Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages

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ABSTRACT

The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power supply reliability and quality. In addition, liberalization of the grids leads to new management structures, in which trading of energy and power is becoming increasingly important.

The interconnection of DG inevitably changes the characteristics of the system to which it is being connected, due to the fact that distribution systems were traditionally designed with the assumption of a passive network. The consequence of the integration of DG is that this assumption is no longer valid. There are a number of technical challenges that needs to be addressed. The main objective of this Task is to study how to achieve a better integration of flexible demand (Demand Response, Demand Side Management) with Distributed Generation, energy storages and Smart Grids.

INTRODUCTION

All around the world, there is increasing use of renewable energy sources and distributed generation (DG) for more efficient use of energy. the role of electricity as an energy carrier is increasing at all and the construction of new transmission networks and large power plants is becoming more and more difficult.

Energy policies are encouraging energy efficiency, distributed generation (DG) and renewable energy resources (RES), increasing production from DG and especially variable output types of DG like wind power, solar, small hydro and so on. wind and DG will likely play increasingly important roles in the coming decades. But really we can refer that integration of distributed generation (DG) and wind energy in the world is still in its initial steps. The production from wind and photovoltaic units is governed by the availability of the primary energy source. There is therefore often no correlation between the production and the local consumption. These technologies have important role in the modern power system structure. In the other hand Natural Resources have the important role in removing barriers in network.

The majority of today's electricity generation and distribution systems waste over 60 percent of their energy in the form of heat before delivering any useful energy to the end user. One promising means of reducing these losses is through the distributed generation of electricity closer to the end user. This has led to a huge increase in demand for solutions such as micro-generation in homes and in industry to be linked with heating and cooling (micro combined heat and power [micro CHP] units) thus increasing total useful energy efficiency levels up to 85 percent .

These technologies have the potential to provide part of the energy needs for urban, rural, as well as remote communities. The installation of these resources has been integrated in distribution networks as well as transmission networks, and helps to supply the energy needs of rural and remote communities, where it offers some interesting advantages.

The main objective of this Task is to study how to achieve a better integration of flexible demand (Demand Response, Demand Side Management) with Distributed Generation, energy storages and Smart Grids. This would lead to an increase of the value of Demand Response, Demand Side Management and Distributed Generation and a decrease of problems caused by distributed generation (mainly based on renewable energy sources) in the physical electricity systems and at the electricity market.

CHALLENGES

There exist a number of obstacles which limits the growth of DGs, and may result in either delays or can even be sufficient to stop potential developers at all. As the interconnection of DG involves a number of specialized fields and problems, the complexity of the problem and the various barriers for this fact. Locally generated renewable sources such as wind, solar and micro CHP are creating new and challenging issues. While in the past the energy flow was unidirectional from the central source to the distributed consumer, now the two-way power flow of distributed generation must be managed.

Distribution Network Operators (DNOs)now face the challenge of providing networks and services that can deal with this new paradigm issues that were traditionally managed at the transmission level .Distribution networks are thus moving from traditionally passive networks (i.e., those that were planned for particular peak loads and for use as fit and forget networks) to more active or dynamically adapting networks in order to manage the increasing demands placed on them. Many small generator units could be run as one large power source, called a virtual power plant (VPP). The connection of smart “white goods” in the home (e.g., refrigerators or freezers) could be managed by the DNO to provide active and reactive load control in the local network, taking smart metering to a new level of sophistication.

Energy storage solutions that smooth the capacity

constraint issues could be part of what is now seen as an Intelligent or smart grid future, which is based on active network management (ANM) and the associated intelligent automation system. Such an intelligent automation system also is required to assist the developing commercial and regulatory structures that are projected onto the physical electrical grid. The liberalized markets now have fragmented commercial stake holders that require different, more flexible administrative solutions than the traditional vertically integrated control and command structures. Regulators require different parts of the supply chain to act and record transactions in a robust manner, while at the same time provide evidence of the most cost-effective delivery of their services.
An optimal smart electricity grid would by utilization of the latest information technologies be able to largely control itself. That is, it would be able to accept any kind of generation source, deliver power of any quality on demand, diagnose itself, and even heal itself through intelligent use of redundancies.
We attempt for addressing some of different challenges that need to be addressed and they are summarized briefly here. Intermittent generation like wind can cause problems in grids, in physical balances and in adequacy of power.

- Relevant Standards

The connection of DG has been addressed to date in various studies and is reflected in various standards as are identified in [2],[3]. These standards have gone a long way and are a good 1st step for increasing DG integration.there are two goals for integrating distributed energy resources locally and globally: network management point of view and energy market objectives.

- Technical

The interconnection of DG changes the characteristics of the system to which it is being connected, due to the fact that distribution systems were traditionally designed with the assumption of a passive network. The consequence of the integration of DG is that this assumption is no longer valid. Introducing this new smart-grid concept opens the door to previously unknown challenges. For example, the power flow may reverse as the generation capacity of one area exceeds the local demand and is used to compensate the load requirements in a neighboring area. These effects may be restricted to the low-voltage level, but may also be felt at the medium-voltage level, as illustrated in Network congestion may result when the transfer capacity of the lines is reached or exceeded. This problem is exaggerated when the distributed energy sources are not close to the main energy consumers. The automation system that manages those challenging situations must have access to the real-time dynamic changing of the whole grid. This requires additional measurement, state estimation algorithms, and flexible control and protection settings.
Furthermore, the automation system should be intelligent enough to cope with generation profiles that may change with the weather and the time of day (e.g., wind or photovoltaic generation).
The result will be a continually changing distribution of power flow and direction, in contrast to the relatively stable, unidirectional power flow typical of a distribution network today. All of these functions require greater use of fast and reliable Information and Communication Technologies (ICTs).
The amount of data required to perform the various smart-grid functions is enormous and diverse.
Data come from different sources and systems and energy market platform, and are both historical and real time with sampling rates varying according to the specific functional and communication requirements. In the new ICT system, a balance between additional sensors and sophisticated state estimates must be found to keep costs low.
The next challenge is to integrate the new ICT architecture with the infrastructure that is already installed by the utilities. Many DNOs are operating electrical and ICT infrastructure that is at least 10 years old and not fit for the rich data flow necessary for ANM. The use of different data communication standards and the inadequate bandwidth of the communication channels are a barrier for an implementation of smart grids in the near future.
Besides the management of the technical performance of a smart grid, the ANM also should support the manifoldadministrative tasks of the grid operators.In a smart grid, generation unitoperators and distribution infrastructureproviders are different legal entitieswith the same need for automating the accounting procedures of theirbusiness.
There are a number of technical challenges, which include:
Distribution network planning and operation Protection coordination Voltage profile and voltage regulation Power quality

- Regulatory

The regulatory aspects related to DG, which includes the connection agreements that are required, policies on metering, as well as the financial value of the energy and ancillary services provided by DG, are critical issues and, in many cases, will serve as the balance that will ultimately decide whether a project will be feasible or not. That said, this is perhaps the area that has received the least amount of attention up to this point. As the technical and standardization aspects become resolved, more of the focus will inevitably need to be shifted towards these policy and regulatory issues in the coming years.

- Research and Development

The modern power system has greatly benefited from microprocessor based devices as well as recent developments in communication for applications ranging from protection to control and operation. DG as an emerging technology also offers the potential to improve power system reliability, increase diversity, and provide greater flexibility to help match the increasing and ever changing energy needs of the world's population. Small capacity generators essentially operate in 3 types of modes: grid connected, remote grids, and capability to operate grid connected or in islanded mode. The 3rd mode can greatly benefit from experience gained operating the former 2. In all cases, the flexibility and ease with which DG can be integrated will depend in large part on the monitoring and communication capabilities present in the network of interest.

- **Distribution System Automation**

The power of communication in a power system is that 1 has greater access to information, enabling improved control, observability and planning of the system. It is apparent that DG will depend on an improved communication infrastructure and therefore would benefit from increased investment in distribution system automation. As many distribution companies are currently implementing distribution system automation (DSA) programs), they are at the same time investing in DG although this is usually not the primary driving force. Not only will this permit monitoring of DG operation but it can also be used in the future to aid in planning and optimized system operation.
Communication between DGs, and between DG and the distribution system operator will increase the likelihood of high penetration of DG. At present it is not clear how this distribution infrastructure should be designed and, more importantly, who will be responsible for these network system upgrade costs.

- **Demand Response Resources (DRR)**

The connection of DG to the main grid can bring about a number of benefits, which can be maximized by coordinating the response of the different units in order to achieve various objectives. Combining the response of generators with on demand load curtailment can further improve the effectiveness of this type of a program. The benefits of DG as part of a demand response program design, such as Sherbrooke Hydro, needs to be considered.
Over the last decade, DR has rapidly gained traction in the power markets thanks to its low capital cost and minimally invasive involvement from customers during DR events. However, the onset of DR auctions has allowed utilities to take a direct role in offering DR services, potentially undercutting companies with higher margins. As a result, pure-play DR companies are being snatched up or phased out by larger energy management companies that can offer a wider variety of services to their customers.

The line between DR and energy-management systems will continue to blur as it evolves into a single market segment. Remaining DR-only providers will need to partner up with energy management companies, offer energy management services themselves, or provide a technological advantage over other DR providers, such as the capability to provide reliable rapidly deployable automated DR.

By nearly eliminating customer involvement in DR events and providing a rapidly available DR resource, DR service providers can gain added value by participating in not only demand response, but pay-for-performance frequency regulation, as well.

- **Remote Applications**

In many countries the use of diesel generation in remote applications and communities is quite important.
The economics associated with diesel and other fossil fuel technologies is tightly tied to the price of fuel and the transportation and maintenance costs, which are typically much higher in remote locations; therefore, there is a greater incentive to consider the application of renewable energy, combined heat and power retrofits, and demand response strategies.

- **Microgrids**

Applied research on microgrids that consider integrated network infrastructure and a power delivery system that can operate in parallel with the grid or in an intentional island mode is being supported by several international research programs
The extension from research to utility adoption will only follow with demonstration that microgrids provide both value and significant benefits. Although various utility case studies have been cited, it has yet to be established whether widespread utility adoption of the microgrid concept can be anticipated. Research on microgrid management and operation strategies that consider the use of renewables and environmentally preferred distributed power; peak-load management strategies; and automated distribution and protection system architecture, have been initiated as part of the DEP program activities

CONCLUSIONS

Decentralized energy production has the potential to offer improvements in power system efficiency, reliability and energy diversity, as well as provide an opportunity to integrate a more significant level of renewable energy into our current generation mix in Canada. While significant knowledge has been gained through past experience, the practical implementation of smaller distributed generation has proved to be more challenging than perhaps originally anticipated. Numerous barriers have presented themselves in opposition to large-scale integration, namely technical challenges, lack of the necessary regulatory framework, and cost. The extent of future DG growth will depend in large part on a greater understanding of its impact on the power system, improvements in current utility system planning tools, and significant collaboration from all stakeholders in cooperatively developing a sustainable strategy for integration of renewable and distributed generation in Canada. As a conclusion of this analysis it can be said that the increased penetration of DG and the technology and market development results in:

new roles of the different stakeholders meaning new business environment and possibilities; on the other hand new tools are also needed in this new business area

metering and ICT technologies are developing rapidly

the above development will result in new products, services and pricing policies which can activate the more deep participation of final consumers in the market Successful integration means that different technologies in supply and demand side as well as in ICT are developed to the level where their integration is feasible both technically and economically and that regulation, policy and market give the successful framework for the integration

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