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Active Distribution System Management

A key tool for the smooth integration of distributed generation

FINDINGS AND RECOMMENDATIONS

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Active Distribution System Management

A Key Tool for the Smooth Integration of Distributed Generation

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TF Active System Management

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DSOs are the main integrators of distributed energy resources

With the EU on its way to meeting a 20% target for renewable energy sources (RES) in total energy consumption by 2020[1], the share of electricity supply from RES is on the rise. A large share of these resources, including intermittent solar and wind, will be connected to low- and medium- voltage distribution networks. In fact, several European countries are already experiencing a high penetration of such distributed generation (DG): for example, in Galicia (Spain), Bavaria (Germany) and the north- and south-west of Ireland, the installed capacity of DG connected to the distribution networks already exceeds the area's total peak demand.

This paper summarises the findings and recommendations of EURELECTRIC's full discussion paper on active distribution system management. The full paper describes the challenges of integrating DG into the energy system. It also discusses possible solutions for the most efficient integration based on practices already implemented or tested in various smart grid projects around Europe. Integrated properly, DG will help make tomorrow's energy system more sustainable. Integrated badly, they will increase the risk of power outages and raise costs for final customers.

The paper focuses largely on DG, whose limited predictability already poses a major challenge for many European distribution grids. Nevertheless, the presented solutions can be largely used to effectively address planning and operating uncertainties of distribution systems that contain other types of distributed energy resources (DER) and flexible loads such as electric vehicles as well.

Distributed generation does not reduce network costs. In fact, it may even increase them.

Building sources of electricity production close to consumption does not reduce distribution network cost. The network must still be designed to cover peak demand for situations when there is no DG production. For example, residential demand is usually highest in the evenings when generation from photovoltaic (PV) is virtually non-existent. Conversely, on particularly sunny or windy days, decentralised RES generators like rooftop solar panels or small wind farms produce more electricity than is needed locally. To accommodate this, more grid capacity is required, not less. In short, there is no reduction in investment by "netting" generation and demand.

In addition, the operation of a system with more DG becomes more complex. In such systems, power flows not only from the power system to the consumer, but also from customers (e.g. with a solar panel on their roof) to the power system. Problems like excessive voltage variations and bottlenecks already occur today, endangering reliability of supply and negatively affecting quality of service. This will occur more frequently in distribution networks with high DG penetration, depending on the different types of connected resources, their geographic location and the voltage level of the connection. When DG production exceeds local consumption or when production and consumption do not coincide, network limits will be breached, requiring additional investment in network reinforcement. Investment in more sophisticated protective relaying and control systems is also needed.

[1] This corresponds to 35% in total electricity consumption.

Active system management can help DSOs use the existing network more efficiently

Today's distribution networks are designed to meet peak loads. The currently used 'fit-and-forget' approach implies that all issues are resolved upfront, at the planning stage. But the shift to more decentralised power production and new applications means that this approach alone is no longer cost-effective. Peaks often occur for only several hours a year and the utilisation rate of network assets declines. Building a distribution network that can accommodate all load and distributed generation within existing quality of service requirements will thus frequently be too expensive and inefficient.

In addition, the priority granted to RES in grid access and connection contributes to inefficiencies in grid development. DG, flexible loads and storage offer the potential for greater flexibility within the grid, but the current approach to grid design means that this potential cannot be used.

EURELECTRIC believes in promoting active system management, which would optimise the distribution network by allowing greater interaction between the key network processes – planning, access and connection, and operation – which take place within different timeframes. Greater flexibility both on the supply side (generation) and the demand side (consumption) will represent a key tool in this respect. While traditional network reinforcement will remain important, such flexibility would help optimise the use of the existing network and thereby minimise distribution grids extensions.

In order to make this paradigm change happen, active involvement of customers is a must. In addition, distribution system operators (DSOs) need to have a more active role and their networks must evolve. DSOs need adequate tools that allow them to comply with their fundamental tasks of maintaining reliability of supply and quality of service in their networks within the appropriate conditions of transparent and non-discriminatory network access.

Setting up active system management will require innovative approaches towards the network and network customers as well as adjusting the regulatory framework.

Ultimately, adopting this approach would allow more distributed energy resources to be integrated into the network at lower cost, compared to business as usual. Unplanned power outages would become less frequent and the costs of avoiding them would drop.

Key elements of active distribution system management include:

1. A variety of network planning and access options that would reduce the need for investment

Traditionally, network operators analyse each connection request as it arises. But with a high demand for DG connection this ad-hoc approach is not always optimal for overall cost and network development. **Long-term network planning would allow DSOs to prevent bottlenecks in the most cost-effective way**, by making best use of the existing network and thereby lowering the need for new investment. To this end, coordination of all relevant actors, particularly transmission system operators (TSOs) and DSOs, will be important.

New types of network access could also help reduce network investments. Variable network access contracts could be one such option. Instead of planning the grid to provide DG and consumers with a firm physical connection to the grid 100% of the time, contractual agreements could introduce variable network access for certain DG or consumers, who would, based on financial incentives, agree to more limited access when the network is constrained – usually for only a few hours a year. Variable network access could be offered as a discounted connection or grid charge contract. The large variety of situations means that a regulated standard solution will probably be unfeasible. However, appropriate regulation can help create sufficient incentives for network users to make use of such flexibility options.

In addition, alternatives involving close to real-time operation should also be investigated. For instance DSOs could procure flexibility services from the market in advance, i.e. by incentivising generation to modify output or customers to reduce consumption during network peaks.

2. Adequately designed connection requirements for DG

DG must fulfill certain minimum technical criteria without which it cannot be properly integrated into the network: it must be able to resist voltage dips and prevent islanding. Separate metering for production and consumption should be provided. DSOs should be able to verify compliance of the equipment with such requirements and know which generation is on-line. Distributed generation should thus be 'registered' with the DSO. DSOs should be able to remotely disconnect such generation if needed to prevent accidents or damage to facilities of other clients.

In addition, distributed generation should bear the same costs for network use as other generators, including adequate connection fees.

3. A new role of services in distribution grid operation

New system services should be created at the distribution level. Such system services could be procured by DSOs as ancillary services from DER or be defined in grid codes.[2]

A. Using flexibility to solve distribution grid constraints

DG, loads and decentralised storage could provide **ancillary services** to support the quality of service and the security of supply in distribution networks. Today, ancillary services are mostly procured by TSOs, mainly from large power producers, to manage the system as a whole and relieve transmission network congestion. But congestion is also a common phenomenon in distribution networks. **DSOs should be able to buy flexibility from DG and consumers in order to solve grid constraints**. Such services could sometimes be more economically efficient than grid expansion, or they could be used as a temporary solution until grid investments and reinforcements are finalised.

Increasing flexibility in this way will require new market mechanisms. **Flexibility platforms** could play an important role, in particular for close to real-time flexibility. They would be used by aggregators who would procure options to market customers' flexibility under mutually agreed conditions. Aggregators would group a large number of DG and consumers, to offer flexibility services to DSOs (for management of local constraints) and TSOs (for balancing and management of transmission network congestions) alike.

To manage the operation of distribution systems, basic system states should be defined, as is the practice in transmission networks today. A "**traffic light scheme**" could be used to select appropriate actions according to different system states. Under normal conditions ('green light'), DSOs would operate using market procedures, without any restrictions for grid users. In alert/insecure states ('yellow light') the DSO would use market-based procedures to incentivise grid users to adapt production and/or consumption to the grid situation. Finally, in well-defined emergency conditions ('red light') the DSO should be able to undertake direct load management or emergency DG curtailment after the contracted options have been exhausted. All actions taken under alert and emergency conditions would have to be justified and compensated ex-post.

[2] For voltage and reactive power contributions by DER and operational information exchange.

B. Improving information exchange

The increasing share of DG and flexible loads connected to the distribution grid raises the need for a well-structured and organised information exchange in distribution networks. Knowledge of DG forecasts, schedules and planned maintenances is key to operate the distribution network in real time and close to real time. Today, DSOs are mostly missing this information. In fact, in some cases the TSO receives information from DG while bypassing DSOs completely.

In the interest of safeguarding system security, a framework for effectively exchanging operational information between network operators – and between network operators and end customers – should be defined. TSOs should typically rely on DSOs to provide them with the operational information they need from final customers connected to distribution networks. TSOs should not be able to bypass DSOs: if safeguarding the operation of the system requires action from these customers, TSOs should transmit these orders to be routed via the DSO in question.

In addition, network operators will need more information on the planned actions of aggregators and independent power producers connected to their networks. The participation of flexibility in TSO balancing markets could create constraints in the distribution grid. Similarly, actions by the DSO to solve constraints could have knock-on effects on transmission grids and the system as a whole. Organisation of this information exchange should be further investigated.

C. Voltage control

Voltage control in distribution grids is a system service managed by DSOs in order to maintain voltage in their networks within certain limits.[3] This minimises reactive power flows and, consequently, investments and technical losses in the system.

With increasing DG penetration, voltage problems are becoming more frequent. They require local solutions, as reactive power cannot be transported over long distances. However, their local nature makes them difficult to resolve with market procedures. They should therefore be managed by DSOs, who should be allowed to explore all local options with a view to choosing the most efficient one. The solutions could be provided by a combination of network users (e.g. generators able to produce or absorb reactive power) and the network itself (e.g. power electronics, controllable MV/LV transformers).

Where user participation is the most cost-effective solution, distributed generators should probably have an obligation to deliver a certain amount of reactive power, to be defined in connection and operation grid codes. If DSOs need to procure additional amounts of reactive power, e.g. to minimise losses, a market-based approach should be adopted.

TSO-DSO cooperation at the interface point is critical to minimise system investments, operation cost and losses.

4. Technical tools that allow DSOs to become real 'system operators'

The success of the abovementioned active system management tools will depend on DSOs' ability to actively monitor their grids, notably at medium and low voltage level. Today, DSOs have no systems installed for acquiring data from DG, in particular small-scale DG. As the share of DER expands, DSOs will need monitoring, simulation, control strategies and advanced protection systems that allow them to supervise and control power flows and voltage in their MV and LV networks. This includes relevant monitoring functionalities from smart meters.

[3] Although voltage control is a part of system operation, it is treated separately due to its relevance for reliable distribution grid operation.

EURELECTRIC calls for coherent policy, adequate regulation and tangible actions to make active system management a real possibility

Distribution networks vary greatly regarding topology, grid equipment and DG density at different voltage levels. A one-size-fits-all solution will therefore be difficult, if not impossible to find. Instead, **each distribution network should be assessed individually to ensure a technically acceptable, cost-effective balance between network investments and the procurement of new commercial services from network users.**

Regulation must be adapted so that it can steer the most cost-efficient solutions and innovation. It must incentivise DSOs to promote the most adequate, cost-effective solutions, be they conventional investment or active system management, and it must ensure that DSOs are adequately remunerated for them. Finally, developments of DG and demand response raise the need to review the suitability of the existing distribution network charging structures.[4]

In this context, EURELECTRIC sees <u>5 key tasks for decision makers</u>:

1. Member states and national regulators:
   Properly implement existing EU legislation, namely the Second and the Third Energy Packages and the new Energy Efficiency Directive. This will enable the creation of new system services at distribution level and ensure fair, transparent and non-discriminatory connection and access to the network.

2. Member states and national regulators:
   Create an adequate regulatory framework that allows network solutions beyond the traditional approach of 'investing in copper'. DSOs should be free to consider both the traditional investment solution and the flexibility service-based solution, or a combination of the two. They should implement the solution which is most efficient and be remunerated via appropriately designed grid fees.

3. The European Commission, ACER and ENTSO-E:
   When drafting EU-wide network codes, take into account lessons learnt from relevant smart grid demonstration projects and already implemented solutions.

4. The European Commission, ACER and ENTSO-E:
   Design operational rules and facilitate the procurement of flexibility from the market. The network codes on system operation and balancing will affect the development of flexibility markets, as a means of supporting distribution grid operation. They should be designed with a view to facilitating such flexibility markets without foreclosing any market design options.

5. The European Commission, ACER and member states:
   Adapt grid connection and access rules for DER to meet the need for flexibility. Today's priority access rules prevent network operators from responding flexibly to emergency situations, trigger inefficient investment in grid extension, and prevent grid and market operators from tackling grid congestion in the most cost-effective way.

[4] EURELECTRIC will present its proposals on this issue later this year.

NOTES

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