The roles of the Distribution System Operators in making microgrids an integrated part of the electricity distribution system of the future

Hadi Safari Farmad
Khorasanrazavi Electric Distribution Co. – Iran
ICTManager@kedc.ir

ABSTRACT

Micro grids will develop over the coming years and become more and more common. The main drivers of this are the increased benefits resulting from the aggregation and decentralised control of demand, storage and (where applicable) decentralised generation for improved security of supply and resilience. It is therefore necessary that micro grids face a regulatory framework that is fully consistent with the one used for the wider grid. In fully developed interconnected grids, the local distribution system operator (DSO) will be the best choice for the development and operation of micro grids. This paper provides a basic overview for understanding how DSOs act in making microgrids an integrated part of the electricity distribution system of the future.

INTRODUCTION

A microgrid is an object within the set of distributed local systems. It requires the capability of being autonomous and requires all its members to be connected (in exclusivity) to a single point in the network. (Pérez-Arriaga, 2014), while a distributed local system does not. Microgrid complexity varies from very simple to very complex and is determined by its objectives and the situation before the microgrid gets deployed.
Micro grids are the best available solution for the provision of electricity in areas where virtually no network electricity infrastructure exists. As the economic development of these regions gradually improves, these micro grids will naturally evolve into larger grids, taking advantage of the benefits of meshed interconnection and resource sharing. In areas where electricity infrastructure is already developed, micro grids can play a role if very high quality of service is required. Fully developed micro grids can provide additional resilience for critical loads and support services, when connected to the wider distribution network, in order to improve overall system security. It is necessary that micro grids face a regulatory framework that is fully consistent with the one used for the wider grid.
A microgrid can be viewed as an active distribution network defined as a low voltage network comprising of renewable energy sources, distributed generator units and loads connected to the main grid as a single controllable load. With varied and mounting challenges facing the urban environment and its energy supply, urban energy systems have undergone increasingly rapid change from centralized systems to the distributed energy systems currently deployed and reported in research. This is due in part to the growth of smart grids [1], distributed energy resources, and their accompanying management structures, multi-energy systems [2], and demand side management. Micro grids will develop over the coming years and become more and more common. The main drivers of this are the increased benefits resulting from the aggregation and decentralised control of demand, storage and (where applicable) decentralised generation for improved security of supply and resilience.
Any economic calculation on microgrids depends on its design and assumptions. People typically associate microgrids with small, rural, renewable-powered and standalone systems that provide electricity to homes across the area. These are often non-governmental (community or commercial), and are in place due to the inability of the traditional grid to supply quality, affordable power. There are also some definitions that attempt to distinguish mini vs. microgrids, such as the 2016 MNRE Draft Policy, but these are often artificial distinctions:
1) Design
2) Source of generation
3) Institutional framework
Proper regulation of micro grids in already developed electricity systems is a key element. The customers of micro grids must have the same rights and obligations as the customers of the wider, integrated distribution grid. The development of parallel micro grid solutions as a result of ill-defined competition rules might give rise to a less efficient system which is more expensive to final customers. It is therefore necessary that micro grids face a regulatory framework that is fully consistent with the one used for the wider grid. In fully developed interconnected grids, the local DSO will be the best choice for the development and operation of micro grids.

THE ROLES OF THE DISTRIBUTION SYSTEM OPERATORS

The electric industry is undergoing a paradigm shift due to a combination of factors including emphasis on increased use of renewable resources both at bulk power and distributed levels, new technologies, increased demand-side participation, and increased emphasis on grid resiliency. DSOs will need to adapt to a system environment where micro grids are a reality, with suitably adapted grid rules and market regulations. From a DSO perspective, it is important to understand how micro grids will affect local/regional systems, maximise the benefits of their existence and efficiently align with the business models which will prevail. DSOs will have to manage their networks in a more active way and share information to make the transition possible. This can be

achieved by clarifying the DSOs' involvement in data management and its contact with customers in case of emergencies or other services, such as new connections. The advent of distributed energy resources is bringing new participants to the market: Consumers are taking an increasingly active role, different service providers are now competing and another set of participants is emerging: platform operators and microgrid operators. All these participants have different behaviors and motivations, and thereby contribute to more diversity and complexity in the system. A new optimisation mechanism for managing the distribution network is needed to cost-effectively maintain high performance of the energy system. This includes:

- Optimising investments
- Optimising capacity management
- Optimising the behaviors of system participants

DSOs could play a vital role in realising new optimisation mechanisms—orchestrating and optimising platforms connecting participants in the energy system. If we think of DSOs as "distribution platform optimisers," we can see that they could perform their distinctive roles in new ways:

- **Bottom-up asset planning:** Focuses on optimal integrated solutions across different energy carriers, combining granular insights in technology development and consumer behaviors with data about the state of the distribution network in the planning process.
- **Active systems management:** Involves investing in intelligent systems that help leverage flexibility from sources connected to the distribution network for managing congestion, primarily through financial incentives.
- **Neutral market facilitation:** Lowers the threshold of access to the energy system and the energy market in a non-discriminatory way, verifying all participants in the energy system are treated equally and can act based on equal information.

DSOs are in a position to become effective platform operators, but they need new smart grid capabilities to perform their tasks effectively. Some of these capabilities run across the three roles of a platform operator. Other capabilities are specific to just one of these tasks.

This section provides a basic overview for understanding how DSOs act in making microgrids an integrated part of the electricity distribution system of the future, and addresses:

- DSOs must act as neutral market facilitators and guarantee distribution system stability, power quality, technical efficiency and cost effectiveness in the future evolution of energy networks towards a smarter grid concept. DSOs are local or regional operators and, as such, they must work to the benefit of customers.
- DSOs are adapting to an evolving energy market by implementing changes in the way they operate and plan their networks. DSOs are establishing a foundation of smarter network monitoring, improved metering, control (including distributed generation) and automation to best fulfil their security of supply obligations in a changing context made up of distributed generation, self/micro-generation, electric transport, new uses of electricity, more active customers and much smarter distribution grids. Smart meters are widely being deployed, distributed generation continues to expand, and customers are expected to play a more active role in demand response and energy efficiency. DSOs are reorganising themselves in terms of new organisational business models, re-training of crucial staff, digitalisation of grid operations and other important managerial issues. DSOs have shown that they can increase existing network headroom through innovative ideas (e.g. using dynamic asset rating and voltage control), which has led to the optimisation of distributed generation connected in a given area without having to invest in traditional reinforcement options. Where legislation allows, DSOs have signed flexible contracts for network customers. These flexible network customers have been providing services, which they are remunerated for, and help network operators manage certain grid issues such as network congestion or voltage constraints. In summary, DSOs are adapting to this evolving environment, implementing the required changes in the way they operate and plan their networks to face future challenges. The DSOs' role will not fundamentally change, but will have to be repowered and strengthened.
- Energy regulators should recognise the broadening role of DSOs as neutral market facilitators and encourage efficient technological innovation. However, performing this new role will lead to extra costs related, inter alia, to the introduction of smart grid solutions and the increasing complexity of data handling. Changes are taking place and energy regulators must ensure that they benefit customers and other network customers. The new setup must make sure that costs are minimised whilst competition is nurtured and a level playing field is guaranteed for all market participants. To meet the challenges ahead, national energy regulators must make sure that DSOs are properly incentivised through a sound regulatory methodology covering both traditional and innovation-related assets. Regulatory schemes must incentivise DSOs to be efficient on a total cost basis, to deliver long-term investment according to a predictable and consistent regulatory framework, and to make efficient tradeoffs between active system management (including flexibility and storage procurement) and physical grid reinforcement.
- DSOs should adequately support their customers. Electricity distribution is a local/regional activity in which the interaction with customers8 and local stakeholders (such as city councils) is very important. In contrast with the transmission network, in which connected customers and connection points to other networks are very few, distribution networks are usually characterised by a large number of customers, self-generators and larger-scale (distributed) generators. DSOs are in a unique position as the technical contact point for distribution customers to meet their needs and choices in terms of connection, quality, security, and continuity of power supply.
- Data management must be fair, efficient, transparent, and non-discriminatory. Data management is key. Although various options are open, data managers must be neutral and must have experience in managing large amounts of data at different levels and through different regions. DSOs are now embracing the technical (active grids/systems) and commercial (demand side response, aggregation, local management of grid constraints, local balancing) changes needed to support the evolving energy market. Data managers must be

neutral and must have experience in managing large amounts of data at different levels and through different regions. DSOs are now embracing the technical (active grids/systems) and commercial (demand side response, aggregation, local management of grid constraints, local balancing) changes needed to support the evolving energy market. DSO functions will have to be repowered so that DSOs can play an active facilitation role below transmission level across the market, thus guaranteeing system stability, preventing local interruptions, and enabling markets and services in a neutral and non-discriminatory manner. DSOs and energy regulators must ensure that residential customers are clear that their main relationship is with retailers, whilst recognising that, from time to time, DSOs will have a direct relationship with residential customers for emergencies or other services such as new connections. More sophisticated or larger customers may sell their flexibility, either directly or through suppliers and aggregators, to DSOs in order to ensure grid stability.

- Network tariffs must be cost-reflective and exclude energy policy or other system costs. Tariff structures must incentivise and reveal actual customer behaviour to ensure grid stability. They should be cost-reflective over time, non-discriminatory, and must exclude non-distribution costs which unduly distort price signals and may trigger the development of inefficient distributed energy technologies affecting overall welfare. Due to the nature of network costs, which are predominantly fixed over time, network tariffs should be increasingly capacity-based without distorting energy efficiency objectives.
- Micro grids should be regulated on a level playing field with existing grids. Regulation must make sure that specific areas are not picked up by micro grid developers simply on the basis of profit margin considerations in the absence of universal service obligations (which conventional DSOs are subject to). National regulators should guarantee that those customers who are connected to a micro grid have the same technical and commercial rights as others. In many situations, DSOs are in the best position to evaluate the need or opportunity for establishing a micro grid and run it. In all cases, unduly justified opportunistic behaviour by new entrants must be avoided.
- Local flexibility markets, especially at lower voltage levels, might not be sufficiently liquid in some local cases. The DSO's new role will introduce the need for flexibility due to the non-firm nature of some connections. Recently, the most controversial area in downstream markets policy discussions is the debate on how DSOs will satisfy these new flexibility needs. Several possibilities must be examined (also in regulatory terms), on a case-by-case basis, before choosing between direct flexibility procurement and local flexibility markets via retailers and aggregators. At some point in the future, which is still to be decided, a market/regulatory liquidity test might be developed to ensure that DSOs do not inhibit market-based services in this stability activity. DSOs will need to manage their networks differently and procure flexibility resources. However, it is necessary to bear in mind that the scope and firmness of flexibility services is not comparable to developing new assets. Flexibility services may be of great help for distribution grid operation and to fix short-term problems, but one cannot rely on them to solve security of supply issues in the longer- term. As neutral market facilitators, DSOs may procure services, either via established level-playing field markets or through bilateral agreements when local markets are illiquid and regulators allow alternative solutions. In any case, it is the end-customer who must ultimately source and make such services available if interested. The DSO must be able to communicate to customers and market parties, such as retailers and aggregators, that there is a need for a certain service so that they can then decide whether or not to participate while still complying with the terms and conditions of their other market arrangements (for instance, a smart heating aggregation scheme or similar). Sophisticated and sizeable customers can engage with DSOs directly. DSOs will want to access local capability/flexibility markets to reduce cost and investment levels. It is therefore important to develop a clear definition of how flexibility should be managed at a local/regional level. Given the geographical limitations of flexibility for active DSO grid management, it is important to ensure fully working, well-populated markets with enough players in place. Otherwise, alternative solutions might be more cost-efficient not only from a DSO perspective, but also – more widely – from a whole energy system perspective. Several pilot and case studies are already available to evaluate the grid optimisation potential of substituting investment in cables and transformers by the use of active flexibility, whether directly procured or fully market-based, depending on local/regional circumstances and on the extent to which flexibility markets can be effectively 'populated'. Several possible business models must be examined at this stage, as it is still premature to identify any exclusive solution to the issue.

Further topics

DSOs are key players for enabling a successful energy transition while providing a high-quality service to all customers

Subject to regulatory terms, DSOs will be the independent and neutral operators of new, local market arrangements designed to ensure that the evolution is efficient and effective in terms of market enablement and customer empowerment. DSOs must act as neutral market facilitators. Being at the heart of the changes that are happening within their own networks, and with a deep understanding of how their own distribution systems work and operate, DSOs are in a position to act as neutral energy market facilitators and coordinators of all network customers. A key part of the DSO's role in facilitating the energy market is data management. The goal of any data management system does not revolve around ownership, but rather around correct and fair information sharing in an efficient, transparent, non-discriminatory way. Current IT systems already allow multiple DSO/ retailers to make data available to each other on non-discriminatory grounds, based on who is entitled to access any given piece of information, when, and to what extent in terms of granularity and aggregation. The evolution of technology and ICT systems, alongside the deployment of smart meter infrastructure, will enable much better observability and operability of the distribution grid, thus speeding up the achievement of

smart grids.

Standardisation of basic smart meter functionalities
Basic smart meter functionalities should be standardised at a minimum level to satisfy needs from customer and market players. Smart meter infrastructure does not need to – or, in many cases, simply cannot – be standardised due to important technical differences across different countries. However, it would be important to get to a point where smart meters have a minimum agreed common set of functionalities. These would include basic concepts like: connect/disconnect remote operations; provide readings to the consumer; support advanced tariff systems; power outage notifications etc. As roll-out programs are underway in many countries, impact assessments might have to be carried out to fully evaluate the adoption of common standards in this field.

REFERENCES

[1] El-Hawary ME. The smart grid – state-of-the-art and future trends. Electr Power Compon Syst 2014; 42:239–50.
[2] Amin SM, Wollenberg BF. Toward a smart grid: power delivery for the 21st century. Power Energy Mag IEEE 2005; 3:34–41.
[3] Giordano V, Gangale F, Fulli G, Jiménez MS, Onyeji I, Colta A, et al. Smart grid projects in Europe. JRC Ref Rep Sy 2011:8.
[4] www.eurelectric.org