Hybridization of Renewable and Non-renewable Sources for Low Cost Rural Electrification

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In this research work a modified islanded clustered legacy microgrid having distributed generation and distributed storage architecture for the electrification of isolated communities is proposed. The standalone centralized microgrids always resulted in failures due to high initial cost, social acceptance, space issues for housing photovoltaics, high losses due to central generation, low load factors of diesel generators, and poor maintenance and ownership plan. Clustering is a technique based on the concept of source and cost sharing utilizing the abundantly available legacy diesel, battery, and photovoltaics in distributed nanogrids for reliable, expandable, and affordable rural electrification. An individual nanogrid is therefore considered a basic building block, whose modular replication and subsequent DC-link integration yields scalability and stability in the microgrid architecture.

In our study, the hybrid energy clustered microgrid is composed of two nano-grids (600W each) and a separate 1200W backup microgrid as shown in Fig.1, connected via a common 48V DC bus. Decentralized scheme of control is used to reduce the communication cost and ensure reliability by implementing novel algorithms. The two nanogrids feeds twelve houses with the permissible load of 100W each on the basis of local generation local consumption. The backup microgrid comes in action whenever there is an energy deficit among the nanogrids. It can also absorb power from self-sufficient nanogrids to ensure voltage stability.

The backup microgrid in our case is being modeled based on the existing facilities at GeePs. The 48V DC system on site at GeePs consists of 3.5kVA Xtender Power Pro off-grid plug and play control unit, 3.5kVA Studer inverter/charger, 5kW MPPT controllers, BSP-500 SoC processor, Studer RCC-02 for onsite or remote parameter setting/ data logging/ central monitoring, 1200W modular solar emulator with capability of age and degradation modeling, 3200W electronic load as a power generator or load in source/sink mode, 1200W Siliken SLK60P6L photovoltaic array (6 panels on GeePs rooftop), 12kWh lead gel battery bank (8 batteries each 250Ah). The overall backup microgrid can be centrally monitored and controlled using a supervisor PC connected via the XCom-232i data logger and communication interface.

The system stability and reliable operation is to be validated using the combination of backup microgrid and the nanogrids which acts as a power source/sink in case of energy deficit or excess. The battery bank in the backup microgrids is used for running the generators on efficient load factors while feeding the clusters during no sunshine or night. The microgrid in itself is expandable and adoptable to the increased power demand over time due to the familiar method of ladder concept by adding more clusters to the existing grid.

The power flow, efficiency, voltage control, and stability tests will be simulated for the analysis of the microgrid with and without legacies using MATLAB Simulink and the same will be validated using emulators and the system on site at GeePs. Further, the system overall efficiency and cost comparison is to be carried out by comparing the performance parameters of the centralized microgrid and the clustered microgrid. Additionally, several parameters such as battery state of charge, and age estimation of the legacy diesel/ storage will be taken into account for controlling the overall microgrid.

Poster

Fig.1 Backup Microgrid setup at GeePs