IJARESM
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN ENGINEERING, SCIENCE & MANAGEMENT

HYBRID RENEWABLE POWER SYSTEM OPTIONS FOR RURAL ELECTRIFICATION

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Abstract: ***The quality rural electricity supply has been regarded as essential for economic development. Harnessing energy from alternative energy source has been recorded since early history. Renewable energy is abundantly found anywhere, free of cost and has non-polluting characteristics. However, these energy sources are based on the weather condition and possess inherited intermittent nature, which hinders stable power supply. In order to handle their fluctuating nature, however, hybrid systems can be applied. These systems use different energy generators in combination, by this maintaining a stable energy supply in times of shortages of one the energy resources. Main hope attributed to these systems is their good potential for economic development.This paper discusses the application of hybrid systems for rural electrification in developing countries by integrating ecological, socio-economic and economic aspects. It is concluded that hybrid systems are suitable to achieve both ecological and socio-economic objectives, since hybrid systems are an environmental sound technology with high quality electricity supply, by this offering a good potential for economic development. It is therefore recommendable to apply hybrid systems in areas with a significant number of villages, which are to be electrified with these systems, in order to improve financial sustainability of these maintenance centres. A hybrid power system functioning as an autonomous entity can provide almost the same quality and services as the national grid. Moreover, with the proper arrangements, it is technologically possible to connect a mini-grid to the national grid. In countries where the national grid may provide users with only a few hours of electricity a day and often suffers from blackouts, rural communities served by a hybrid mini-grid conceivably could receive with more reliable service than their fellow urban consumers.***

Keywords: **Renewable Energy System (RES), Hybrid Renewable System, Generator Set (Genset), Photovoltaic (PV), Wind Power, Bio Gas, Small Hydro,**

1. INTRODUCTION

The rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present day demands. Alternative energy resources such as solar, wind, ocean thermal, small hydro and tidal have attracted energy sectors to generate power on a large scale. However, solar and

wind energy systems are being considered as promising power generating sources due to availability and the topological advantages in local power generation. It is prudent that neither standalone wind energy system nor solar system can provide a continuous supply of energy due to seasonal that combine solar and wind generating units with battery backups are implemented to satisfy the load demand.

A hybrid mini-grid combines at least two different kinds of technologies for power generation and distributes the electricity to several consumers through an independent grid. Thus, the mini-grid is supplied by a mix of renewable energy sources (RES) and a generator set (Gensets), generally supplied with diesel, used as a back-up. It is a mature and cost-effective technology solution that provides high quality and reliable electricity for lighting, communications, water supply, or motive power, among other services. A hybrid power system functioning as an autonomous entity can provide almost the same quality and services as the national grid. Moreover, with the proper arrangements, it is technologically possible to connect a mini-grid to the national grid. In countries where the national grid may provide users with only a few hours of electricity a day and often suffers from blackouts, rural communities served by a hybrid mini-grid conceivably could receive with more reliable service than their fellow urban consumers.

1.1 ADVANTAGES OF THE HYBRID SYSTEMS

- Optimum utilization of renewable energy sources in a remote area
- The certainty of meeting load demands at all times is greatly enhanced by the hybrid systems
- In some hybrids, batteries are used in addition to the diesel generator, the batteries meet the daily load fluctuation, and the diesel generator takes care of the long term fluctuations.
- Designed for easy to operate, service and maintenance when required.
- Most eco-friendly and clean source of power.
- The hybrid systems provide more consistent year round renewable energy production. These systems are modular and can be expand easily.
- Lying of the expensive grid line, transmission and distribution losses can be eliminated.
- Eliminates any associated expensive electricity bills.

TYPES OF HYBRID RENEWABLE SYSTEMS

Power systems using multiple generation sources can be considered as *'hybrid power systems'* [6]. Hybrid power systems range from small systems designed for one or several homes to very large ones for remote island grids or large communities. Alternative energy resources such as solar, wind, ocean thermal and tidal have attracted energy sectors to generate power on a large scale. However, solar and wind energy systems are promising power generating sources due to availability and the topological advantages in local power generation. It is experienced that neither standalone wind energy system nor solar system can provide a continuous supply of energy, due to environmental differentiations the combine solar and wind generating units with battery backups are implemented to delight the load demand [7].

Power systems utilizing renewable energy such as wind, solar and micro-hydro require control methods to maintain stability due to the real time variation of input energy and

load, while maximizing the use of renewable resources. Using, diesel generator installed capacity is sized to meet the peak power demand, but is used in practice to supply power only when the wind power output is insufficient to meet the load demand.

2.1 DESIGN CONSIDERATIONS OF HYBRID ENERG SYSTEM:

Hybrid systems can technically be designed for almost any purpose at any capacity. Main applications for rural electrification in developing countries include independent electric power supply for

- Villages,
- Residential Buildings,
- Hospitals,
- Schools,
- Farmhouses,
- Missions,
- Hotels,
- Radio Relay Transmitters

The design of hybrid energy systems involves the following steps

- Selection of the energy resources to be used (this will depend on the of potential of different renewable energy resources in the area).
- Choice of the system configuration
- Load profile determination of the area to be served (seasonal/monthly/yearly)
- Sizing of the system components and switchgear, distribution networks etc.
- Economic analysis of the project (payback, NPV etc.**)**
- Environmental/socio-economic evaluation for sustainability
- Provision for expansion, land costs and environmental clearances
- Testing of the system design through simulation exercises.
- Modification of the system configuration on the basis of simulation feedback

Once the main considerations have been finalized, the system is ready for the implementation stage. The subsequent performance of the system will then be governed by appropriate system management strategies, which can promote local employment, conservation and high efficiency.

2.2 TYPES OF THE HYBRID SYSTEMS: Hybrid systems are another approach towards decentralised electrification, basically by combining the technologies

- Solar and wind Hybrid system
- Wind and Diesel Hybrid system
- Solar and Diesel Hybrid system
- Wind and Diesel and Fuel cell Hybrid system
- Wind and micro-Hyde Hybrid system
- Wind diesel and solar Hybrid system

THE HYBRID RENEWABLE TECHNOLOGIES IN DEVELOPING COUNTRIES

A common hybrid system for the application in developing countries generally consists of the following main components:

1. A primary source of energy, i.e. a renewable energy resource;
2. A secondary source of energy for supply in case of shortages, i.e. a diesel genset;
3. A storage system to guarantee a stable output during short times of shortages
4. A charge controller;
5. Installation material (safety boxes, cables, plugs, etc.);
6. The appliances (lighting, TV/radio, etc.).

Hybrid systems are applied in areas where permanent and reliable availability of electricity supply is an important issue. Maintaining high availability with renewable energies alone usually requires big renewable energy generators, which can be avoided with hybrid systems. At favourable weather conditions, the renewable part of the system satisfies the energy demand, using the energy surplus to load the battery.

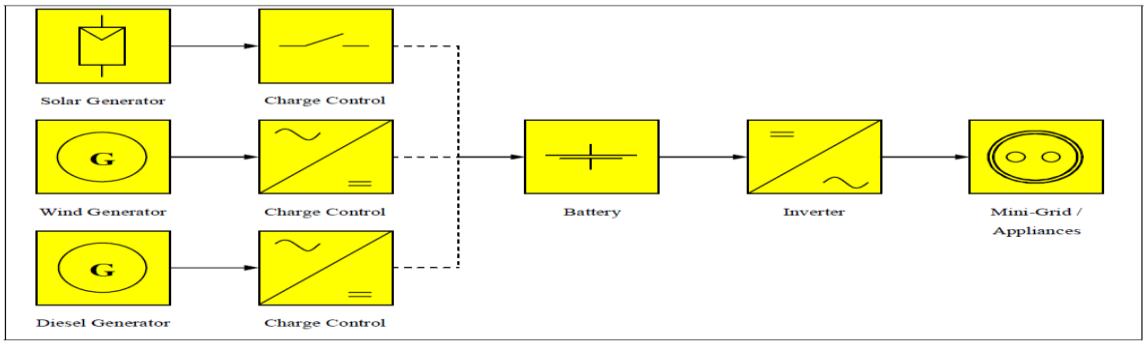

Figure 1 Principle Circuit of Hybrid Systems

3.1 PV/Diesel:

Combining Photovoltaic arrays and a diesel Genset provides a rather simple solution and is feasible for regions with good solar resources. PV/Diesel hybrid systems require a DC/AC-inverter if appliances need alternating current, since PV modules provide direct current. Compared to the common solution for rural off-grid electrification using diesel Gensets alone, the hybrid solution using photovoltaic offers great potential in saving fuel.

3.2 Wind/Diesel:

Wind/Diesel combinations are, in principal, built up in the same way as are PV/Diesel systems. From a perspective of financial competitiveness, they can be applied in regions where average wind speed is around 3.5 m/s already speed is sufficient, the wind turbine is in charge of the provision of energy. During short periods of time with low winds, the battery maintains a stable system, being replaced by the diesel generating set when low winds occur over longer periods of time.

3.3 PV/Wind and PV/Wind/Diesel:

In some regions the exploitation of both wind and solar resources can become favourable, i.e. at coastal or mountain areas with high degree of solar radiation. Of utmost importance is here that wind and solar energy supply complement each other so that energy provision is possible over the whole year.

While for the other hybrid systems applying diesel Gensets, the objective in designing the system is to maximise the exploitation of the renewable energy resource, the situation is different for PV/Wind systems. Here, accurate assessment of the resources is essential for the decision on the appropriate system design.

A PV/Wind hybrid system is able to provide energy all time of the day, if weather conditions are favourable. However, breakdowns in energy supply are possible, which is not suitable for some non-household applications, i.e. hospital electrification. Thus, a PV/Wind hybrid system might ideally be supported by an additional diesel generating set for times of extremely unfavourable weather conditions.

3.4 Biogas Hybrid Systems:

3.4.1 PV/Wind/Biogas: ASE GmbH as the performing organisation has created an autonomous hybrid power supply systems for the purification plant of Körkwitz, situated close to the Baltic Sea in North-eastern Germany, using the renewable energy resources

photovoltaic, wind and biogas for energy provision. The objective was to provide 80% of the necessary energy, being able to feed up to 30% of surplus energy under good performing conditions into the public grid.

In the first stage, the system was implemented using just wind energy and photovoltaic arrays, however preparing the energy management for further expansion using biogas in a decentralised cogeneration plant. The main components of the system include a 250 kWp solar generator and a 300 kW wind turbine with 3 inverted rectifiers connected in parallel Information on the performance of the installed system and about the further expansion with biogas could not be obtained within the framework of this work. This is due to the fact that the participating companies have been declared insolvent since implementation and the new operator of the systems could not be identified.

3.4.1 Wind/Biogas: The concept of a Wind/Biogas system is to some degree similar to Wind/Diesel hybrid systems. Instead of the diesel Genset, here engine generator sets, small gas turbines, or some kinds of fuel cells can be used to generate electricity in addition to the wind turbine. The engine is fuelled by biogas, which is produced in an anaerobic digester.

If the production of biogas is at times not sufficient, conventional gases as propane can be used instead.

3.5 Hydropower Hybrid Systems:

3.5.1 Wind/Large Hydropower: On a seasonal basis, the two resources wind and hydropower tend to complement each other to some extent (Iowa, 2002a). Especially in winter, when river flows are low, wind has the potential to take over electricity supply. However, during late summer, both resources might become low, and the combination of both is then disadvantageous. Moreover, while hydro generators on rivers are usually at lower levels, wind resources are better at high elevations. For constant electricity generation, another energy resource would therefore be necessary. Since the combination of wind and hydropower offers just limited advantages, it is unlikely that these resources are combined in a project in developing countries, since this opportunity does not seem economically attractive. However, for some locations the situation might be different, so that the feasibility of Wind/Large Hydropower systems needs to be assessed for each case individually.

3.5.2 Wind/Micro-Hydro and PV/Micro-Hydro: While hybrid systems with large-scale hydropower generators seem unattractive, micro hydropower is more feasible. Micro-hydroelectric generators are turbines that are able to operate under low elevation head or low volumetric flow rate conditions, being suitable for small rivers (Iowa, 2002b). Where rivers have inconsistent flow characteristics (dry in summer, frozen in winter), a hybrid system applying wind or PV support can be attractive. A careful assessment of water resources is therefore essential.

CONCLUSION

A hybrid mini-grid combines at least two different kinds of technologies for power generation and distributes the electricity to several consumers through an independent grid. Thus, the mini-grid is supplied by a mix of renewable energy sources (RES) and a generator set (Gensets), generally supplied with diesel, used as a back-up.

Rural electrification is commonly seen as essential part for the development of rural areas in Developing countries, and is integral part especially for furtherance of economic progress.

However, rural electrification is a problematic issue. The extension of the conventional grid is often economically not feasible for remote rural areas, and can as well be undesirable from a point of view of environmental sustainability.

However, the adaptation of this hybrid system for rural electrification in developing countries seems unlikely especially from a financial perspective. Combining three different types of renewable energy systems certainly involves investment costs too high for this purpose.

Common practice to meet the problem of rural electrification in developing countries is the use of diesel Gensets. This approach, however, is as well unfavourable not only from an environmental, but also from a socio-economic and economic perspective, since diesel Gensets usually cannot evolve the full potential of electrification for rural development.

Modern approaches, therefore, address the challenge of rural electrification with decentralised energy supply systems applying renewable energies. Renewable energies are an environmental benign solution for rural electrification, and have several additional benefits related to their use; renewable energies, i.e., use locally available resources and offer a high potential with regard to local independence compared to grid extension and diesel gensets, since they are less dependent on external interference.

Despite these numerous advantages, however, the application of renewable energies for rural electrification has not yet been the success story it was expected to be. In many cases renewable energies have failed to meet the expectations of rural population, on the one hand by unrealistically high expectations on side of the population, on the other hand due to problems with reliability of the systems. The main problem for the application of renewable energies in rural electricity supply, however, was and is the intermittent supply of power due to the fluctuating nature of the resources, which has lead the customer dissatisfaction in many cases.

This problem is recently met with the application of hybrid systems. So assessment for the sustainability of hybrid systems for rural electrification with regard to environmental, socio-economic and economic issues, and to identify key success factors to improve the sustainability of a hybrid rural electrification project.

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