

# Viewpoint

Insights and opinions from Baringa Partners

## The future role of network operators: The emerging active DSO model

GB experience and its relevance to the pending European market redesign



# The future role of network operators: The emerging active DSO model

Ever since the early days of electric power, which was characterised by small local networks, the trend has been towards greater integration, resulting in the large, centrally-managed transmission networks we see today. Whilst the ownership structures have varied over the years and from country to country (private vs public, vertically integrated vs unbundled), the picture has been one of power flowing, often over large distances, from large scale generators connected to the high voltage grid to consumers connected to the low voltage grid, with a central system operator balancing the generation and consumption in real time.

In that world, operators of lower voltage distribution networks have played a passive role in system operations with largely unidirectional flows of power across their networks from grid supply points to end consumers, leaving the real-time balancing of the national system to the Transmission System Operator (TSO) on the higher voltage network. The Distribution System Operators (DSOs)<sup>1</sup> have concentrated instead on connecting customers and maintaining and reinforcing the network, with real-time operations focused mainly on network outage and fault management.

## ► What is driving the need for change?

In recent years the trend towards centralisation has effectively reversed, with smaller-scale “distributed” generation (DG) becoming a material part of the

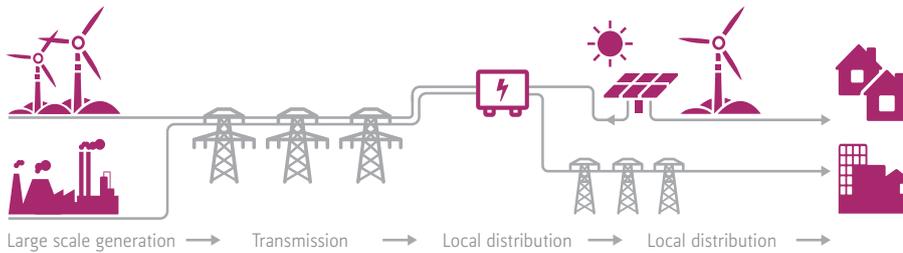
system, and an increasing interest in connecting batteries to the distribution network. This, combined with the advent of “Smart” control technologies, is leading to the emergence of a more active DSO model. Whilst this Viewpoint focuses on the GB experience, similar underlying drivers are being seen across a number of European countries. Each of these countries has its own approach to managing the electricity network, and its own vision of the future DSO role. By exploring the GB experience, we hope to contribute to this discussion.

By necessity, more balancing activity is taking place at a local level with distributed generation, frequently intermittent in nature, leading to greater variability in flows, including bi-directional flows, on distribution networks, and exports onto the transmission network. At the same time, new smart grid technologies are providing DSOs with the ability to

access flexible distributed energy resources such as dispatchable embedded generation, storage and demand-side response, allowing them to operate their networks closer to their operational limits and reducing the need for reinforcement. Regulatory frameworks, focused on total expenditure rather than capital expenditure, are evolving to incentivise DSOs to seek out such operational solutions and thus reduce costs for end consumers.

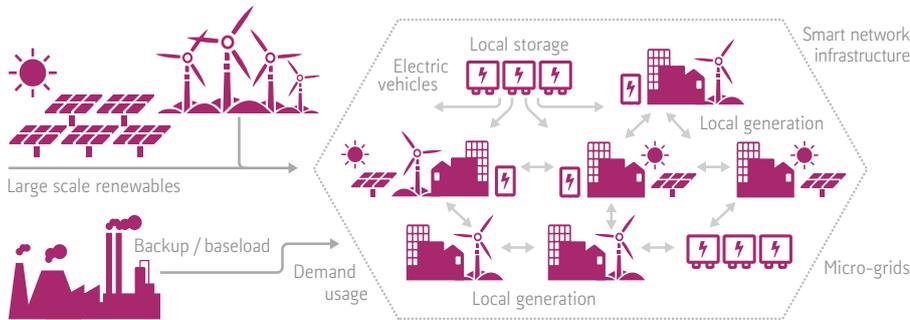
Although this “new world” presents opportunities to design and operate the electricity system in a more efficient way, the transition will not be without risks. Existing network operators will need to take on new roles and implement new systems, whilst market rules will need to be adapted to accommodate more localised energy markets running in conjunction with existing system level wholesale and balancing markets.

1. In the UK, the term “Distribution Network Operator” is more typically used, describing an entity that owns and operates the physical distribution network but does not perform energy balancing role of a “System Operator”. However, internationally the term “Distribution System Operator” is more generally applied, so we have used this terminology for the purpose of this Viewpoint.



### 'Old World'

- ▶ linear electricity provision provided by major utilities
- ▶ 95 per cent provided through large-scale generation and transmission
- ▶ niche distributed generation
- ▶ no Smart Grid / Smart Homes.



### 'New World'

- ▶ distributed generation providing significant proportion of domestic power
- ▶ Smart Grid and Smart Homes
- ▶ large-scale renewables on both the distribution and transmission networks
- ▶ local / DG battery storage and EV deployment
- ▶ remaining grid-scale storage
- ▶ emerging markets may not even require large-scale generation.

## ▶ Increasing complexity in the "new world"

Under the "old world" the relationship between the network customer and the DSOs was relatively straightforward: a new customer (typically demand, but sometimes generation) would determine the size of the connection required, the network operator would determine the cost of that connection, and the customer would decide whether to proceed with the connection on that basis. General network reinforcement could be planned based on relatively predictable growth in background demand.

In the "new world", the behaviour of network customers becomes more complicated to manage:

- large volumes of DG, storage assets, increasing demand-side flexibility, and new types of load such as electric vehicles and heat pumps can create complex and unpredictable power flows on the network, with the potential to affect the planning and operation of both the transmission and distribution networks

- customers are becoming willing to accept less firm grid access (ie accepting a level of curtailment) if it means it will reduce the cost or speed up the connection process, and may come to expect the option of a flexible connection in the future
- all customers (consumers, generators and storage) on the distribution network may choose (or be obliged) to offer flexibility to the TSO, resulting in variable import/export profiles and potential conflicts with the operation of the distribution network.

Managing these complex interactions is expected to become an intrinsic part of a future active DSO model. However, the initial steps along that road are already being taken. In particular, the increasing prevalence of flexible network connections<sup>2</sup> for generators provides a good opportunity to examine some of the potential opportunities and risks.



2. Sometimes called "alternative connections", "non-firm connections" or "Active Network Management connections"

## ► Flexible connections: a glimpse of the future DSO-customer relationship

Connections traditionally have tended to be financially 'firm' meaning that, as long as the network was operating normally, customers would get access to a fixed network capacity all year round. Under a flexible connection, if the network is constrained, the DSO can use Active Network Management (ANM) to curtail generators. This allows customers to connect to a constrained part of the network without needing first to reinforce it, making the process faster and cheaper.

In a world of increasing embedded renewable generation, flexible connections can be more economically efficient since:

- **renewables have low load factors:** Wind and solar generate at their maximum output only infrequently, so for most of the time they are not using their full capacity allocation
- **not all generators' outputs are peaking simultaneously:** With a diverse mix of generation and demand, the theoretical maximum is almost never reached, so it can be hugely inefficient to reinforce for the "worst case" scenario.

In most countries the cost associated with new connections tends to be shared between the developer and the network operator, as shown in Table 1. In those countries with "shallow" or "shallowish" connection charging, the DSO (and therefore its wider customer base) is required to pay for some of the upstream costs associated with new connections, and hence can benefit from flexible connections.

Table 1. Distributed Generation connection charging<sup>3</sup>

Shallow	Shallowish	Deep
Belgium, Portugal, Switzerland, Czech Republic, Germany, Italy, Netherlands, Poland	Great Britain, Sweden, France, Georgia, Lithuania	Denmark, Spain, Norway, Estonia

To date, developers in Great Britain have yet to embrace the idea of ANM connections wholeheartedly, despite the potential improvements in connection cost and speed. The primary reason for this seems to be that these developers

(and their lenders) are concerned about a downside curtailment risk that they are unable to mitigate. There are a number of possible options for alleviating these concerns as shown in Table 2 below.

Table 2. Options for encouraging flexible connections

Improve and harmonise curtailment estimates	Improve curtailment efficiency	Cap curtailment risk	Compensate curtailment
Provide better information (common data provision, assumptions and analysis) for developers to assess curtailment risks.	Reduce the expected cost of curtailment, perhaps by introducing market mechanisms, allowing storage and DSR to participate.	Provide a maximum level of curtailment beyond which a generator would be compensated.	Socialise curtailment costs by compensating generators for lost revenue.

Under a flexible connection, if the network is constrained, the DSO can use Active Network Management (ANM) to curtail generators.

3. Eurelectric (2013) Network tariff structure for a smart energy system, Online: [http://www.eurelectric.org/media/80239/20130409\\_network-tariffs-paper\\_final\\_to\\_publish-2013-030-0409-01-e.pdf](http://www.eurelectric.org/media/80239/20130409_network-tariffs-paper_final_to_publish-2013-030-0409-01-e.pdf)

Connecting to the lower voltage distribution networks is typically the most cost effective option for renewables projects, particularly the smaller scale or community-based schemes. The evidence to date suggests that it is possible to connect DG successfully under flexible arrangements without having to pass the risk onto end consumers or providing preferential treatment to particular technologies, but in order to do so developers need to be given the information and mechanisms to minimise their exposure to curtailment.

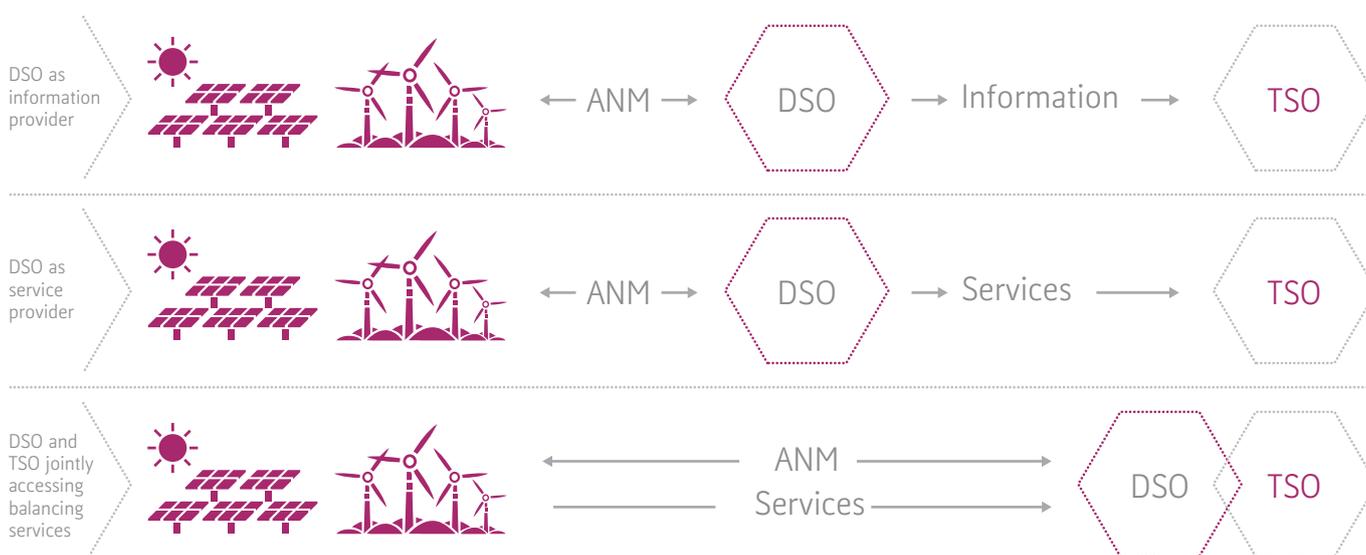
### ► TSO-DSO interaction in the DSO world

Flexible connections provide an early glimpse into one part of the emerging DSO role, namely the increasingly active relationship between the DSO and its network customers. However, the other crucial dimension to a future DSO role concerns the interaction with the TSO, given the increasing complexity of power flows and balancing across the transmission-distribution boundary. Figure 1 summarises some options for how that interaction might occur.

**Table 3. Comparing distribution connections between Great Britain and Germany**

Topic area	Great Britain	Germany
TSO-DSO consistency	Very different rules underlying curtailment by DSO vs curtailment by TSO	Broadly similar treatment of generator curtailment by DSO and TSO
Renewables priority	No preference allowed between renewables and non-renewables	DSOs must curtail thermal generators before they can curtail renewables
Curtailment compensation	DSO not obliged to pay for curtailment, with loss of electricity and green subsidy revenues	Renewables receive feed-in tariff revenues even if curtailed by DSO
Connection delay risk	Developers bear the risk of connection delays associated with the local works required for their connection	DSO takes on the risk of connection delays, compensating developers for lost revenues if they are late

**Figure 1. Options for the relationship between the future DSO and TSO**



The DSO could simply pass information about its network to the TSO. It could use the flexibility present on the distribution network to act as a service provider (as has been seen in GB with Electricity North West's CLASS project) or use a third-party aggregator to facilitate this. Alternatively, both the DSO and TSO could access the full suite of flexibility offered by connected assets, using market signals to find the optimal way to use those resources.

It is likely to be some time before a preferred option emerges, and it may be that different countries take different approaches. What we already know, however, is that even before DSOs start becoming truly "active", DSOs and TSOs are already considering interim solutions to manage the increasing levels of DG being seen on the networks:

- the TSO needs to anticipate future demand growth, which is made more difficult by DG offsetting that demand, especially when a lot of it is hidden behind customer meters, as is the case with rooftop solar, for example
- in some parts of the network, the volume of DG is such that for parts of the year generation is exceeding local demand, resulting in reverse flows onto the transmission network. If these reverse flows become sufficiently large, this can lead to transmission constraints and, ultimately, the need to reinforce the transmission network. These transmission costs are not necessarily seen currently by the DSO or connecting DG customer.
- on operational timescales, the TSO needs to balance the system on a second-by-second basis. The problem is that some DG is both unpredictable and invisible to the TSO, making this balancing more difficult and more costly.

As DSOs take on more of an active role, more potential issues arise. ANM allows more DG onto a given network, potentially creating constraints on the transmission network as explained above. More than this, though, the rapid and autonomous behaviour of ANM operated by the DSO can undermine balancing actions taken by the TSO. Some of the issues can be resolved through greater information sharing between DSOs and TSOs. Others may require protocols defining which parties can take which actions under what conditions.

Whilst it could appear as though the current trajectory creates more problems than opportunities for the TSO, this does not have to be the case. If the technology and processes can be sufficiently harmonised, the TSO could gain access, either directly through DSOs or through aggregators, to a large number of small generators and flexible consumers, thus increasing the level of competition in the provision of balancing services. That said, if a fully active DSO role does emerge, the TSO may have to compete to secure those new players' services.

The emergence of an active DSO role could result in profound changes to the interactions between the TSO and DSO, and the way in which the whole electricity system is balanced. It should also not be underestimated how substantial a change this could be for the operating models of the distribution network operators:

- if the TSO wishes to acquire direct control of distributed generation flexibility, this could involve a substantially more complex control room operation, and would need to take account of a range of constraints on the distribution network
- if, however, the DSO were to act as the intermediary between distributed flexibility and the TSO, this could require significant upgrades to its control system and processes, a more involved customer services function, and potentially a willingness to take on and manage commercial risks.

### ► Adopting price signals across the network

One of the key concepts behind the DSO model is that there should be a coordinated whole-system approach that makes the most efficient use of the available flexibility, combined with incentives to encourage new customers to connect at optimal network locations given their generation or demand characteristics.

The use of flexibility on the GB distribution networks to date has been largely limited to rule-based curtailment to manage local network constraints. Behind a given constraint, this curtailment has tended either to be shared equally amongst all constrained parties (a so-called "pro rata" approach) or imposed more

---

## The emergence of an active DSO role could result in profound changes to the interactions between the TSO and DSO, and the way in which the whole electricity system is balanced.

heavily on the more recent connections (so-called “Last In First Off”, or “LIFO”). Experience to date has shown that such mechanistic approaches impose curtailment costs that are higher than necessary, does not encourage the efficient siting of new resources, and becomes a cumbersome process to manage in all but the simplest systems.

Introducing price signals could have a number of advantages, including:

- finding the most economical way of using the available flexibility to manage a given network constraint, whether that involves curtailment, DSR, storage or network reinforcement
- providing the longer-term signals to all new customers to connect to parts of the network where they impose the lowest cost or have the highest potential benefit
- providing consistency with the approach already taken on the transmission network, thereby allowing flexibility to be used with maximum efficiency for the network as a whole, and providing appropriate reinforcement signals.

## ► Outlook – lessons and questions for the future DSO model

On the basis of the trends we are witnessing in GB, the future role of network operators is likely to be driven by a combination of technical innovation and market forces. We see a similar direction of travel in countries such as Germany, Denmark and Sweden where the DSO today is already playing an increasing role as market facilitator, taking a much more pro-active approach than had been seen in the past. These developments have been accelerated through the roll-out of smart meters and the introduction of time of use

tariffs, which encourage the installation of micro-generation and storage devices by consumers.

Because of the levels of coordination involved, there is an important role for network operators and regulators in ensuring that an efficient solution emerges that delivers benefits for the end consumer and wider society. Across Europe, the standards defining the precise TSO-DSO relationship, as well as on the role of the DSO in managing its customers and their associated flexibility, are still in a stage of regulatory infancy.

There is a tension between the need to provide a clarity of vision around which disparate stakeholders can rally and the need to keep options open as the range of viable technical and commercial models are explored. A related question is how feasible it would be to attempt to standardise the approach, within countries and across countries in Europe, and what benefits such standardisation could bring. It is worth remembering that we are not all starting from the same place so understanding these differences would be a sensible first step.

If standardisation is to be a goal, we may wish to address some of the following questions as we begin to define the role of the network operators:

- how should market design evolve to best facilitate the efficient investment in, and operation of, distributed energy systems?
- what does this mean for how TSOs and DSOs should be incentivised? What role can technology and innovation play in the incentives placed on the future networks?
- how do TSO, DSO and other stakeholder roles need to change to facilitate the energy transition?
- what changes will they need to make to their operating and business models to allow that to happen?
- how should networks be planned in the face of uncertainty?

The forthcoming 2016–2017 Energy Union package may help to clarify some of these questions as part of the European electricity market redesign discussions. Whilst progress has been made in many areas, there is clearly still a lot to do, and a great number of risks and opportunities are likely to present themselves. We look forward to discussing these issues with our customers and colleagues across Europe, combining the valuable GB experience acquired to date with related activities taking place internationally.



For more information please contact:

Erik Rakhou, Senior Manager, Energy and Resources  
erik.rakhou@baringa.com +44 (0)775 665 0308

Chris Collins, Manager, Energy and Resources  
chris.p.collins@baringa.com +44 (0)797 663 5731

## About Baringa Partners

Baringa Partners is an independent business and technology consultancy.

We help businesses run more effectively, reach new markets and navigate industry shifts. We use our industry insights, pragmatism and original thought to help each client transform their business.

Collaboration runs through everything we do. Collaboration is the essence of our strategy and culture. It means the brightest and the best enjoy working here.

Baringa. Brighter Together.

