PV-Diesel Stand Alone Hybrid System at a Royal Project Research Station: Observations on Power Quality

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ABSTRACT

This paper describes a PV-Diesel hybrid system used to power the Mae-ya-noi Royal Project Research Station located at msl 1200m in northern Thailand. It is not electrified and about 6 km from distribution network. This system consists of a 0.6 kWp PV array, a 12 kWh lead-acid battery bank, a 5.25 kVA diesel generator set and a 1 kW bi-directional true-sine inverter. The system is configured to operate in 3 modes, namely, PV only, generator only and PV-generator modes. The best power quality, measured in terms of voltage regulation, power factor, %THDv and %THDc are obtained with the PV only mode.

1. Introduction

The Royal Project, initiated nearly 30 years ago, deals with opium substitution and watershed management in cool, mountainous northern Thailand. The area is inhabited by various ethnic groups. Major activities are replacing of opium growing with temperate climate vegetables, fruit and flowers. There are 36 field stations for research and extension. In addition, there quite a few satellite stations. All are on mountainous terrain with difficult access. Many are connected with remote grids with frequent power outage or undervoltage operation. Some stations are not electrified and are supplied from diesel generators. Stand alone or grid connected renewable energy generation is suitable in such situation. Our group are now designing and testing systems in a number of stations. We report here performance results of the system at Mae-ya-noi Royal Project research station at msl 1200m.

2. Experiment

The electrical loads of the system are fluorescent lighting, household and office appliances, amounting to a daily load of a few kWh, typical of loads at remote stations. We have chosen PV as the renewable energy source. The station is remote, there is no on-site data on radiation. In sizing the system, based on the NREL Homer program, we used the data at the meteorological station 30 km away at Chomtong at the foot of the mountain where the station is located, but in a valley. We realize that the actual radiation at the station at mls 1200m would be less than the lowland value due to cloud cover.

The system consists of a 0.6 kWp PV array, a 12 kWh lead-acid battery bank, a 5.25 kVA diesel generator set and a 1 kW bi-directional true-sine converter. We have to choose a generator with bigger wattage than necessary because it is the smallest rating available for sound proof generators which is required for hill stations. With a PV array and a generator as two possible power sources, there are 3 combinations of power sources and modes of operation, i.e.

- **PV**: The PV array continuously charges the battery bank. In this mode the converter functioning as inverter draws DC input at constant voltage close to the design operating point from the battery bank. The inverter then operates at high efficiency and with small harmonic output.
- **Generator**: Switching on the generator sets the converter into battery charger mode. Generator output is fed to loads as well as charging the battery bank. Power quality of generator output will determine the power quality of the load. Most locally produced

![Fig. 1 Block diagram of the system.](image-url)
generators for stand-by operation provide not purely sinusoidal output. 

**PV and generator:** The converter is in the battery charging mode. The battery bank is charged both by the PV array and the generator. Loads draw power only from the generator.

In our present phase of study, the actual load is at most 10% of the inverter rating. However, this will definitely increase as more activities are brought in.

Following measurements are taken:
- load voltage
- real, reactive and apparent power, power factor and harmonics of loads
- % THDv and % THDc

3. Results and Discussion

Under three possible modes of operation and with either resistive or inductive loads we obtained the following results.

**AC voltage regulation, Power Factor and %THDv**

Using PV as the sole power source, the best voltage regulation, power factor and the %THDv are achieved, as shown in Figures 2, 3 and 4. This is because load power is supplied from the true sine wave inverter operating at a constant DC voltage of the battery bank.

Finally, operation of some telecommunication and electronic equipment sensitive to harmonics requires power of quality. We can improve power quality from the generator mode and the PV-generator by re-routing the power flow from the generator to only charging the battery bank without directly supplying the load. We may need to increase the battery bank capacity for this.

4. Conclusion

We report a power quality study of a stand-alone PV-diesel hybrid system at Mae-ya-noi Royal Project Research Station located at msl 1200m in northern Thailand. This system consists of a PV array, a lead-acid battery bank, a diesel generator set and a bi-directional true-sine inverter. The system is configured to operate in 3 modes, namely, PV, generator and PV-generator modes. The best power quality, measured in terms of voltage regulation, power factor, %THDv and %THDc are obtained with the PV mode.

**REFERENCE**

Anon, Intanon Royal Project, Royal Project Foundation, Chiangmai