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CAPACITY MANAGEMENT IN A GENERALIZED SMART GRID FRAMEWORK

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Abstract. Smart grids are being developed in various parts of Europe. Numerous energy service providers are working on projects to deliver smart energy products and solutions. Without a common framework each of the projects will be confronted with limitations when implementing in the distribution network and might result in a set of incoherent solutions. Moreover, capacity management of the distribution network with the accelerating use of Distributed Energy Resources (DERs) and new forms of loads will be a real challenge for the network operators. This paper discusses the necessity of a generalized framework for the smart energy services. To optimally use the network capacity and increase the market flexibility within the common framework, a control mechanism is also presented.

Keywords: Capacity management, Flexible management, Generalized framework, Limiting capacity.

INTRODUCTION

The electrical power system has traditionally been ‘vertically’ operated consisting of a transmission system that transfers energy from large scale generating plants over long distances and a distribution system that distributes power to consumers with mostly passive behavior. The distribution system being very extensive supplying large amounts of loads, yet is almost passive in nature. This is principally due to the little or no communication possibilities and very limited local control mechanisms. This limited interaction between the power system and the loads has to be modified in order to avail greater flexibility and controllability [1].

However, the conventional supply system of electrical energy will be significantly altered in the upcoming years facilitating bidirectional power flow, supported by sophisticated information and communication technology infrastructure [2], [3]. In addition, interaction between the consumers and suppliers of electricity will also increase by means of the aggregator concepts like the Virtual Power Plant (VPP) [3]. For optimum operation of the network to meet the challenges that lay ahead and to accommodate the new market roles, a flexible and sophisticated operational framework is very important.

This paper discusses the features of a framework for smart operation of the distribution network taken the network constraints in account. Within the framework different controlling structures are distinguished. This allows flexibility to be introduced in the market to resolve congestion issues. The following sections discuss background, need and outline of capacity management within the generalized framework.

A GENERALIZED FRAMEWORK

Future grid problems

The massive implementation of small-scale renewable energy production and the introduction of new forms of loads, consumption challenges all involved actors including network operators, market entities, and customers. Among other challenges, capacity management, as known and treated at transmission system level, becomes a main concern at distribution networks as well. Due to the highly stochastic nature of the renewable energy based generating units (e.g. solar PV, wind turbine) and consumer behaviour (heat pumps, electric vehicles) the load flow in the distribution network will be much more complex incorporating bidirectional and unpredictable power flows, voltage variations, larger peak demands, imperfect short-circuit protection etc.

The need of a common framework

Approaches to integrate new services and technologies individually into the existing energy system do not address the fact that the current value chain in the power system is neither designed for a bidirectional flow of power nor prepared for introduction of new market roles like with prosumers. Without a common framework each of the projects will end up with the limitations of the current system without being able to effectively alter it to their needs.

A close cooperation between all the parties active in the energy distribution system together with industries that provide innovative energy products, services and solutions is essential to transform the system into a modern integrated system which meets the needs of all stakeholders in the energy value chain. Development of a suitable framework for smart energy services would create an essential competitive advantage for all partners involved and would enable them to setup sustainable business that delivers smart energy solutions that can be implemented worldwide in the upcoming decades.

CAPACITY MANAGEMENT WITHIN COMMON FRAMEWORK

Challenges for the DNOs

The main concern of Distribution Network Operators (DNOs) is an optimal utilization of network capacity, which encompasses preventing overloading of assets, optimizing asset capacity investments, keeping quality of supply and minimizing energy transport losses. Small-scale customers in most cases do not allow a DNO to directly control their generation and/or consumption. Market-based operating systems (e.g. PowerMatcher) in which prices are communicated to devices, can be used to influence the customers [4]. However, this kind of demand response can exploit only customer's flexibility in a general sense and it is difficult to include specific network constraints.

There is an enormous potential from the large number of small-scale customers to support network operators operating and controlling the power grid. An appropriate incentive-based and/or price-based mechanism can realize this potential and provide for congestion management. For instance, prosumers aggregated in VPPs can be active in the energy market by providing ancillary services [3]. They can offer flexibility services to the network operators to minimize congestions in the hotspots of the distribution network.

Flexible operating structures

In the classic operating mechanism of the grid only two scenarios are observed. In normal operations, i.e. - when the load flow in the network remains within acceptable limits, the market can operate freely. But as the system load increases beyond the network limit, the market can no longer operate and power outage takes place. Within these two scenarios the generalized framework can introduce two more operating regions namely 'flexible management' and 'limiting capacity'.

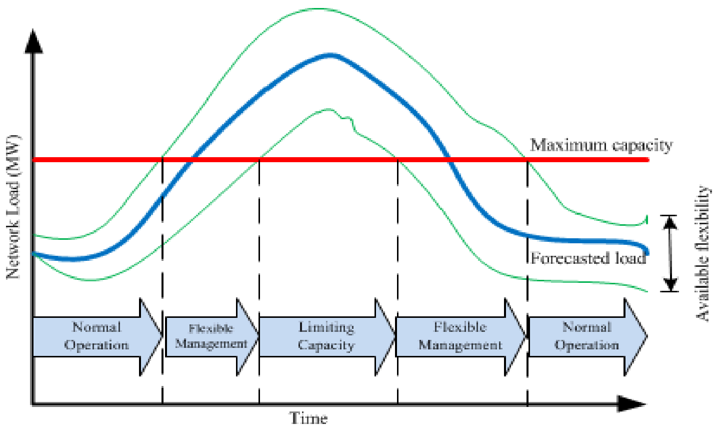

Figure 1. Flexible operating structures in the framework

The amount of energy that can be transported and distributed is limited by the peak capacity of the grid. In flexible management scheme the DSO uses flexible power options to keep the peak loadings under control. This can be achieved by procuring flexibility at both the demand and supply side in such a way so that currents and voltages stay within acceptable limits. The flexibility can be procured through a 'flexibility market' based on bilateral contracts and/or locally available flexible capacity.

The network starts the process of limiting capacities when the market is no longer able to solve the problem. This can be done by stepwise limiting the connection capacities until the network resolves the issue. Priorities can be set to differentiate between clients who critically depend on energy and connections like fast-charging stations of electric vehicles which can be temporarily limited in their charging speed without any real damage.

CONCLUSIONS

The focus of the work has been to develop a Smart Grid environment that will help the network operators to handle the capacity management problem. It will therefore, enhance the flexibilities of the control mechanisms to deal with network issues. Concerns related to optimally exploiting local distributed resources are also being looked into. The final paper will present detailed analysis of the proposed control mechanisms and expected impact. The advantages of the network operators will also be presented.

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