

The Application of Fuzzy Logic in Smart Distributed Power Systems or Micro-grids with a High Penetration of Renewable Energy

This project proposes to apply the principles of fuzzy logic and intelligent systems in the control and regulation of power flow in highly distributed micro-grids. Maintaining voltage regulation in power systems with unpredictable and intermittent sources of power is a challenge both industrial and academic experts are yet to address. Indeed this is the most pressing problem for today's academic and industrial power engineers. The current electrical grid is at the threshold of a revolution that will forever transform the manner in which electrical power is generated, transmitted, distributed and consumed. Today's grid has served society efficiently and reliably for approximately one century, however, new global challenges demand a more flexible and energy efficient electrical grid that will, however, be harder to control and regulate. The motivation behind this revolution is the need for energy security and the reduction of society's reliance on carbon-based sources of power. As it currently is, power delivery in the grid is

1. highly centralized i.e. bulk power generation is concentrated in a few power stations
2. unidirectional i.e. power flow is from the power station to consumers through National grid owned transmission facilities and distribution feeders controlled by commercial operators
3. Predictable and deterministic i.e. power generation from traditional synchronous machines is well understood can easily be controlled.
4. High voltage alternating current i.e. electrical power is distributed through transformers and transmission lines primarily in the form of high voltage AC.
5. Rigid with no storage i.e. power is generated according to immediate demand with little or no storage ability. This is very wasteful and inefficient.

The changes ahead will make power delivery more

1. distributed i.e. less centralized as other sources of energy like on-shore/off-shore wind farms, photovoltaic arrays, geothermal, solar-thermal etc are integrated into the grid at different power levels and different geographic locations
2. multi-directional i.e. with energy storage, electric vehicles and roof-top solar cells, consumers will also be feeding power back into the grid.
3. Unpredictable and stochastic i.e. wind and solar power are known to be subject to weather conditions and are therefore difficult to control because they are intermittent
4. High Voltage Direct Current i.e. this is necessary for long distance off-shore wind farms where overhead cables on pylons is not feasible over water.
5. Flexible with storage capability i.e. peak demand will be managed more efficiently with power reserves built during peak supply.

Hence, the power grid is moving from predictable demand, predictable supply to unpredictable demand, unpredictable supply. In comes fuzzy logic and intelligent systems. This project will be a data intensive simulation based study that will model micro-grids with a high penetration of stochastic renewable energy. Electrical load demand data together with wind/photovoltaic supply data will be used to optimize how intelligent controllers can make real-time decisions on power flow with the maximization of energy efficiency being the ultimate goal. This project will eventually lead to a PhD project as funding is currently being sort and seems highly probable.