**Research Proposal**

**Title of research: Optimal Power Flow in Future Energy System**

**Keywords: Optimal Power Flow, Future Energy System, Probability Model, Optimization**

For the environmental reason and the diminishing of current fossil fuel suppliers, the future power system (Smart Grid) need integrate much larger percentage of renewable energy resources, such as wind power or solar power, into the current electricity grid [1][2]. Unlike the current thermo based power system, the new energy sources in their nature are highly variability and instability. This makes the traditional deterministic optimal power flow analysis methods hard to direct applying to Smart Grid.

In this research, the probabilistic methods will be used in the Optimal Power Flow analysis for the Smart Grid. For the stochastic problem’s in nature harder than the corresponding deterministic problem, the research will start from the reviewing of the current deterministic OPF approach so far.

The typical OPF problem, such as security constrained minimize generation costs problem, can be expressed as the following form [3]:

Where,

is the generator cost vector;

is bus loading, which contains active load and reactive load ;

is the generator reactive powers;

is the generator active powers;

V and represent bus voltage and angles;

, , and are the transmission lines power flow and current.

This is a kind of non-convex nonlinear programming problems (NLP). In nature it is a NP problem.

The traditional deterministic approach for this problem is firstly transform the problem into some simplified approximation form, for example, the standard simplification for above AC power flow problem is transform it into the Linear DC power flow approximation form[4][5][6][7], which assumes the voltage variances across the network is too small to negligible, the bus angles are small () and transmission line resistance is much smaller than its reactance (). Then the problem can be solved with proper optimization methods such as Successive Linear Programming (SLP) method[8], Successive Quadratic Programming (SQP) method[9][10], Newton-Raphson (NR) Method[11][12], Interior Point(IP) Method[13], or various Stochastic based optimization methods such as, Genetic Algorithm (GA)[12][14], Ant Colony Optimization (ACO)[15]**,** Particle Swarm Optimization (PSO)[16], etc.

The working of above deterministic OPF analysis relies on the current thermo and hydro based power system, where the generator output is controllable, that is, the generators can be adjusted as needed and operated continuously to deliver power to the load. With the worst case (N-1) contingency criteria[2], which means for the N contingencies system, any one contingency’s failure shouldn’t affect system’s proper running, the system scheduling can handle most possible system outages or failures.

But in the future power system, because the highly uncertainty of the renewable energy, the direct applying above worst case criteria will lead to a very large system generator reserve which makes the optimal scheduling impossible. So in this case, the generator powers ( and ) and bus loading () should be treated as the random variables.

On the other hand, in the future Smart Grid system, with the ubiquitous components such as sensors, smart meters and advanced two-way communication system, the system operators can real-time monitor system status in more detail. This make the performing more tight system control criteria based on system probability characteristic possible[1][17][18][19][20]. [2] proposed a risk-limiting dispatch formulation based on loss-of-load probability (LOLP) using the real-time information about generators and loads. [17] did some simulation for risk-limiting OPF with Guassian distribution for a scenario where the wind power is the primary sources.

But so far, compare to the deterministic approach, the studying for the Smart Grid with Stochastic OPF approach is still in its initial stage. For example, in [2]’s risk-limiting proposal, the Stochastic based conceptual framework was discussed, but the problems about implementation proposed scheme leave for future works; in[17]’s simulation, the energy storage was included, but the dynamic characteristic of the storage was not considered. Furthermore, in its simulation, the Guassian distribution was used for simulating wind power and system load, this was difference from standard wind power’s Weibull distribution.

In this research, after the carefully reviewing of the current progress in OPF methods, the ProbaOptimal Power Flow (P\_OPF) scheme for the Smart Grid will studied and proposed. The scheme need consider the proper system components (including generators, storages and user load) probability model and dynamic characteristic. Based on these, the computational approach for the scheme will be studied and developed. Then the application to real case will be studied.

The fundamental goal of this research is to develop a P\_OPF scheme for the Smart Grid close to real system which can be used for system optimization.

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