ABSTRACT
Along with durative development of Shanghai and shortage of electric power, distributed generation (DG) is used to eliminate the contradiction between peak and valley. It has a great impact on node voltage, power quality, system protection, supplying reliability and short circuit of distribution network, while the degree of impact is closely related with the location and capability of DG. It is also an essential challenge to traditional distribution network planning, as planners should consider more when selecting the best project.

INTRODUCTION
Along with the flourish of Chinese economy, distributed power (DG) is used more and more widely, and it can be combined with existing power system to form a flexible and efficient system. DG, which is also known as distributed or embedded power supply, is the power supply connected directly to the power distribution system, such as small-scale wind power, solar power generation, fuel cells, and so on. The emergence of DG brings its effects on many aspects of current power system, such as power generation system, that is the electrical impact on macroeconomic planning; transmission grid and distribution system, that is the impacts on operation and planning; on power quality, that is the effects on quality and power users; and sales of electricity, that is the influence on electricity market and economic power. In addition, it allows DG to compete with existing power generation companies equally under market conditions, Therefore, it is quite important to plan in advance taking all issues above into consideration. Many scholars have made their efforts, such as in Ref. [1], who researched on DG planning on the basis of uncertain factors of market.

Shanghai Municipal Electric Power Company is concerned about the application of DG in Shanghai, in particular the effect on downtown distribution network, such as operation and planning so as to accept and eliminate those impacts, There is no pure power in traditional distribution system, it receives power from upper grade network through substations. Connecting DG makes distribution system full of load and power supply, which provides a sharp contrast for the traditional system.

THE APPLICATION OF DG IN SHANGHAI
DG refers to the small-scale, distributed, efficient, and reliable power generation technology located around users with the power of a few kilowatt to 50MW. The power generation facilities mainly included: internal combustion engines with liquid or gaseous fuels, microturbines, photovoltaic batteries, fuel cells, wind turbines, biomass generators. DG has become one of the important energy suppliers in the new century.

At present, DG technology develops rapidly on a global scale, solar photovoltaic and wind power technology have progressed to mature. Current data shows that total output of solar cells grows at the rate of 30% to 40% each year, total installed capacity of wind power is growing at the average rate of more than 30% per year. Germany, the United States, Netherland and other countries have put forward the project of "photovoltaic roof". Besides this, Germany, Denmark, and other countries are also planning a large-scale wind field project on the sea. The worldwide forecast about future electricity market shows that after next 10 years, the capacity of DG all over the world will be expected to meet 20GW per year. By 2010, the new distributed power will account for 20% of the total capacity of new power (see in [2]). In some developed countries, new energy power generation may account for 30% to 50% of their electricity market by 2050.

Shanghai is an international metropolis which is developing fast and a lack of primary energy, by the year 2007 the city has the largest electricity load of 8362MW. With the reconstructing of Shanghai's industry, with the improvement and adjustment of urban functions, in addition to continuous production, a stable heat (cold), some of the industrial enterprises of electricity load, the buildings which have high requirement on the indoor comfort such as: a high standard of hospital, Star-level hotels, City University, shopping malls, office buildings, integrated group, leisure and entertainment centers appear a new wave of construction, the buildings have a growing demand for electricity, heat, cold, which create a broad market prospect for the development of DG energy systems. At the same time, a large-scale construction planning and construction of the 2010 Shanghai World Expo require the use of clean and efficient, environment-friendly green energy technologies, DG power supply system using the natural gas or renewable energy is bound to be widely used.

There are two kinds of common technologies of DG in Shanghai:
(1) Gas Distributed Energy. This technology can effectively reduce the load demand to the grid when peak time and ease the difference between peak and valley of the regions power grid. When the heat absorption refrigeration technology was used in system, it can further
reduce the peak power load of cooling. According to the statistics of the Shanghai Electric Power Company, air-conditioning electricity consumption in Shanghai accounts for more than 40% of the peak electricity consumption in summer. In order to alleviate the pressure on power supply, Shanghai prepare to increase 600 new gas-fired air-conditioning units in the next 3 years, it is expected to ease more than 200,000 kW load; at the same time construct ten DG energy supply system which can generate electricity, refrigerate, heat by gas. In order to encourage the use of gas-fired air-conditioning, Shanghai government introduced a subsidy program: from 2004 to 2007, the gas-fired air-conditioning and stand-alone 10,000 kW and below Distributed Energy Systems Project which is took into the air-conditioning and distributed energy supply system promoting plans in Shanghai, give subsidies by installed capacity of 700 Yuan / kW, gas-fired air-conditioning give subsidies by cooling capacity subsidies of 100 Yuan / kW. 

(2) Distributed cogeneration cooling heating. We encourage that distributed cogeneration cooling heating should be developed as a measure of rational energy utilization, energy saving, regulating supply and demand status of power, gas, oil products, and peak-valley contradiction, and the development regulation should contain large, middle and small scales. In the point of view of thermoelectric engineering development status, distributed cogeneration cooling heating could be a supplement of large, middle thermoelectric engineering, especially to some special occasions, such as banks, hospitals and other users which require high power supply safety and stability, as well as users which require diversification of energy demand.

**INFLUENCE OF DG ON DISTRIBUTION NETWORK OPERATION**

**Influence on loss**

By accessing DG nearby loads in distribution network, the power flow direction of the whole distribution network will change. There are 3 conditions according to the relationship between nodal load and DG’s contribute value (see in [3]):

1. The load of every node in the system is bigger than or equal to the output value of DG of this node;
2. At least one node’s DG output value is bigger than the load of this node, but the whole system’s DG output value is smaller than the system’s total loads;
3. At least one node’s DG output value is bigger than the load of this node, but the whole system’s DG output value is bigger than the system’s total loads.

As for condition (1), DG will have effect on reducing loss of the distribution network. As for condition (2), DG will probably increase the loss of some lines in the distribution network, but generally speaking, the whole system’s loss will reduce. As for condition (3), if DG’s total output value is twice smaller than the total load, the result is similar to condition (2), otherwise, the whole distribution network system’s loss will more than that without DG. Therefore, the application of DG may increase or reduce the system’s loss, which is up to the location of DG, the relative size of DG and loads, and network’s topology, etc..

**Influence on voltage**

(1) Influence on the voltage distribution of steady state (see in [4]). Traditional distribution network shows radial voltage declines along the feeders’ power flow direction under stable operation. After accessing DG, as the reducing of feeders’ transmission power and DG’s output reactive support, the voltages along load nodes of feeders somewhat increase. The amount of voltage increasing is relative to the location of DG and the size of total capacity.

(2) Influence on voltage fluctuation (see in [5]). In traditional distribution network, active and reactive loads changing with time will cause system voltage fluctuation. Along the direction to line end, voltage fluctuation is bigger and bigger. If loads concentrate around the end of the system, the voltage will fluctuate acutely; this should be avoided as possible as we can. After accessing to the distribution network, DG will influence distribution network, makes it increase or reduce by two means: (a) DG operates harmoniously with local loads, that is, its output value increases (reduces) when the load increases (reduces), under this situation DG would restrain voltage fluctuation; (b) DG doesn’t operate harmoniously with local loads, such as DG generated by natural resource, which is hard to control for the output is heavily influenced by the property of natural resource(such as wind speed, sunlight radiation intensity), can hardly operate harmoniously with local loads and may increase system voltage fluctuation.

**Influence on electrical energy quality**

Gained access to the distribution network, Distributed Generation will bring various disturbances to distribution network which is mainly manifested in the following two parts (see in [6]):

1. Voltage flicker. DG could cause the voltage flicker directly or indirectly on the condition as following: (a) large DG system start up; (b) DG output changes suddenly or takes place in a larger change; (c) The interaction between DG and voltage control devices of feedback link.

2. Harmonic. DG could cause the Harmonic on the condition as following: (a) Distributed Generation itself is a Harmonic source; (b) DG gained access to the distribution network by the inverter based on the power electronic technology.

**Influence on system protection**

Since the traditional radial distribution network Power Flow is unidirectional flow from power to users and in consideration of 80% of distribution fault is instantaneous (see in [7]), the traditional distribution network protection design is used to installing reverse over current relay in the substation, furnishing auto-reclose equipment on the main feeder and fixing fuse on the branches. Based on the principle of disconnecting fault branch only and reclosing for the transient fault traditional distribution system protection brings the auto-reclose equipment and fuses of each side branches into line and each fuse is coordinated with the fuses of the upper branch and lower branches.
With the DG introduced, the distribution network becomes a multi-power system, which request the protection has direction. However, the fuse and traditional auto-reclose equipment has no directions. And if we use directivity sensitive elements such as relay to take instead of all the fuses of distribution network and auto-reclose equipments but which is financially unfeasible.

**Influence on reliability**
If the distributed generation is only used as the standby power supply, it can improve power supply system reliability; but if there is parallel operation between DG and power network, the reliability of power supply system is possible to be weakened. For instance: there are a great deal of DG in the system, if DG is failed to coordinate with each other DG will decreases system reliability. In addition to that, when there are disturbances appearing ,due to the high un certainty of DG (such as the photovoltaic cells influenced by the intensity of solar radiation), the system reliability is also probably decreased. At present, once there disturbances arise in actual system; it’s used to cut off all the DG to renew the system to the original structure, however, which is not the best way.

Ref. [8] is on the study of optimal load shedding when there big disturbances happened in distribution network with DG system and on the state of emergency. Ref. [9] brought forward a DG solitary island operation strategy. Which could improve system reliability? The integrated use of the two ways, when big disturbances happened in distribution network, which could cut off a part of load connected with DG unit to ensure the stability of the system and also ensure the relevant DG unit could still supply power to the load cut off. Then the reliability of the system would be improved much and the users would enjoy continuous power supply.

**Influence on fault current**
The accesses of distributed generation have enhanced the fault current level. DG’s influence on fault current depends on many factors, such as DG’s technical type, operation mode capacity, permeability and the system interface ways.

**THE IMPACT OF DG ON THE DISTRIBUTION NETWORK PLANNING**
The appearance of Distributed power generation technology has made an enormous impact on the run of distribution network, brought a substantial challenge to the traditional distribution network planning as well, making power planners must take into account the impact of the distributed power generation in the selection of the best programs. The general power of distributed is always directly connected to the power distribution system, so that when a large number of Internet, it will seriously affect the design, control and operation of the distribution system, then affect the reliability and security of the system. This requires that the methods of traditional distribution network planning to make appropriate changes. The impact of DG on the distribution network planning (see in [10]) includes the following areas.

First of all, the appearance of DG will make the load forecasting, planning and operation of the power system have greater uncertainty than that in the past. Due to the large number of users will install the electricity provided by DG, making distribution network planners have more difficulties to accurately forecast load-growth that in turn affects the follow-up accuracy of the distribution network planning. In addition, DG can reduce energy loss and can delay or reduce the investment of power network upgrade, but if the location and capacity of DG is inappropriate, it could lead the loss of power to increase, and lead the voltage of some nodes in the network to drop or Over-voltage, also change the size, duration and direction of the fault current. Therefore, in order to obtain a correct decision-making, must make an accurate assessment on the impact of DG on the distribution network, that is, the optimization tools must be able to accurately assess the impact of DG on the grid, give the best location and capacity of DG, making the gradual penetration of DG in grid will not undermine the security and economy of the grid-operation.

Secondly, the traditional distribution network planning is generally considers the length of 5 to 20 years, in its life, usually assumed the load of power grid growing year after year, new low-voltage and mid- voltage nodes emerge constantly, in a result one or more of the substation will be added. Due to the dynamic properties of programming-problems associates with its dimensions (usually taking thousands of nodes), if a number of generators nodes appear, will make it more difficulty that finding the optimal network layout program (That’s the programs making the construction costs, maintenance costs and power loss minimum) in all possible structure of the networks.

Finally, for the users or the independent power producers who would like to install the DG in distribution system would conflicts with the power grid company (the power companies, power companies) who want to maintain the existing security and power quality level of the system. This is because after a large number of DG access distribution system, It will have a profound impact on the structure of the distribution system, making the distribution system gradually reduce dependence on the large distribution network of power plants and transmission, the original one-way power feed characteristics of the tide have been changes, a series of comprehensive distribution network problems arising from the distributed generation technologies, including voltage regulation, reactive power balance and Protection of the complex will have an impact on the operating system. In order to ensure the security of power grids, high-quality operation, the DG must be able to accept the dispatch. To achieve this goal, we must acquire the necessary power electronics equipment, the necessary control and regulation, DG units will be integrated into the existing distribution system. This will not only need
to transform the existing distribution automation systems, but also changes in thinking from passive to active management of the power grid.

In addition, because of the type of DG units and the use of primary energy diversification, how to determine a reasonable distribution network in the power structure, and how to coordinate effective use of various types of power has become an urgent need to be addressed. DG’s widely used, making the national energy policy directly to the infiltration of DG and the power system planning, thus affecting the planning of the decision-making process.

CONCLUSIONS

With the characteristics of saving investment, reducing loss, improving system reliability and diversifying energy varieties, DG represents the development directions of industry in the 21st century. Along with sustained economic development and further tension of electricity use, DG using natural gas or renewable energy will alleviate the great difference between peak and valley in Shanghai. Aspects of distribution system such as nodes voltage, trend line, short-circuit current, and so on will be affected because of the allocation of DG, while the degree of impact is closely related with the location and capacity of DG. All these issues can be a big challenge for traditional distribution network planning as people should consider more about DG when choosing the best planning project.

REFERENCES


BIOGRAPHIES

Saifyi WANG was born in Ningbo, Zhejiang Province of P.R. China, on January 30, 1978. He received his Ph.D. in electrical engineering in Tianjin University. His research interests include power network planning and he is now working in Urban Power Supply Company, SMEPC, SGCC.