New microgrid integration layers

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Abstract

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44 Z REE N°2/2017 LES MICROGRIDS DOSSIER 1 Introduction Smart Grids are fundamental to make possible to electricity grids to address growing and new demand profiles, re- newable intermittent and distributed ge- neration, and environmental pressures. By 2020, around 50 billion electrical devices of various kinds could poten- tially be connected to each other world- wide. Electricity grids will progressively become the foundation of new sys- tems of systems, made up of “constel- lations of microgrids,” supplying power to practically all the other components while making use of new possibilities of Information and Communication Technology (ICT) enabling transactive controls across these systems. The addition of these systems, inte- racting with each other, is considered as the overall Smart Grid system, permitting the optimal system-wide energy dispatch through the coordination of millions of microgrids. Evolving to this new Smart Grid era systems requires to fundamen- tally reconsider the way control principles have been designed historically to enable bi-directional communication and power flow capability across generation sources (conventional and renewable) and custo- mer loads. We have then to look again at the way transactions are organized along the energy value chain, from genera- tion interactions with wholesale markets down to end user virtual power plant portfolios integrating renewable curtail- ment, demand response and storage. Electricity companies have progressi- vely evolved towards these new Smart Grid concepts through series of Pilot and Demonstration projects to define an optimum transition path while main- taining the same reliability standards on their Grid infrastructures. Grids were traditionally operated through simple one-way real-time com- munications requiring connections with a reduced number of dispatchable generating points while considering IT platforms where dispatch optimal- ition is run through a limited number of Central Computing platforms. Most of the consumption data was forecasted mitigating errors across large grid areas and reconciled financially through meter readings and profiles happening few months after the fact, according to theo- retical load profiles. Distribution opera- tors had very limited access to real-time metering data from their grid edge. With Smart Grids, communication becomes multi-dimensional, with infor- mation flowing among several layers of the energy systems across devices, computers and market stakeholders transacting with each other through real- time connecting generation assets to demand responsive loads. The ultimate objective is to allow the entire system to be operated more flexibly, facilitating the penetration of larger amounts of inter- mittent renewable generation through more interactive grid infrastructures enabling customer demand response as well as storage and electric vehicles. Smart Grid technologies aim at coor- dinating the needs and capabilities of all centralized and distributed transmis- sion and distribution grid infrastructures, end-users and other electricity market stakeholders to manage all parts of the system optimally in a given regulatory context. Their purpose is to minimize the overall system social welfare in consideration of operating costs of the various components, environmental impacts and associated penalties while maintaining system reliability, resilience and stability. Microgrid definition A microgrid is a contiguous section of the grid and its interconnected distri- bution networks. New microgrid integration layers Laurent Schmitt General Secretary, ENTSO-E Microgrids have recently emerged as one of the undisputed innovation resulting from recent Smart Grid pilot projects as the obvious path to improve distributed energy resource integration at the edge of the power system. By 2020, around 50 billion electrical devices of various kinds will likely be connected to each other trans- forming the electrical system into a new system of systems architecture, made of “constellations of microgrids” with transactive controls across these systems. The article sum- marizes the main associated architectural concepts and use cases bringing early evidence of that new transformation. ABSTRACT Les microgrids ont récemment émergé comme une nouvelle innovation de rupture des diffé- rents projets de démonstrateurs Smart Grid dans le monde permettant une meilleure intégration des ressources éner- gétiques distribuées aux interfaces du réseau électrique. D’ici 2020, environ 50 milliards d’objets électriques connectés transformeront le système électrique en de nouvelles architectures de type « systèmes de systèmes » composées de “constellations de microgrids” interagissant entre elles au travers de nouveaux signaux de contrôle transactionnels. Cet article résume les concepts fondamentaux associés à ces nouvelles approches, les applications associées, en mettant en avant des signaux faibles de cette future trans- formation. RÉSUMÉ REE N°2/2017 Z 45 New microgrid integration layers buted energy resources (i.e. generators, loads, storage devices, electric vehicles) in
a business arrangement such that they can operate in a coordinated way to respond to specific grid constraints – typically related to grid congestions or instability. Microgrids can operate as to-tally independent disconnected electri-cal islands in scenarios where the main grid requires it. It is typically managed through a virtual power plant (VPP) operator, managing and aggregating the microgrid distributed energy resources (DER) into the grid and market. The convergence of the growing demand for distributed renewables, technology shift in Smart Grid ICT archi-tecture towards distributed architectures and progressive customer empower- ment for customized demand response services are naturally evolving towards decentralized microgrid approaches offering new business interactions with grid operators. Microgrids offer the fol-lowing benefits to the main grid system: self-consume their privately owned distributed renewables installed within the microgrid boundary hence mini-mizing dispatch losses and impact on main grid congestions; continuity on microgrid critical loads during periods of main grid outages; - ted energy resources dispatch into ener-gy markets and grid ancillary services; investments for critical intake substa-tion reinforcement; community energy management busi-ness models within microgrid tenant and owner as an alternative to traditio-nal wholesale generation supply. Qualitative and quantitative assess-ments of the business benefits lar-gely depend on microgrid business ownership and associated operational responsibilities versus the main grid system. They can broadly be characte-rized by the following market segmen-tation: Private industrial and commercial organizations - they are privately owned, operated by facility managers with limited uti-lity interactions; - the primary focus is to support owners’ industrial and commercial business operations with economic and reliable power supply; - more recently new developments have been observed in academic campuses with stronger focus on innovation; Government organizations - military base microgrids have strong focus on energy reliability; - these organizations are interested to improve economics making use of their microgrid in parallel to the operation of the main grid system; - cities have started to consider micro-grids as a key driver to develop their ‘Smart City’ energy vision. Electric utility companies - vertically integrated utilities consi-der deploying microgrids to serve customers with specific, localized requirements, in areas which are exposed to grid constraints (Cf. the microgrid typically deployed by Enedis in France in the context of the Nicegrid Project around Carros); - deregulated utilities collaborate with Distributed Energy Resource aggre-gators to improve service quality across the distribution grid and mi-crogrid operators; - utilities are investigating to offer utility expertise as a service to non- Figure 1: Microgrid architectural concept at Nicegrid – Source: GE Grid. 46 Z RÉE N°2/2017 LES MICROGRIDSDOSSIER 1 utility microgrid owners to improve customer satisfaction. Key microgrid use cases A major intersection between microgrid and main grid infrastructures is the mana-gement of distributed energy resources. Microgrid management systems are there-fore largely derived from applications origi-nally deployed in distribution utility control rooms which in the case of privately owned microgrids are operated by other business entities. These systems typically cover the following key building blocks: and Communications - industrial communication hardware leveraging wireless or power line carriers; - substation and feeder automation hardware; - automation for distributed energy resource controls. - vices - microgrid operating mode manage-ment: island detection, re-synchro-nization, interconnected operation; - power balancing and frequency controls; - voltage control; - microgrid topology assessment ; - alarms and logging. - distributed renewable forecasts, including PV, combined heat and power, wind, - load forecast, demand response (DR) and storage availability forecast; - energy price forecasts; - distributed energy resource dispatch optimisation ; markets - virtual power plant aggregators: contracts, compliance, performance; - real-time markets: bidding, instruc-tions, settlement & billing; - grid control rooms. Looking ahead the operation of future electric grids is evolving toward coordinated operation of microgrids through virtual power plant aggregation. Even though each of these microgrids will be managed by its local control enti-ty, a new business aggregation layer has emerged to facilitate the coordination of individual microgrids against transmis-sion and distribution grid operators. Figure 2 illustrates a layout of future integrated grid system control room connecting with multiple microgrids. New Smart City microgrids Looking few years ahead, micro- grids are emerging as critical corner-stone to interconnect community users with infrastructure through new layers of intelligence. Advanced information and communication infrastructure are playing a decisive role in supporting the overall integration of these systems to-gether, while allowing distributed control and optimization decisions through mul-tiple tiers of the electrical system infra-struc-ture. In cities particularly, where energy systems are particularly constrained, we should expect these architectures to expand beyond the boundary of the electrical system, interconnecting toge-ther gas, heat and electrical transport systems. These new systems should distribute anonymised information to Figure 2: Microgrid integration with Grid Control Rooms. RÉE N°2/2017 Z 47 New microgrid integration layers end users to allow individual carbon effi-ciency benchmarking as well as smarter decisions in the use of energy and trans-portation resources by people. In the same time, we should expect the same information to be put at the disposal of large city infrastructure owners to better plan their investment strategy, thereby improving the overall service quality. A significant challenge in deploying these new architectures is their capabi-lity to offer sufficient openness to inter-connect historically siloed information while matching end user privacy regula-tions and mitigating cyber security risks. These new systems should facilitate de-ployment of optimal operational plans across energy infrastructure which have traditionally been scheduled individually as per their own intrinsic information and constraints. In the past years, IT system specifici-cactions and industry standardization for data exchanges have remained confined within single infrastructure silos with highly customized and proprietary sys-tems platforms in each domain. Moving forward, the unbundling of several markets, such as telecom, energy and transportation, is redistributing roles and responsibilities of service companies while raising new expectations for cities to monitor and benchmark performance of service operators. The IT industry is in the meantime also evolving toward new industrial Internet platforms leveraging new open Big Data cloud-based archi-tectures opening new system deploy-ment opportunities. Overall, these new IT platforms will allow to infinitely scale intelligence wit-hin layers of grid infrastructure (from the cloud to millions of Web objects distributed within the city) and orga-nization levels according to roles and actors within future Smart Energy eco-systems. Ultimately, we see transactive controls across microgrid constellations becoming the new foundations of future
energy systems. L'AUTEUR Laurent Schmitt started his career 19 years ago with Alstom in the field of power generation controls. With Alstom, AREVA and more recently GE Grid, he led teams of solution specialists that integrated software, control and automation technologies to enable grid modernization towards smarter, more digitalized and more efficient infrastructure, facilitating renewable integration. In January 2017, he joined ENTSO-E as General Secretary.

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