# Research on Optimal Flow Control of Distributed Network Containing DG Power

Shanlin Cui
Jinzhou Power Supply Branch
State Grid Liaoning Electric Power Supply Co. Ltd
Jinzhou, China
e-mail: chuishanlinjz@163.com

Hui Lv
Jinzhou Power Supply Branch
State Grid Liaoning Electric Power Supply Co. Ltd
Jinzhou, China
e-mail: lvhuijz@163.com

**Abstract—Along with the construction of smart grid in China and the gradual implementation of the electricity market, the traditional mode of centralized power supply has been unable to meet the social demand for electricity, distributed power supply has become a new trend in the future development of the electric power grid. The introduction of distributed power generation technology can not only solve abuses of the centralized power ,for example large investment, long construction period, regulation is not flexible and the scope of the accident, which can effectively solve the world energy crisis and environmental pollution problems. Due to the introduction of distributed generation in distribution network, which will appear a lot of new node types, if using traditional algorithm is often difficult to achieve the desired effect with these nodes, and power flow calculation is the base of a distribution network, other research work .Therefore, distribution network power flow studies with distributed power calculation is very important. Through theoretical derivation and experimental verification, based asynchronous generator power voltage model for wind farm in the determination of static voltage stability analysis of wind power, the simulation model of wind power system voltage to achieve optimal power flow.**

***Keywords-electricity; technology; accident; algorithm; flow (key words)***

## I. INTRODUCTION

In recent years, the modernization of power system planning in developed countries is driven by the smart grid. Smart grid distribution system will integrate smart meter infrastructure (AMI), distribution automation (DA) and Distributed Energy Resources (DER) Function [1].With the development of economy and society, national demand for energy is growing. Wind energy as a clean and renewable energy, is attention by the world. Since 1990, the wind power generation technology obtained the rapid development, the average growth of cumulative installed capacity of the global wind power is more than 20%. According to the World Wind Energy Council, only in 2006, global wind power capacity increased by 25.61% over the previous year, up to 74.223GW; to 2010, global wind power capacity will be doubled again, reaching 149.5GW. Signed in the European Wind Energy Association and Greenpeace "wind 12" report, 2020 global wind power installed capacity will reach 1200GW, wind power generation will account for 12% of the total global power. Therefore, wind power is not inessential supplementary energy, wind power as an emerging industry with commercial development prospect, has become an important force to solve the world's energy problems indispensable [2].

Wind power generation can be divided into the form of off grid and grid connected type. Grid connected wind power generation is the main form of large-scale development of wind power, but also the main trend of wind power development in recent years. Grid connected wind power usually have multiple large capacity wind turbine composed of wind power generator group, called the wind farm (also known as a wind farm, Fengt). So the wind farm with large-scale units (50kw~2MW), centralized installation and control characteristics. There are two main types of the wind power generator: synchronous generator and induction generator. At present, the most is the asynchronous generator. Asynchronous generator because of its low cost, high reliability, without excitation device and a brush, simple structure small size, strong and durable, basically no need repair, it has become the most ideal equipment for wind power and other power generation system. Asynchronous generator as the grid connected power generation equipment scheme can be divided into two categories: the constant speed and constant frequency power generation system and the VSCF wind power generation system [3]. Wind power grid connected converter unit composed of a wind turbine, generator, tower, converter and its control system, power transmission device and other mechanical devices. Among them, the wind turbine converts wind energy into mechanical energy, generator converts mechanical energy into electrical energy, and the converter through the power to transform the energy fed into the grid generator output. With the development of aerodynamics, materials, generator technology, computer and control technology, the development of wind power generation technology is very rapid, single capacity increase, from the initial tens of kilowatts to the development of megawatt scale level set. Large scale wind turbines on system reliability, power quality and the efficiency of utilization of wind energy has put forward higher requirements, converter speed control technology of the corresponding unit and power control technology continue to progress, experienced the development from the constant speed to the speed, the propeller to the pitch process [4].

The requirement of China electric power and the distribution of wind energy resource in the situation do not match. Power demand much in coastal areas, wind farm access convenient. However, the shortage of land can provide the limited land area of wind farm construction. The vast northern region is rich in wind resources and land resources for the construction of wind farms, but the grid impact resistance capacity is relatively weak, and the electricity demand is relatively small, need put power transmit to the power load center . While the powers load centers concentrated in coastal, with offshore wind farm power technology development mature and economic feasibility improvement, development prospects will be bright.

Compared with the conventional power plant, the wind farm has two obvious characteristics in the process of operation:

First, wind generator is adopted as asynchronous generator, idle work need absorb from the system which established field required. Therefore large grid connected wind farm will be on the local power grid voltage level of influence;

Second, wind speed is random variation, so the power output of wind farm is random, thereby which affects quality of the local power grid power. Wind electric field is sparsely populated, its position is at the end of the power supply network, bearing impact ability is weak, the voltage fluctuation, harmonic pollution problem and voltage flicker to distribution network. At the same time, due to their stochastic formulation for power generation and operation plan has brought many difficulties [5].

Wind power has brought the adverse effect to the grid: wind tune fluctuation, sending power extremely unstable, the tune network impact; wind power generate active uncontrollable, in order to guarantee the stability of the system, we must increase other types of units the same volume flow heat reserve capacity of many, the impact on the existing scheduling; wind farm is not able to emit no work, need absorbing no work from the system, impact on system voltage; wind power quality have harmonics, flicker and voltage instability problems.

## II. THE PROBLEM OF OPTIMAL POWER FLOW

The so-called optimal power flow is in the given structure parameters of the system and load, by optimizing the control variables, find can satisfy all given constraints and one or more performance index of the system can achieve the optimal flow distribution [6]. Because the upper power system state variables and related function has a certain distance, control variables can also be in the certain range adjusted, so for a certain load conditions, theoretically flow solution exist at the same time a large number and can meet the requirements of the power. Corresponding to each load flow solutions here in the system have a specific mode of operation, with performance indicators corresponding economic or technical (such as the total fuel cost, total system have (no) power loss etc.) [7]. In order to optimize the system operation, it is necessary and feasible solutions from the trend of all picked out the performance index is a best solution; this is the optimal power flow problem to be solved. The trend is to obtain steady-state power system voltage at the fundamental frequency of the process. An efficient algorithm is required for all scenarios trend has fast convergence rate, the lowest use of memory (computationally efficient) and numerical stability calculation. Gauss - Seidel method, Newton - Raphson transmission network trend research methods and its decoupling algorithm has been developed very well.

Distribution power flow calculation is the basis of the analysis of the distribution network, network reconfiguration of distribution network, fault treatment; non reactive power optimization and state estimation are needed for distribution network power flow data. Because the distribution network structure characteristics are open loop operation of distribution network, radiate, resistance and reactance of distribution lines is relatively large, using the conventional method for power flow calculation can cause the algorithm does not converge, the backward sweep method is linear convergence, solves the difficult problem of flow convergence. In recent years, the development of distribution management system (DMS) has become the focus of research. Power flow calculation is one of the advanced application software DMS, more is the basis of research and analysis.

## III. THE SIGNIFICANCE OF OPTIMAL POWER FLOW

In the modern power system, it has a lot of relating to the safety and economic operation optimization problems which can be attributed to the solution of optimal power flow. The power flow transmission capacity constraint is an important constraint of optimization problems, and in some cases may even become the bottleneck constraints of safety and economic operation of the system. Therefore, the study of wind power optimization method for power flow control problem is a better direction [8].

Based on optimal control trend of wind power mainly has two kinds of patterns：

### *A. Two mode*

The first mode is custom-built power transmission, in this control mode it can be divided into two categories: in the injection mode of determination system, it uses optimization method that solves control parameter of the wind; in the injection mode of variable conditions, solving the optimal operation state and wind power control parameters.

The Second mode is Global optimization control model based on wind energy, Analysis equations of optimal power flow with wind power.

Optimal power flow problem with wind power control can be unified with the following formula as (1):

$$\min f(x,u) \qquad\qquad (1)$$

$$\begin{cases} g(x,u) \\ h^{\min} \le h(x,u) \le h^{\max} \end{cases}$$

In the formula, $f()$ is the objective function of optimization system, in the optimization of power system analysis which can be the generation cost, congestion cost and network loss; $g()$ is equality constrained optimization problems, in this paper, $g()$ represents the power flow equations; $h()$ represents inequality constrained function optimization problems involved in, such as the node voltage level constraints, transmission power constraint. And $h^{\max}$ and $h^{\min}$ is the upper and lower bounds for the inequality constraints. As $x$ is the system state variables, $u$ is control variables of the system.

Through the front analysis, when the power model is equivalent to the wind power injection, optimized equation of power system containing wind power control function (including equality constraint equation, inequality constraint equations and the objective function equation) can be expressed into two parts, one part with not considering wind power the system optimization equation form is the same; another part is expression of additional power of the wind power . Using the formula as (2).

$$\begin{cases} f(x,u) = f_1(x,u_1) + f_2(\square S) \\ g(x,u) = g_1(x,u_1) + g_2(\square S) \\ (x,u) = h_1(x,u_1) + h_2(\square S) \end{cases} \tag{2}$$

Among them, $u_1$ is not considering wind power when the original optimal control variables in the, $f_1()$, $g_1()$ and $h_1()$ is not considered when the wind power optimization objective function and constraint equations in question; $f_2()$, $g_2()$ and $h_2()$ is FACTS, additional power expression.

### *B. The oscillation problem caused by power flow constraints*

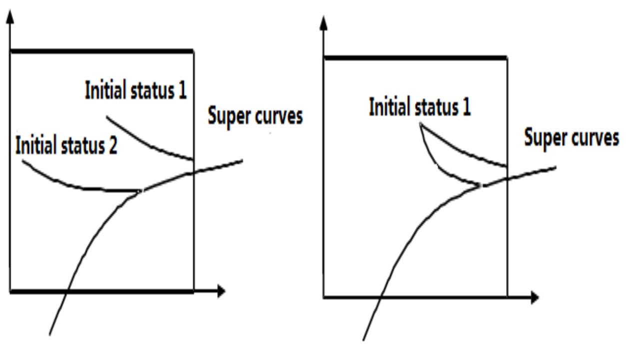


Figure. 1 Effect of initial and Power flow Constraint multipliers condition on the convergence properties

Let us suppose that the variable of all inequality constraint equation is limited in a bounded region, constraint equations of all tide equality form a super curve in the variable space intersection, two pose feasible solution vectors, such as rectangle in Fig. 1, shown in Fig.1. When the initial starting point is in the near field region boundaries (initial state 1), algorithm will make it mobile to optimal solution of unrestricted situation, may encounter a bounded region boundary. However, the current solution may not satisfy the constraints, not in the super curve. If that is the case, in order to make the final solution on power flow solution curve, algorithm will tend to the oscillations near the boundary. If we start from a bounded region boundary that is far away from the initial point (initial state 2), the algorithm will realize power flow constraints, and in the bounded region a solution curve and flow confluence, and after finite iterations reach the optimal solution [9].

### *C. Optimal power flow simulation and steady-state voltage characteristic of wind power system*

The continuous power flow simulation of wind farm and wind power system in addition to considering the voltage characteristics of wind farm, but also to consider the specificity of wind power growth. Installed in the same wind conditions, wind power generation growth depends on wind resources, idle work of wind power farm corresponding changes. The wind farm has a active, absorption characteristics which send active power and absorb idle work, therefore it has the important meaning of continuation power flow simulation of wind field and the access point voltage change on the study of wind power system and its stability analysis.

Here the basic principle based on optimal power flow and combining the advantages of conventional calculation, static power voltage characteristics into the wind, thus completing the flow simulation of wind power system and wind farm and static calculate voltage stability limit of wind farm.

## IV. CONCLUSION

Based on grid connected wind power generation system, with genetic algorithm it research the planning and design of wind farms, according to the characteristics of the wind farm power cost and wind resources, unit arrangement, set parameters and other factors, the reasonable location to determine equipment models, as far as possible to reduce the cost of power generation, improve the competitiveness of wind power. Considering power voltage characteristic and power growth law of wind asynchronous generator, calculating methods for determining the wind electric power system and the basic principle of continuous power flow calculation combined with conventional power flow [10]. Study on wind power planning of power system based on various security risks, in the planning and the possible factors of uncertainty, improve the existing power grid planning convergence speed, better coordination of the power grid planning and planning of power, congestion management and transmission pricing of power network planning effect. Through theoretical derivation and experimental verification, based asynchronous generator power voltage model for wind farm in the determination of static voltage stability analysis of wind power, the simulation model of wind power system voltage to achieve optimal power flow.

## ACKNOWLEDGMENT

The authors gratefully acknowledge the contribution of co-workers and reviewers' comments.

## REFERENCES

[1] R. Brown, "Impact of Smart Grid on Distribution System Design," IEEE .Pow. Ene. Soc.Gen. Meeting, 2008, pp.1-4

[2] H.Y.Chen,J.F.Chen,and X.Z.Duan, "power flow calculation of distribution networks with distributed generation,"Auto.Elec.Pow.Sys, vol. 1,pp.20-25, May 2006

[3] H.B.Wu and,L.Cai.,"Improved optimal power flow of Tabu search of distribution network with distributed generation," Pow.Sys.Prot.Con , vol. 9,pp.2-5, July 2002

[4] Y.Sun,N.S.Hang,and R.Q.Li, "Optimal power flow model by considering the frequency quality constraints," Chin.Jour.Elec.Engi, vol.22,pp.34-39, April 2010

[5] X.Lin and J.W.Gu, "Calculation of wheeling cost with optimal power flow," Pow.Sys.Auto, vol.22,pp.128-135, June 2007

[6] S.M.Zhong, X.H.Han, D.W.Liu,and M.X.,Wang, "The Benders Decomposition Algorithm of security constrained optimal power flow meter and control," Proceedings of the CSEE Chinese,vol.1,pp.12-15, May 2011

[7] H.B.Wu and L.Cai, "OPF distributed power distribution network including improved Tabu Search Algorithm," Pow.Sys.Pro.Con, vol.40,pp.6-10, May 2012

[8] R. Brown, "Impact of Smart Grid on Distribution System Design," IEEE Power and Energy Society General Meeting, 2008, pp.1-4

[9] Z.Q.Wang, S.Z.Zhu, S.G.Zhou, Y.L.Huang, and L.G.Wang, "Distributed generation on voltage distribution of distribution network," Auto.Elec.Pow.Sys, vol. 6, pp.4-8, April 2004

[10] S. Herraiz, L.Sainz and J.Clua, "Review of Harmonic Load Flow Formulations," IEEE .Trans. Pow. Del, vol.3, pp.1079-1087 April 2003