find an installation site close enough to the users to avoid the use of transmission lines. For wind generation systems of tens of kW the installation site is generally further away and requires transmission lines.

Wind energy systems used for micro-grids necessarily require an invertor because electricity can only be stored from direct current sources. Electricity is produced for single loads (for household applications) can use DC directly and avoid the use of invertors. See *Wind for Electricity Generation* http://practicalaction.org/wind-for-electricity-generation.

Diesel sets - In the past Diesel sets have been popular for rural electrification, especially in places where hydropower energy sources are scarce. More recently (since the 1980s), rural electrification promoters have been trying to avoid the use of this technology; among other reasons because access to Diesel fuel is difficult and expensive in rural areas. Rural electrification promoters have been trying to use alternative solutions, renewable energy systems or hybrid Diesel plus (wind generator or solar PV system or both), but with limited success.

Diesel sets are still a viable solution when other energy sources are either scares or too expensive to provide electricity. Diesel sets are generally installed close to the users and do not need transmission lines, apart from applications in big villages and/or scattered villages with widely dispersed populations. Diesel sets always generate an alternating current, AC, and so do not require inverters or storage. See *Biodiesel* http://practicalaction.org/biodiesel-1.

Biomass systems - Biomass fuel for electricity generation can be obtained as solid, liquid or gas. Wood chips or agricultural residues can be burned to produce heat and operate steam turbine to produce and supply electricity. Oil can be extracted from seeds of several species of plants and processed to produce bio-diesel; Ethanol fuel can be obtained from cellulose plants such as sugar cane and sorghum and used directly in internal combustion engines to generate electricity; gas can be produced from organic products (including any kind of plants of trees) via fermentation and the used to produce electricity.

Liquid fuels from biomass have been successfully introduced to the transport sector; Biodiesel and ethanol are now commercially available for cars. Solid and gas fuels from biomass are also used in the industry and are commercially produced/installed. See *Liquid Biofuels and Sustainable Development* http://practicalaction.org/liquid-biofuels-and-sustainable-development.

Biomass fuels (solid, liquid and gas) have been promoted for micro-grids for rural electrification for some decades; like solar PV and wind systems the success of biomass electricity generation for rural villages has been limited. Although countries like Brazil and India claim that they are implementing successful rural electrification programmes using small biomass gasifiers.

Technology	Advantages	Disadvantages
Solar PV	• Solar radiation is found everywhere most of the days of the year (although at a different intensity • Modularity of the technology, PV systems can be sized to meet any demand • Proven technology and commercially available around the world • Short time implementation	• Dispersed (require large areas to obtain useful quantities) • Require large storage systems • Unit cost of energy ($/kWh) is high • Most components are manufactured in a few countries, (developed countries and transition economies), little can be made locally
MHPP	• Can generate electricity 24 hours a day all-year-round • Electricity unit cost is generally low ($/kWh) • Convenient to promote productive uses and businesses • Most of the components can be build or found locally at reasonable costs	• It is site specific, it is found in hilly wet regions • It takes longer than any of the other electricity generation option to install (from ½ to 3 years) • Hydropower turbines are manufactured at request in certain countries and therefore are expensive and generally need considerable time to manufacture and ship from its place of origin
Small wind generators	• Some components can be manufactured locally • Short time of implementation • Unit energy cost is moderately high (lower than with solar PV, but higher than with MHPP)	• Wind turbines are manufactured at request in certain countries • Wind energy sources are site specific • Require large storage systems because wind speed can vary and easily not be available for several days

Diesel sets	• Mass produced, available in most countries • Short time to install • Simple to install	• High unit cost of energy ($/kWh) • Environmentally harmful • Require specialised staff for maintenance
Biomass systems	• It is possible to have access to some kind of biomass and obtain either solid, liquid or gas fuels, almost everywhere in the world (except in desserts)	• Small size technology (for micro-grids) has not been fully proven viable • The production of fuels is cumbersome, • Generation with locally produced fuels require a long chain (because requires agricultural production, processing and then use for generation
Hybrid systems	Comments	
Hybrid Diesel and MHPP	Sometimes MHPP can generate full capacity for 9 or 10 months while 2 to 3 months can do partial capacity (when water flow is scares). Hybrids MHHP and Diesel sets may be convenient in these cases to provide energy security the full year round	
Hybrid Diesel and wind generators	Diesel-wind generator hybrids have been tested in several cases with mixed results. One of the drawbacks for micro-grids is that, because the random behaviour of the wind speed, the only way of providing secure supply is adding a large storage system, and this makes the system expensive	
Hybrid Solar PV and Wind generators	Solar and wind hybrids have been tried in several opportunities for rural electrification, especially with very small (family units). As a technical solution hybrid PV solar and wind generation is fine, however it is costly.	
Multiple technologies	The use of multiple technologies (more than 2) is technically viable, but economically and financially, in most cases is not.	

Table 2: Advantages and disadvantages of the different technologies.

Planning a community micro-grid

Good practise planning contributes to successful implementation and to the sustainability of the scheme; it includes evaluation of resources, evaluation on energy needs, dimensioning of the scheme, cost estimation, establishing ownership and type management. The planning process should be made in dialogue with the community (energy users) and authorities.

Electricity demand - The electricity demand is quantity of electricity expected to be consumed by the village/community and it is generally expressed in a monthly basis. Two indicators are used to quantify electricity demand; average energy consumed per family (kWh/month per family) and the maximum expected demand by the village/community at any one time (peak power).

Although both indicators are important for any technology installed or used, average energy consumed is more commonly used when the technology requires storage to make energy available to the village, typically when the technology used is solar PV and wind generators, while peak power is more important when energy storage is not present (MHPP, Diesel sets, biogas and others).

Worldwide references show that electricity needs range from about 30kWh to 100kWh per family per month; but less in poor and isolated villages/communities without access to transport. For example; Practical Action has found that 70% of families in isolated communities in the Andean region in Peru and Bolivia consume less than 20kWh per month after 6 to 10 years of connection (T. Sanchez, 2006a). Regarding peak power, it has been found that poor villages/communities use electricity mainly for lighting during early hours of the night, for about 3 to 4 hours; during these hours electricity consumption, in most cases, is three times or more the daily average power

(T. Sanchez, 2006). This, peak power, has a big implication in the design of the system (when storage is not present).

Quantifying electricity demand in isolated rural villages/communities with precision is difficult no matter how rigorous the planner is in collecting information on the community needs. In practice a good judgement regarding average potential electricity consumption and peak power together with a simple survey about their energy habits can be enough to find out the required energy and power of the system.

A simple survey can comprise: a) number of families in the community/village, b) number of rooms in the houses, c) income of the families, d) evening activities of the families, e) expenditure on energy sources for lighting such as; kerosene, wax candles, batteries or any other source which is providing a service replaceable with grid electricity.

With the survey results and an understanding of the village/community potential for development the planner is in the position of judging the values for both, kWh/family per month and peak power needed, and decide the size of the system.

Practical tips in the planning phase are:

- Knowing or having a good idea about the amount of money spent by households in traditional energy options for lighting, communications, cooking and productive uses, helps to discuss and agree about the tariff whenever that negotiation occurs.
- An appropriate size of the generation capacity of the system is important; too large a system will result in a higher implementation cost and wastage of energy, too small a system will result in social conflicts.
- Poor and isolated communities close to roads connecting large towns and cities tend to grow quickly when electricity arrives; isolated communities not connected to roads tend to grow very slowly. This should be taken into consideration when the projected demand is estimated.
- Solar energy, wind energy and biogas systems generally require storage systems, in this case the critical parameter to size the scheme is kWh/family (per month). When solar PV systems or tiny wind generation systems are installed separately for each user (solar home systems – SHS), considerations of peak power are not necessary, however with micro-grid electricity, peak power is important, smart controls are required in order to limit the energy consumed.
- Micro-hydro schemes, diesel sets and biomass systems (other than biogas) generally do not require energy storage; therefore the main parameter to sizing the system is peak power.
- It is advisable that ownership and the sort of management during the planning phase is considered; Practical Action's experience is that ownership of the system should be clearly defined, better if this is defined during the planning phase.
- Define the management system; this will give the opportunity to the community or to the owner or to both to choose and train the operation and management team during the implementation phase.
- The transmission and distribution costs can represent the biggest single expenditure for some mini-grids, so it is important to have a good estimate of the costs associated with this infrastructure. You can measure the distances and number of households using GPS or even satellite imagery (www.developmentmaps.org is useful for this).

Operation and management

Operation and management of micro-grids has always been a complicated issue, especially in small and isolated villages in developing countries; among other reasons because:

- The users of electricity are not used to pay bills regularly (monthly)
- Cash in these sorts of places is generally scarce
- Historically they have been subject of offers of free electricity (by irresponsible politicians or poorly informed leaders)

- There is lack of local skills to operate and manage electricity generation schemes

Several management models have been tested and promoted around the world by different national and international organisations, among them are the following:

a) Energy Service Company (ESCO)[2]. The main characteristics of this model are: the ESCO owns the system; it charges a fee to the household and is responsible for proving a continuous and reliable service; the ESCO may be a monopoly concession regulated by the government or may operate competitively without explicit monopoly status[3].

   Similar model to ESCO, based on private entrepreneurship are the SMEs (Small and Medium Enterprises) or the MSME (micro, small and medium enterprises)[4], one of the most important promoters of this model has been promoted by the World Bank. The main idea of the World Bank has been to support the creation of local private enterprises which would be in charge of providing energy access to the users through the sells of products, Examples of use of this model can be found in the off-grid systems of the rural electrification programmes in Nicaragua, Peru, and India, more recently also in Africa. The Energy Service Providers (ESP) is a similar model where the “service providers” are private enterprises; E & Co and USAID[5] are among the main promoters of this model, they show successful cases that happen in a range of countries in Latin America and Asia.

b) The Energy Consumer Companies (ECC) model has been developed and tested by Practical Action in Sri Lanka, in village hydro projects, this model followed Practical Action’s participatory implementation of projects and involves mechanism of participation in the management and ownership of the systems. The application of this model requires that villages form a Society before requesting any technical assistance for the implementation of a small hydro scheme; the ECS were formed to involve all potential beneficiaries and become the operational and implementation conduit for the project. Then promotion of ECS evolves to become ECC. The ECC is a legal body with the status of a small company therefore it has capacity to manage bank transactions and other operations that are reserved to legal entities (Dhanapala, Priyantha, 2008).

c) Small Enterprise Management (SEM) model developed and tested by the Practical Action Peru office, applied to small hydro schemes and small drinking water services for remote communities. The principle of this model is that the energy (electricity in particular) should be treated as a service, the implementation of the scheme is with participation and full consent of the users, the investment is promoted and made by anybody interested on energy access, this could the government, the church, international aid (through NGOs) or any other, or a combination of different investments including the community participation in the investment, therefore the ownership could be the community’s, the local governments, central governments, or other, however the critical issue is the management of the operation and management of the electricity services, which should be in the hands of a small private local enterprise. This generally requires the creation of a small private enterprise and training on all the issues related to energy generation, operation and management, safety, accounting, tariff setting and bill collections, as well as extension of the services required. The SEM is legally registered and therefore can manage financial operations and others activities. The balance of power within the energy users’ providers is arranged through the auditing committee (Sanchez, 2006).

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[2] http://www.energyagency.at/projekte/energyservice.htm

[3] http://www.martinot.info/Martinot_Cabraal_WREC2000.pdf

[4] http://www.esmap.org/filez/activity/35200721053_LACNicaraguaTAforimproved.pdf

[5] http://www.energyandenvironment.undp.org/undp/indexAction.cfm?module=Library&action=GetFile&DocumentAttachmentID=1657

d) Community Shareholders Model (CSH) model has been proposed and tested in several part of the world, although there have not been many reports about its performance. It was proposed and implemented during the 1990s, the World Bank being one of the promoters. The concept was that the investment and implementation are done by the government, but the operation and administration of the systems are carried by a company created for that purpose. The company was formed by all the users, therefore the users are shareholders of the company. Like any other company it should have a board of directors, composed of elected members.

e) Electricity (or energy) Community Cooperatives, where the properties of the assets are in the hands of the community as a whole, where the shares are not split between the members of the cooperative but it remains property of all. Although there is not much information available regarding the genesis of this model, the concept was basically a step forward of the energy rural electrification committees which used to be formed by the communities to claim electricity services from the government, the difference being that the committee did not have any legal status, while the cooperative was supposed to be registered legally.

f) Rural Electrification Services Companies (RESCO)[6] model has been primarily promoted by Electricite de France (EDF) in South Africa and other neighbouring countries, with capital investment made by EDF and its associates. Each project relies on the creation of local a Rural Electrification Company (RESCO) which trains, employs and is managed by local people and forms part of the local community. Presently EDF claims that it has reached 670,000 users through this model of energy services in Africa, mainly in South Africa. Energy access programmes work closely with The World Bank, UNDP, and a number of multi and bilateral donors to make capital investment possible.

Example of a micro-grid (MHPP) in Wvem, Cameroon

Figure 2: Wvem village, Cameroon. Photo: T. Sanchez, Feb 2014.

Wvem is a rural isolated community of about 200 families, 76 of them live close to each other forming a small village (see photo). This village has two elementary schools, one secondary school and a health centre; families have running water, which is supplied through pipes to a few collection points in the village, have not electricity, no landline telephone service, but have access to mobile telephone services.

ADEID, a local NGO, was asked to provide technical support for the installation of a MHPP in Wvem. ADEID found that the best technical and economic option to provide electricity to this village was the installation of a MHPP using water from a local stream. This will generate 21kW during the dry season (2 to 3 months and year), using the minimum average flow, and 35 kW the rest of the year. It has also been found that the village requires less than 21 kW to cover all its needs during the first eight years; after which the villagers will need to either install a second scheme using another local stream or install a small Diesel set to complement electricity generation during the 2 to 3 months of dry season.

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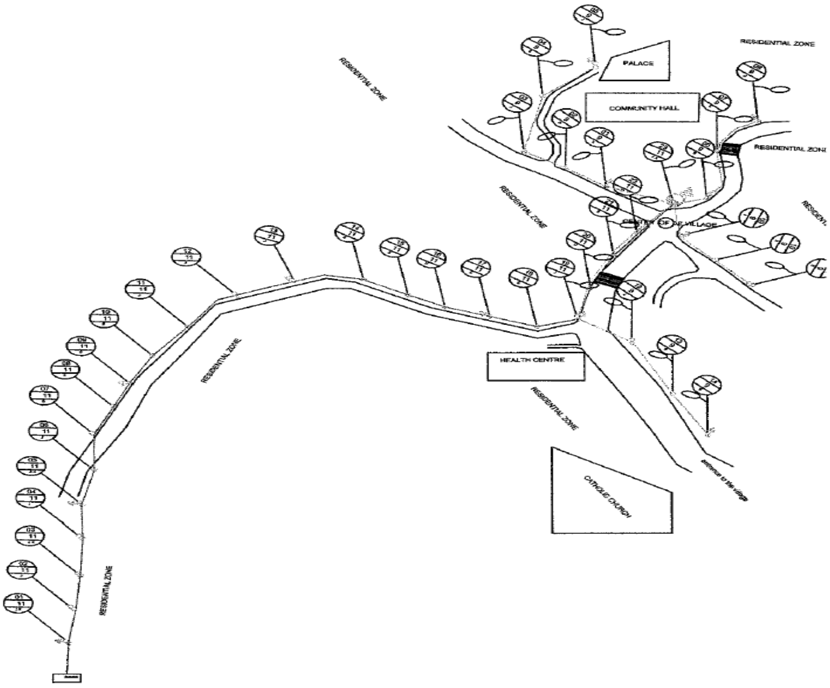

Figure 3: Layout of the MHPP of Wvem mini-grid showing the transmission and distribution lines. The circles in the diagram indicate the specifications of the posts and lights.
Diagram: Raoul Etcheu, ADEID).

The village is located 1.5 km away from the generation point (powerhouse), therefore a 1.5 medium tension transmission lines system is to be installed. The village will have electricity with home connections for 76 families initially (the number of families will increase with time), electricity will also be supplied to schools and health centre. ADEID is planning to implement the Practical Action “small enterprise management model”.

Life cycle of micro-grid

In the past it was common practice to consider the life span of the micro-grid the same as the expected life of the technology used. The life span of most renewable energy technologies (solar PV, hydro power plants and wind energy systems is estimated to be between 25 to 30 years, therefore micro-grids, using these technologies, will be designed for that period of life, and are sized to comply with the estimated demand for the last year of life. Diesel sets have much smaller demand. When a combination of technologies with different lifespans is used, the life span of the micro-grid in most cases is considered the same as that of the technology with the longest period of life. The idea is that when the time arrives there would be an assessment of the micro-grid and appropriate refurbishment would take place to extend its operation for a new period.

Similarly, in the past little or no consideration has been made of what to do if the main grid reaches a particular micro-grid, therefore when this happens, the grid planners simple ignore the existence of micro-grids, and most micro-grids become redundant, and the infrastructure is lost (wasted).

It is expected that after the loud claims of many important world development agencies regarding the importance of energy for all, micro-grids are designed with possible future connection and potential contributor to national/regional grids in mind. This consideration is even more important if micro-grids are going to play such important role in rural electrification worldwide as the IEA predicts. For this to happen, policy makers of governments need to develop legal provisions accordingly.

Further reading

- *Grid Connection,* Practical Action Technical Brief http://practicalaction.org/grid-connection
- *Energy for Rural Communities,* Practical Action Technical Brief http://practicalaction.org/energy-for-rural-communities-1
- *Micro-hydro Power* , Practical Action Technical Brief http://practicalaction.org/micro-hydro-power-2
- Corbyn, D. et al, *Renewable Energy to Reduce Poverty in Africa* Christian Aid, Practical Action Consulting http://practicalaction.org/renewable-energy-to-reduce-poverty-in-africa
- T. Sanchez, *The Hidden Energy Crisis,* Practical Action Publishing http://developmentbookshop.com/the-hidden-energy-crisis-pb
- L. Rodriguez & T. Sanchez, *Designing and Building Mini and Micro Hydro Power Schemes* Practical Action Publishing http://developmentbookshop.com/designing-and-building-mini-and-micro-hydro-power-schemes-pb
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