TEXAS TECH UNIVERSITY
National Wind Institute™

Dr. Sundari Ramabhotla
Postdoctoral Research Associate and Instructor
National Wind Institute (NWI)
Texas Tech University

Design and Modeling Advanced Control for Microgrids

A microgrid is a combination of Distributed Energy Resources (DERs), Energy Storage, and Controllable Loads. It is connected to the main grid through the Point of Common Coupling (PCC). The main objective of this research is to optimize energy flow within a microgrid with regards to economic dispatch, reliability and availability in both grid connected and islanded modes. A microgrid with Combined Heat and Power (CHP), Natural Gas Generator, Diesel Generator, Solar energy, Wind energy, and Battery Energy storage with power ratings 1.5MW, 1MW, 1MW, 500kW, 500kW and 500kW respectively is considered. A critical load of 2.5MW and non-critical load of 500kW are considered in this research. The critical load is always supplied with power in both modes of operation of the microgrid. In the grid connected mode, the main grid supplies power to the non-critical load.

Reduced Gradient Algorithm method is implemented to find the economic dispatch of a microgrid. The total cost of microgrid in the islanded and grid connected modes is optimized using MATLAB code. The total cost includes the operation and maintenance cost, investment cost, fuel cost, replacement costs, etc. The optimization of generation cost is obtained by minimizing the cost function of the system while meeting the load demand. The minimum total cost of the system is obtained by comparing different scenarios of the energy sources along with the change in the wind profile of the microgrid.

An event oriented analytical method called Fault Trees Analysis (FTA) is implemented for reliability optimization using PTC Windchill Solutions software in a microgrid. The reliability of each component in each energy source of the microgrid is calculated using Fault Tree Analysis. The reliability of critical and non-critical loads is evaluated. The quantitative and qualitative results of Fault Tree Analysis are evaluated in order to interpret the results of fault tree. The sensitivity and uncertainty of the fault tree results for both critical and non-critical loads are deduced by calculating the importance measures such as Risk Achievement Worth, Risk Reduction Worth, Criticality Importance and Fussel-Vesely Importance. Then, from the results, the components that are sensitive and at high risk are deduced. This illustrates that they must be maintained well to increase the reliability.

Then Economic Dispatch using Reduced Gradient Method is implemented for the optimization of energy in the islanded mode of microgrid using MATLAB. The optimization of operation and maintenance cost of microgrid is obtained by minimizing the cost function of the system while meeting the load demand. The Operation & Maintenance cost (O&M) of each energy source is considered in its cost function. The minimum O&M cost of the system is obtained by comparing different scenarios of the energy sources along with the change in the wind and battery profiles in the microgrid.

Lastly, the availability of microgrid is optimized by considering the total cost and Operating and Maintenance cost of microgrid in both islanded and grid connected modes. Then, the availability and generation cost of each energy source is compared and optimized in islanded as well as grid connected mode of microgrid. In the total cost and availability optimization, the optimized availability and minimal cost are obtained in both grid connected and islanded modes of a microgrid by considering the change in the wind profile. While in the O&M cost and availability optimization, the profiles with change in the wind forecast and battery energy storage are considered to obtain the optimized availability and minimal cost in both grid connected and islanded modes of a microgrid.