INSULATED RURAL AREA ELECTRIFICATION: ASPECTS, ENERGY POLICIES AND DESIGN PRINCIPLES

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Abstract

Electrification of rural insulated area aims social, cultural and economic development of a community. Using renewable resources to achieve this objective involves specific and particular aspects regarding: hybrid systems which utilized intermittent energy resources (solar, aeolian, etc.), impact and accommodation of the consumer with these systems, as well as some particular aspects related to their design. This paper try to approach rural electrification from this point of view and finally, to present some conclusions.

Keywords: rural electrification, hybrid systems, renewable resources

1. INTRODUCTION

Rural settlements are spread on a large variety of climatic and geographical zones, electrifying those, especially the insulated one, far from local electricity network are being done successfully with hybrid power systems.

For punctual applications are utilized photovoltaic or aeolian low power autonomous systems:

- Public lightning;
- Rural telephony;
- Small irrigation and water desalinization stems;
- Small refrigeration systems (Figure 1).

a)

b)

Figure1: Punctual applications: a) wind irrigation system; b) milk refrigeration solar system for insulated village

For other application of larger power, on which the energy consumption is higher, is used hybrid power systems (HPS - Figure2) based on renewable resources available onsite (wind, sun, hydro, biomass, etc.):

- Large irrigation system;
- Water desalinization/purification plant;
- Schools
- rural medical centre;
- Insulated hamlet.

Figure 2: Solar wind Diesel hybrid power system for small village

Any combination of electricity generation systems based on renewable is possible (pv panels, wind turbine, battery, etc.), generally these are provided with a genset based on diesel or LPG (Figure1).

2. SPECIFIC ASPECTS REGARDING RURAL ELECTRIFICATION WITH HPS

The aim of the rural electrification is to raise the living standards of a community, to assure a social, cultural and economic development of it. Choosing the best suitable way to achieve this gold is a real challenge involving several aspects that must be taken into consideration.

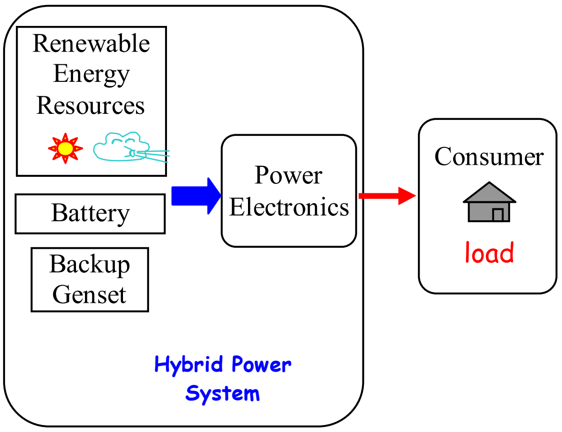

Figure1: Hybrid power system scheme

One of the most important aspect is that most of the small insulated rural consumers (hamlet type) have a low degree of financial supportability so the demand for electricity is mainly for indoor/outdoor lighting and at most for small home utility: refrigeration, tv/radio/communication. The problem of assuring domestic water supply with a small hydrophore had to be taken also in consideration. This is needed to be taken into account in establishing the electrification offer.

On the other hand, rural electrification with HPS may lead to a surplus in general economy of the consumer household. This surplus is because the consumer no longer needs to spent money on kerosene for lamps, candles, disposable batteries.

Depending of the household level of growth it may be possible that the access to electricity of the consumer lead to a micro-enterprise development (handcraft, sewing, etc) or to a rural tourism growth. The energy demand of these consumers as well as financial supportabilities is very different from regular rural consumers.

Therefore, electrification of rural insulated area with HPS may be a useful tool to:

- Gain an immediate access to reliable electricity at any time;
- Strengthen local cohesion by providing access to electricity for all users;
- Allow for a better use of local natural resources;
- Increase economic productivity and create local employment opportunities [1];

3. ENERGY POLICY IN RURAL ELECTRIFICATION WITH HPS

To electrify an insulated rural consumer with hybrid power system it must take into consideration some aspects regarding energy policy that had to be applied during design process:

- Accurate receiver assessment on the consumer;
- Exact calculus of each receiver absorbed power;
- Establishing a strict number and type of receivers, especially for lighting;
- Verifying the correlation between electric energy possibly to obtain from renewable resources with the loads, on each household and overall the site;
- Final establishing of the consume and the electric energy possible to produce;
- Setting through discussion on the site with each user the total quantity of electric energy possible to produce as well as the limitation of the hybrid system from this point of view;
- Finalizing by contract with each user the electrification proposal with HPS;
- Limiting by design the Ah possible to absorb by the user.

Each of these aspect are aiming to avoid the increase in time the consumption which is inevitable and uncontrolled due to the tendency of the user to buy, sometimes with sacrifices, new household appliances. These will lead to cascade consequences:

- consume abuse;
- increased number of operating hour of Diesel group;
- premature discharge of the battery bank;
- overcoming the capabilities of HPS;
- often disconnections of the consumer;
- increasing discontent of the user and finally the failure of electrification with HPS [2].

4. DESIGN PRINCIPLES OF THE HPS FOR RURAL ELECTRIFICATION

For insulated rural users from technical point of view it is possible to design any combination of generators based on renewable resources, it depends of how high are the demand and how much availability are the renewable.

How to determine the optimal solution for the HPS involve a feasibility study based on data acquisition for each available renewable resource onsite.

To design the configuration scheme of the hybrid power system must take into consideration the specificity of each consumer (location, resources, load demand) as well as the technical, economical, financial and cultural consideration pointed out in previous chapter.

Once the final configuration of the HPS is established it has to do a responsible selection of the components taking into account the following:

- ✓ Quality: it has direct implications in reliability of the HPS and energy availability at the consumer;
- ✓ Demand and offer: directly influencing the total cost of the system;
- ✓ Regular maintenance demand: refer in particular to Diesel generator;
- ✓ Availability of spare parts, especially for Diesel generators;

- ✓ Availability of the HPS components: it had to be taken into consideration the life cycle of the inverters, pv, wind turbine, batteries, gensets because on the total life cycle of the HPS some of them had to be completely replaced.

One of the most important aspect during HPS design is choosing the lowest consumption home device, because it has direct influence on acquisition price of the components (PV panels, battery, inverter, wind turbine, Diesel group) and finally on the total life cycle cost of the system.

For example, to electrify a hamlet far from electrical grid, one we can consider to assure the following:

- indoor and outdoor lighting;
- refrigeration;
- water pump;
- tv, radio/ communication.

In order to make an economy, it is necessary to choose the lowest consumption home device. If for example to a fridge, water pump, washing machine, tv or radio it can be done very little (class A ++ is the best that exist in ac current) for lighting we can be done much more. Table 1 shows home devices chosen for a remote hamlet and for each the calculus is being done using a handbook providing by SANDIA laboratories [3].

Table 1: Home devices considered for the hamlet

Load description	Qty	Load current [A]	Ac 220v load power [W]	Daily duty cycle [hrs/day]	Power conversion efficiency	Un [V]	Load [Ah/ Day]
Lighting	5	0.041	45	8	0.8	48	9.4
		0.145	160	8	0.8	48	33.3
		0.45	500	8	0.8	48	104
Fridge	1	0.8	176	10	0.8	48	46
Water pump	1	3	660	0.5	0.8	48	8.6
Washing machine	1	6	1320	1*	0.8	48	5
Tv	1	0.4	88	10	0.8	48	23
Radio	1	0.113	25	6	0.8	48	4

* (and weekly duty cycle one hour per week; 1/7)

For lighting we take into consideration three types of bulbs existing on the market: 9W LED, 24W economic and 100w regular and we supply the HPS only with one type. The results are shown in table 2.

Table 2: PV and battery calculus for the HPS

Type of bulbs	Total load [Ah/day]	Hybrid battery capacity [Ah]	Hybrid array power [W]	Total No. PV	Total No. Batt.
LED	90	284	636.5	8	8
Economic	106	336	662	8	8
Regular	176	556	1248	12	16

Taking into consideration that nominal voltage of HPS is 48V in all three cases, the PV and batteries are chosen respectively the rated module current of the array and the capacity of selected battery, the result is given in Table 3.

Table 3: The bulb type influence on price

Type of bulbs	Rated module current [A]	Capacity of selected battery [Ah]	Total PV module + battery bank price [$]
LED	9.48	150	8072
Economic	9.48	175	8224
Regular	9.48	180	13308

In the case of LED and economic bulb, the difference on price is because of battery, the nominal voltage being the same in all three cases as 48V.

As we see in Table 3, the type of the bulb we chosen has direct influence on the price of the components, and here we taken into consideration only two of them, Pv and battery. For example if we make electrification with economic bulbs, as a company we can supply the consumer the bulbs, this plus of investments of 23$ make a real economy of about 5000$.

The question of establishing with the consumer the type of appliances he wants to use has to be a matter of contract and part of electrification policy and could lead to substantial economies.

5. CONCLUSIONS

Electrification of remote rural areas with hybrid power systems based on renewable involved a specific and very different approach form classic electrification by the grid. There is particular and sensible aspects regarding the consumer, implications in social and economical developments, energy policies that had to be adopted by the HPS supplier and assimilated by the user, having the main purpose to protect HPS from consume abuse and also to meet the user demands. Having a high availability of electric energy from intermittent energy resources implies adequate design and a carefully selection of the HPS components.

Thus electrification with hybrid system of the rural areas far from electricity grid is a real challenge involved both technical and economical aspects as well as the availability for common good.

5. REFERENCES

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