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MANAGING OF POWER SYSTEMS INCLUDING RENEWABLES

Abstract: Connection of distributed generation (DG) on power system, especially intermittent renewable energy sources (RES) like wind and photovoltaic panels, may represent a major problem for the system. Considering their small size and their potential great number, these sources are not always dispatchable. Detail analysis of impact of DG, especially on power quality is needed before connection of DG. The greatest challenge is integration and managing RES in smart grids. While integration of DG in power systems requires solution of specific issues and detail analysis of local power system, most of European countries have their own technical criteria for connection of DG.

Key words: *Distributed generation, Renewable Energy Sources, Smart grid*

Sažetak: Priključivanje distribuirane proizvodnje (DG) na elektroenergetski sistem, naročito intermitentnih obnovljivih izvora (RES) kao što su vjetrogeneratori i fotonaponski paneli, može predstavljati značajan problem za sistem. Imajući u vidu njihovu malu snagu i potencijalno veliki broj ovi izvori nijesu uvijek dispečibilni. Prije priključenja DG potrebna je detaljna analiza uticaja DG na sistem, posebno u pogledu kvaliteta električne energije. Najveći izazov je integracija i upravljanje RES u konceptu tzv. pametnih mreža. Dok integracija DG u sisteme snage zahtijeva rješenje specifičnih problema i detaljnu analizu lokalnih mreža, većina evropskih zemalja ima sopstvene tehničke kriterijume za DG priključak.

INTRODUCTION

Technological, environmental and economic factors are encouraging the development and installation of distributed generation (DG) in established power systems. The range of DG technologies includes renewable energy sources (RES), storage devices and the smallest generation devices, connected to low voltage (LV) networks. Energy from RES [1] (wind, solar, aero-thermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases) also have an important part to play in the security of energy supply,

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technological development and innovation and providing opportunities for employment and regional development, especially in rural and isolated areas.

DG poses a number of new challenges for distribution network operators (DNOs). DNOs will need to perform new types of analysis to plan and design their network, and implement appropriate commercial arrangements to ensure a reliable and high-quality electricity supply is maintained.

However, in certain circumstances it is not possible fully to ensure transmission and distribution of electricity produced from DG without affecting the reliability or safety of the grid system. Along with the connection of distributed generation (DG) on power distribution network, the network becomes active instead of conventional passive distribution network thus requiring solution of technical, economical and regulatory issues from all participants in energy sector. Detail analysis of impact of DG, especially on power quality is basic determination for network operators and is needed before connection of DG. In order to reduce negative impacts of DG on power system, technical criteria and standards for connection are prescribed. While integration of DG in power systems requires solution of specific issues and detail analysis of local power system, most of European countries have their own technical criteria for connection of DG.

Perhaps the greatest challenge in realizing a sustainable future is to develop technology for integration and control of RES in smart grid distributed generation. The smart power grid distributed energy system would provide the platform for the use of RES and adequate emergency power for major metropolitan load centers and would safeguard in preventing the complete blackout of the interconnected power systems due to man-made events and environmental calamity and would provide the ability to break up the interconnected power systems into the cluster smaller regions.

FAVORABLE FACTORS AND BARIERS FOR DG CONCEPT

The development of DG concept is motivated by a number of important factors [2] including:

– Capability to achieve higher efficiency in conversion from primary energy sources by means of the diffusion of cogeneration of heat and power (CHP) and to reduce joule losses;

– Low environmental impact and capability to capture RES;

– No additional transmission costs and savings in distribution costs (although this depends on DG location);

– New DG technologies are intrinsically modular and a low scale factor to for both investment and running costs is expected in the future;

– Improvement in reliability and quality of power supply from the customer side;

– Adoption of targets by international organizations/national governs and provision of subsidies, especially to support development and deployment of RES and CHP based generation systems;

– The creation of open and competitive electricity markets (even though DG participation is still a problem that has yet to be resolved).

To-day three key barriers which are in some way constraining the development of the DG concept are:

– High technology cost;

– Existing distribution networks are not designed or configured to support DG integration. Therefore criteria and rules for the operation of distribution systems have to be modified;

– Contribution of DG to system security and the capability to provide ancillary services are currently not fully recognized.

The definite success of DG is related with the development of so called Smart Networks, i. e. active distribution grids with widespread integration of small size generators and of distributed intelligence, able to support end users interactivity with market and grid operators. Figure 1 depicts [3] the direct current (DC) architecture and alternating current (AC) architecture of green and renewable power grid DG systems consisting of wind turbine, solar arrays, fuel cell (FC) plant, high-speed micro-turbine generator (MTG), and storage systems. The FC and solar power outputs are low-voltage DC that are steps up to a higher-level DC power for processing using DC/DC converters. However, the output power of wind turbines is variable-frequency AC power, and the output power of MTG is high frequency AC power. For these two sources, the AC/DC or AC/AC converters are used.

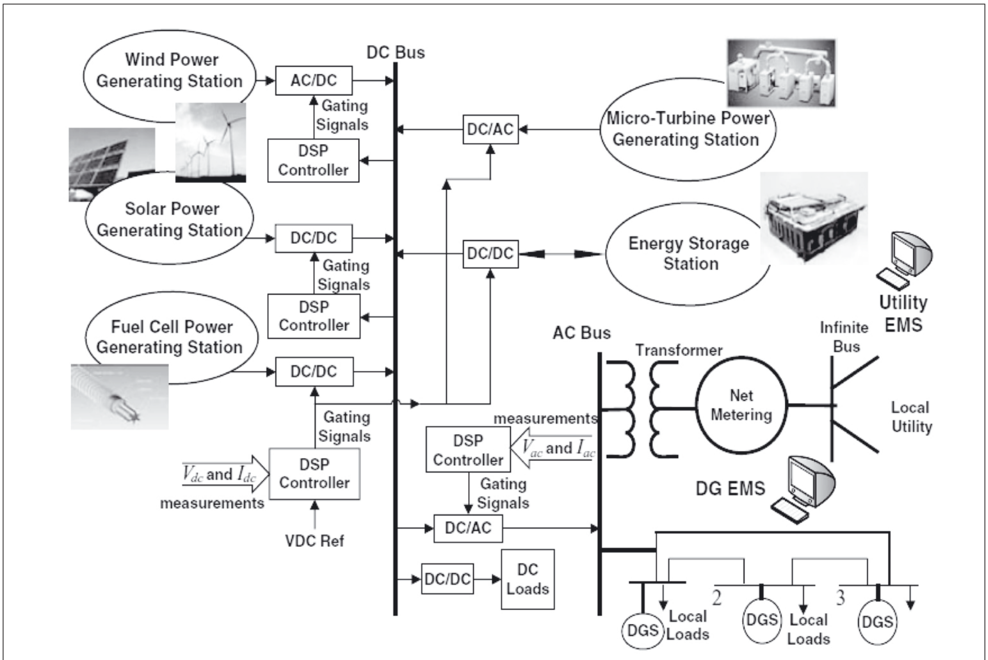

Figure 1. The DC architecture of green and renewable power grid DG systems.

PROBLEMS IDENTIFICATION

The main problems that should be considered with the connection of DG units on distribution networks are [3]: (1) steady state and short-circuit constraints, (2) power quality issues, (3) reactive power and voltage control, (4) stability and capability of DG to withstand disturbances,(5) protection aspects and (6) islanding operation. It follows the short comments of all above listed problems.

(1) The power delivered by a DG unit may lead to an increase in the current flowing on the distribution grid, depending on where it is connected and the size of the installation. Moreover, in faulted situations, the DG plant contributes to the fault currents on the network what is depending on the "coupling system" used (e. g. machine directly connected to the grid, or coupled through power electronics converters).

(2) Depending on the primary energy source and on technology used for the conversion process, the connection of DG units to the grid may reduce the quality of the supply on the network. The level of power quality degradation depends largely on the short-circuit power available at the connection point of the DG unit. Therefore the grid weakness may be one of the limiting factors which determines the number and size of DG units that can be connected. The impact also depends on the technology used for the coupling with the grid. For instance, use of an electronic interface may help to limit or even to avoid voltage fluctuations or flicker, but it may carry a risk in terms of harmonic pollution.

(3) The connection of a DG unit changes the voltage profile on the grid due to the change in the active and reactive power flows. Generally, the voltage increases at the connection point and on the feeder. The control of the voltage or the reactive power is therefore an important issue for the Distribution Network Operator (DNO). The larger capacity of DG unit requires the greater potential and more complex device to contribute to the voltage control.

(4) Stability of DG units and their capability to withstand disturbances become a more and more important issue. Following the occurrence of disturbances on the network (short-circuits, important line outages, voltages dips, loss of generation plants, or important load variations), the loss of DG plants results in a loss of generation and of support to the network. Depending on the amount of lost DG generation, the situation on the grid may worsen and in some case lead to very severe stability problems. The stability problems influenced that in distribution grid connection criteria are already specified the capability of DG to operate under specific voltage and frequency ranges that can occur in degraded conditions.

(5) The connection of DG units may affect the sensitivity and selectivity of the protection system as a hole. For instance, some faults may be undetected by the protection normally dedicated to their detection or their clearing may require the tripping of much larger parts of the network than necessary. Generally, detailed case studies have to be done to determine whether the protection system will still operate properly after the connection of DG.

(6) Unwanted islanding is not desirable because this may cause large voltage and frequency variations on the islanding grid and the supply of power to the customers under abnormal conditions until either the system collapses (or DG units are disconnected), or the balance between generation and consumption is obtained. There is also a possibility that an islanded situation will not be detected, in which case there may a risk for the safety of people and equipment.

In order to reduce negative impacts of DG on power system, technical criteria and standards for connection are prescribed in many developed countries. Whereas regulatory aspects can differ greatly between countries, in general interconnection requirements are similar, usually the result of collaborative efforts in the development of internationally accepted standard.

A LOOK INTO THE FUTURE

One of the potential key benefits of DG/RES, being connected at MV and LV networks, is increase in service quality, reliability and security. A radical shift from traditional central control philosophy to a more distributed control paradigm is provided by Microgrids. These systems can be operated in non-autonomous way, if interconnected to the grid, or in an autonomous way, if disconnected from the main grid. The operation of Microgrids requires significant efforts in research, development and deployment of new technologies and required information and communication infrastructure, but is likely to deliver significant benefits over the traditional control policy in the long term.

The future activities shall be addressed to further use of distributed intelligent technology to develop advanced management and control systems of active distribution networks integrating DG in Microgrids. Main topics are: management and remote control of power sources, storage and demand, control of power flows and voltage profiles, network reconfiguration and intentional islanding operation, power quality control, extended use of ICT, sensors and actuators.

CONCLUSION

While there have been major developments in DG/RES generation and significant penetration in power systems over the past couple of decades (especially the installed wind farm capacity in Germany, Denmark and in the other countries), the industry is not yet mature. Pushed forward by energy policy changes which favor RES, new technologies are only now being adopted, with many new planed DG/RES projects worldwide, employing power electronics, ICT and other actual and future technical achievements.

In addition to above-mentioned, very important developing steps that follow are: (1) harmonization of standards supporting the certification of the different Microgrid equipment for successful managing various DG/RES connection problems and (2) identification of evolution requirements in regulatory aspects (e. g. possibility to dispatch local energy, DNO control on DG and loads, market constraints, etc.).

LITERATURE

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