Capgemini Consulting

Unlocking the Grid: Challenge and Opportunity in the UK Energy Industry

Executive Summary

The nature of energy generation and distribution is changing from a one-way process, with supply going from producer to the consumer, to a more distributed network where individuals and businesses are no longer simply consumers: they have the means to produce and supply power to the grid themselves.

This has significant implications for the UK's power generation and distribution industry as Distributed Energy Resources (DER), such as solar and wind power, change the way the grid operates. The system of the future will be less about transmitting power from a central source and more about the local management and balancing of generation, supply, demand and storage.

As a result the organizations and infrastructure needed to handle the UK's energy market need to change, with smaller Distribution System Operators (DSO) handling disparate sources of energy generation. In a move away from today's much larger Distribution Network Operators (DNO) the DSOs will operate with a more local focus, facilitating a market of multiple, small scale generators as well as remaining accountable for local demand balancing; under the supervision of a national Transmission System Operator (TSO) able to oversee the integrity and effective operation of the entire energy ecosystem. The future DSO will need to understand and operate a Smart Grid to maximum effectiveness and create and manage contractual and commercial relationships.

Faced with this fundamental change, today's DNOs must begin the transformation to a DSO over the next two years, developing the functionality and culture required to exploit the opportunity to grow and increase margin. This includes moving towards a substantially Smart Grid and preparing to enter RIIO2 as a DSO, with a robust business model and a platform to influence the regulatory framework that will oversee the new environment.

This paper explores the model that will best support that transformation, examining how the separation of the asset owner and system operator roles will allow one part of the organization to manage the requirement to build assets, whilst the other contracts with the wider industry to exploit the commercial opportunities of market facilitation and managing flexibility.

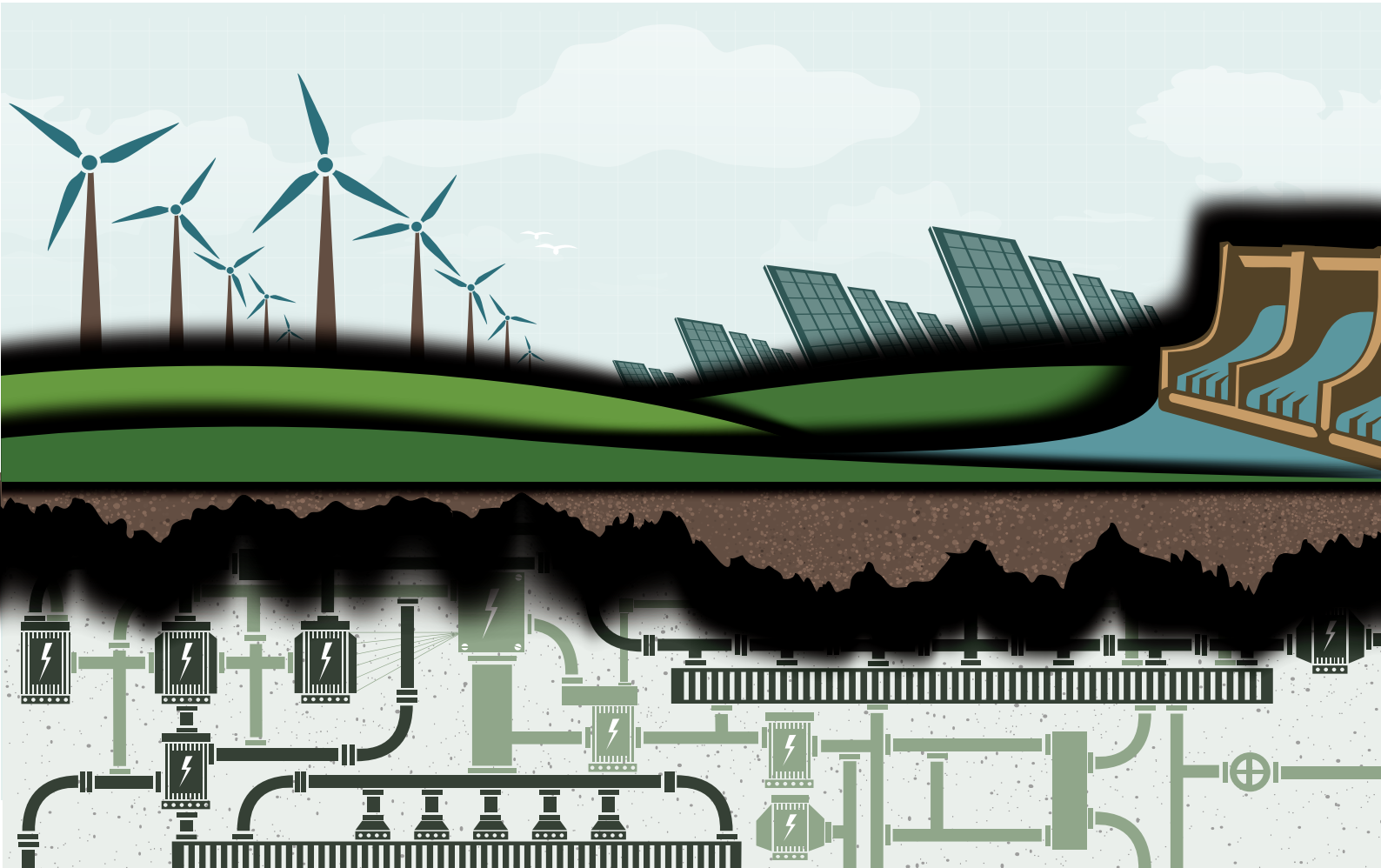
The DSO model is the future of the industry. If existing DNOs do not act they will be vulnerable to new and disruptive organizations that are ready to enter the market — and with RIIO2 less than six years away, change needs to start now.

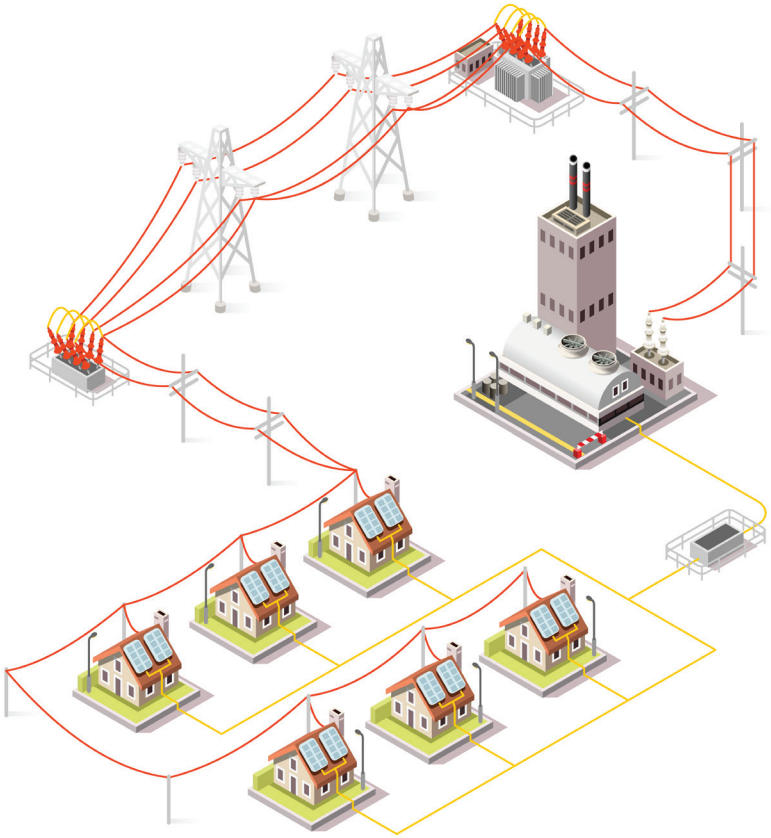
What is driving change in the power distribution system?

> **The future involves a DSO model predominantly supplied by Distributed Energy Resources. But when will we reach the tipping point?**

As the cost of renewable energy production falls, deployment increases, whilst coordination of the bulk power system across the national grid is driving down renewable energy integration costs. In addition, the lower price of renewable energy is encouraging customers to own their generation systems, providing resilience in the event of grid failure and a choice of where and how they source their power. This trend is likely to continue as the cost of most forms of DER is still declining, with sources including biomass, wind, solar PV and a multitude of distributed storage options, as well as electric vehicles.

Extrapolation of this trend suggests increasing penetration of DER and a larger proportion of existing consumers becoming simultaneous producers and consumers of power, or "z". As these technologies interact with the grid at low-voltage levels the power system architecture and organizational roles/ relationships will also have to change.

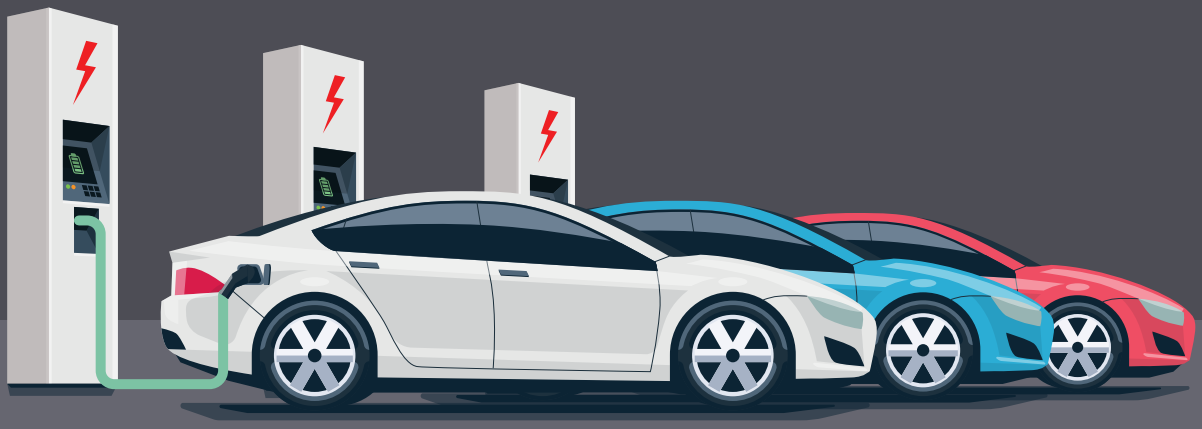




Thus it is clear that the future involves a DSO model predominantly supplied by DER. But when will we reach the tipping point? And what will the system look and have to operate like once this occurs?

Solar sources now provide 14GW of power across the UK – which just four years ago was the forecast for 2030. In addition, electric vehicles accounted for 4.2% of new cars registered in the UK last year – an increase of 28% over the previous year.

Clearly the tipping point is closer than many predicted and it would not be surprising to see close to 50% of the UK's power needs coming from DER in RIIO2. Indeed, some regions such as London and the South West may reach that point sooner.



What does the power distribution system of the future look like?

In Germany small DSOs provide upwards of 80% of load from DER.

Tomorrow's system will need to manage increased volatility of net demand, reverse flows from DSO to TSO level and complex/aggregated energy trading and contracts at a micro level.

The market must be able to aggregate and coordinate many supply/demand points to allow the on-going operation of the wider power system, whilst at the same time supporting the ability of the Prosumer to independently interact with their local system based upon their own needs.

What is more, if DNOs fail to interact with the individual Prosumers (likely to be higher credit individuals) as they move to DSO status, they may be left with a customer base of lower credit households that may well cost more to maintain.

The UK network is currently structured to make the most efficient use of the geographically spread resources of large power stations. If the requirement in the future is to knit together all types of DER then the current model could become unfit for purpose. Lack of action is not an option. If a DNO or TSO attempts to maintain its existing business model it runs the risk of increasing inefficiency, inadequate infrastructure or becoming the owner of 'stranded' individual assets.

DSOs will continue to ensure sufficient delivery capacity in the distribution network, report faults, status and anticipated demand to the TSO. However, as DER and local storage increase, requiring greater system flexibility, management information requirements will become more onerous. This will drive the TSO's coordination and management of the interdependence of DSOs, supporting them through bulk supply capacity. This will need a close working relationship between all parties to keep the system reliable and stable.

This model can be observed in Germany, where small DSOs provide upwards of 80% of load from DER and the TSO balances the system by pushing flow when required, acting as a net importer from certain regions at high sunlight/low demand periods.

This suggests four possible future states for the industry:

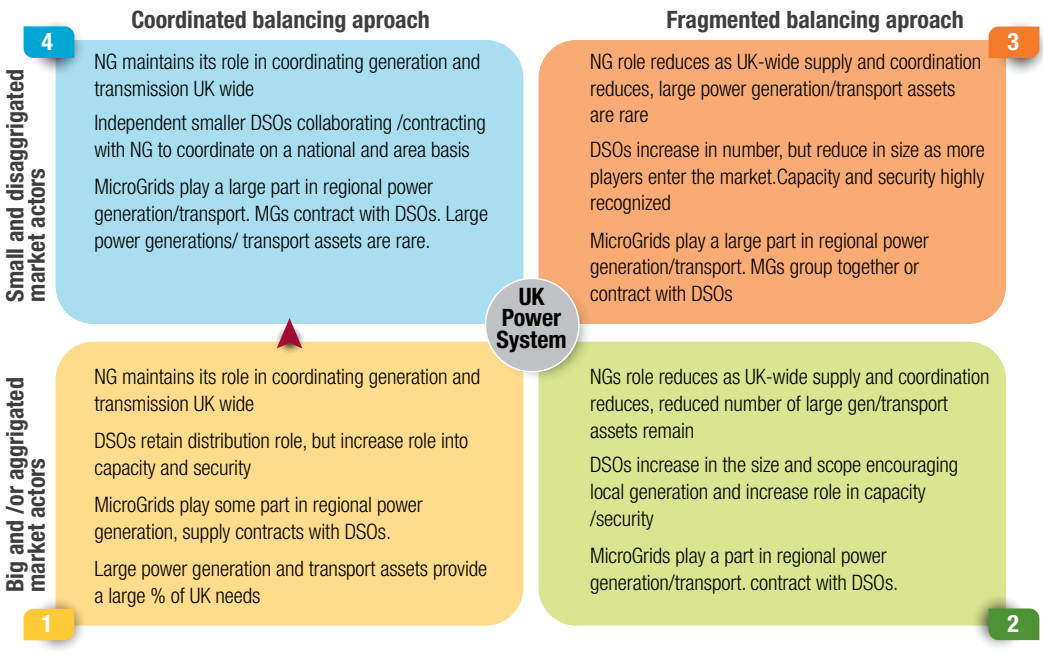
New Game, Same Players

- A 'status quo' model where the national TSO and DSOs remain the size and shape that they are, large assets provide the bulk of power needs and DER holds a complementary role.

Thin TSO, Broad DSO

- A fragmented power system, with a small number of large DSOs coordinating wide areas, and a reduced role for the national TSO.

'Lack of action is not an option.'



DNOs must act quickly to align themselves to the Managed Iterdependence model.

Ecosystem

- A fragmented power system, with a larger number of small DSOs managing small independent areas and a reduced role for the national TSO.

Managed Interdependence

- A coordinated power system, with a larger number of small DSOs managing small independent DER-supplied areas, with the national TSO shifting focus from predominantly managing supply through large assets to managing interdependence between areas.

Managed Interdependence seems the most likely future UK model for a number of reasons:

- There is still a clear need to coordinate the UK power system at a macro-level, regardless of where power is generated, due to the fact that access to power is a public need and some large generation will endure due to its inherent efficiency. Therefore there will need to be an overseeing TSO role.
- The increasing proliferation of DER will require more localized management which would lend itself well to smaller, focused System Operation business units that may be subsidiaries of parents which were the original DNOs we see today.
- Given the potential to separate Transmission Owner and System Operator roles, the opportunity exists for DSOs to own numerous smaller System Operation business units to enable them to be more nimble contractually in a very open market.

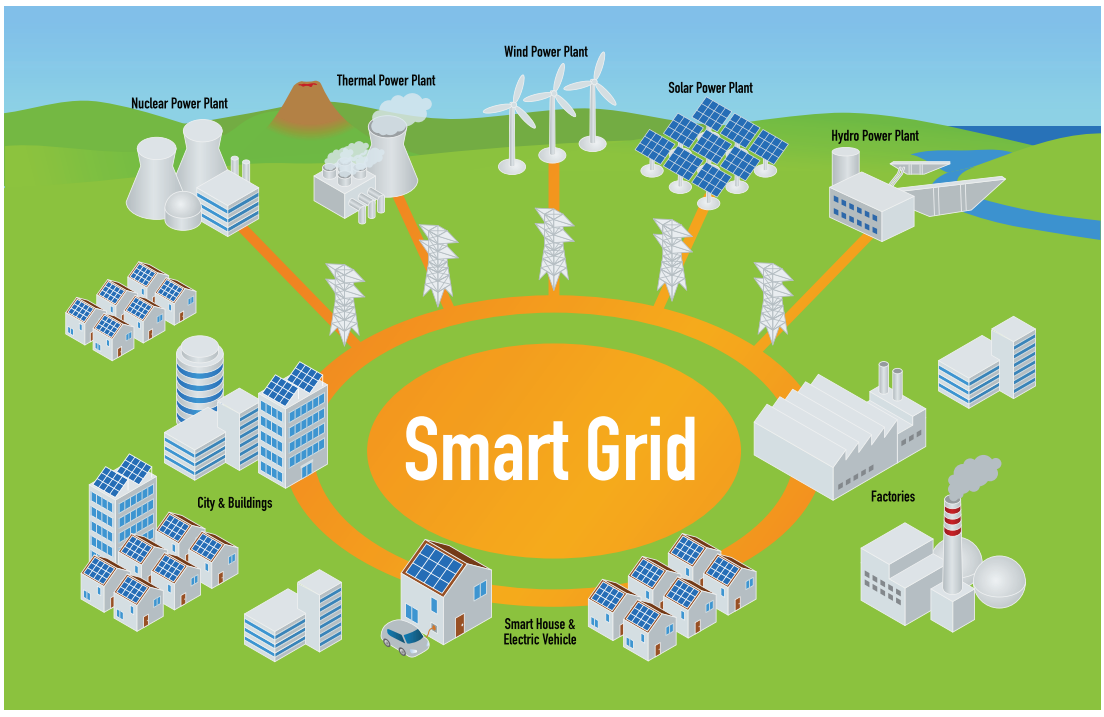
If the existing DNOs wish to be among those providing the future DSO services the pace of change needs to be high as other organizations will be ready to enter the DSO market and provide competition. DNOs must act quickly to align themselves to the above model.

What will be the responsibilities of UK DSOs?

If we assume the Managed Interdependence model then the DSO of the future will be responsible for a number of core services, with others that it may take on for business benefit. These core services will include coordination and balancing of the system; and an organization that creates the best platform for engaging all parties could dominate the new DSO market. This will entail balancing energy demands at a distribution level across the network through access to DER suppliers, heat networks, and the TSO. Interaction with the TSO will also support transmission-level balancing, as DSOs in different regions will have varying supply-demand balances depending upon geography, nature of built environment and demographics.

To achieve this position, the DSOs will be in charge of an increasingly 'smart' distribution grid as well as acting as a facilitator for the suppliers, Prosumers and other generators that access the grid. As such they will need to adapt their interactions to most efficiently meet the commitment of their core services.

- Beyond this there is the opportunity for the DSO provide other services to enhance market share and profitability.
- Active local electricity market facilitation, or network platform, for DER. Network access for other third parties. This includes formally contracting with Prosumers, generators, storage, aggregators and electric vehicle charge points for services to deliver the response required by the distribution grid.
- Becoming an owner and/or operator of electric vehicle charging infrastructure. This could even extend to owning/operating an electric car rental business as a way of providing mobile energy management.
- Providing energy efficiency and environmental consultancy services, such as options appraisals and potentially investment and/or entering into joint ventures on energy efficiency projects.
- Becoming an owner and/or operator of power storage and CHP plant, which may become increasingly important when the supply of DER power starts to outstrip demand in certain regions (this would require regulatory change).



- Taking on the ownership and management of public lighting, as opposed to just supplying the power, as is the model for some European DSOs.
- Provision of energy and consumption data at grid and micro grid/local level. There is large commerciality around the resale of insights derived from this data especially if the 'energy intensity' data is matched with socio demographic, climate, travel to work, spend and other market variance data. (This type of data analysis could be the platform for a Green Bank concept and allow for investment and carbon reduction evidenced through consumption, production and network losses to support sustainability and carbon reduction.)

Given the market model and the core/potential responsibilities, the shape of the DSOs' contractual relationship with the overall system will have many touch points. The model below demonstrates the complexity of these contractual relationships which will involve the TSO, neighbouring DSOs, and a wide range of DER generators. Each of the arrows represents a contractual/business relationship that will need to be set up and managed. One of the key aspects to note is that the TSO/DSO relationship is no longer a 'centre-out' one. It becomes highly two-way and may even be owned/driven more by the DSO than the TSO as the balance of power generation shifts from large central plants to regional DSO-controlled DER networks. DSOs thereby act as both market intermediary and market for distribution and associated network services.

Of course, for the DSO to take on many of the above service offerings and work within the contractual/relationship framework set out above there would need to be a shift in the regulatory landscape. This is something we address later in this document.

> ***DSOs will be perfectly placed to offer new, beneficial and profitable services.***

Energy efficiency consultancy is an interesting opportunity for the DSO. They have the opportunity to develop platforms to facilitate more DER and demand-side management. This will allow them to work with consumers to identify how they most effectively interact with these platforms to regulate their demand in terms of volume and timing or consumption, and to choose where their energy is generated (and how much could be self-generated/ stored). Given the visibility DSOs will have of both the demand and supply patterns of energy for all types of consumer they will be perfectly placed to provide this service.

DSOs could offer environmental services centred on green tariffs and the ability to identify and manage green energy use in a manner that supports carbon credits, largely in the industrial and commercial markets as an extension to what is in place today. The competition for DSOs in this space will come from the larger environmental consulting businesses.

How will UK DSO create new value?

It is clear that these services are only practical if they prove profitable, but the DSO will also need to demonstrate a public good in providing them in what will remain a monopoly position within a regulated market.

As enablers, the central demand balancing and coordination processes managed by the TSO will need to be well designed in consultation with DSOs in order to create a system where all can profit; and clearly the regulatory framework will need to adapt to the changing roles and innovations.

The DSO will need to develop a commercial model for the responsibilities and opportunities above. For example, local balancing of micro grids is likely to be an effort-intensive role, so there will need to be clear way to make this efficient and financially rewarding. The current distribution charging DUOS mechanism could be adapted with charges for Availability, Energy Shipped and Maximum Demand applied at a domestic level when a customer switches to being a Prosumer.

A central element of the local electricity market could be capacity auctions, where the DSOs set up auctions for various suppliers, Prosumers and aggregators to provide power directly to their grid, or via micro-grids. The DSO would need to do this in order to make money from entities connected to the grid that were net producers and not consumers (outside of emergency needs) such that the DSO derives some financial benefit by providing Prosumers the stability of being connected to their grid.

However, whilst a capacity auction initially sounds appealing, it does come with the problem that if Prosumers end up in a bidding race to the bottom for they may simply defect from the grid entirely, resulting in falling customer numbers. An additional social consideration is that those customers who can defect are likely to be from better-off demographics, which would leave the lower-income demographics with increasing grid charges to compensate. It is unlikely that and government would allow that situation to occur and this will thus be a key driver in Ofgem's decision making around the DSO model.

The auction trading model is likely to heavily automated and via a portal service, in some ways similar to the retail switching sites. The DSOs with the best platform will be the ones with first mover advantage over smaller players looking to enter the market.

Clearly there is a delicate balance to be struck here as the economic incentives for all participants need to be sufficient to make the envisioned system work. The DSO will thereby have to make money by trading 'flexibility' in the system at a regional and national level. This will require setting up virtual power plants by grouping Prosumers and other small generators – such as PV and wind – and working together to sell into the day-ahead market. To do this, the DSO will need to create a system with a clear incentive for participants to flex their consumption and production to meet the demand management needs of the DSO – in effect, back-to-back contracts which allow the DSO and other actors to make financial gain from

> ***The DSO will need to develop a new commercial model to meet its roles and esponsibilities.***

balancing the needs of the regional/national system – even if Prosumers will not actually have visibility, or even awareness that this is what they are part of.

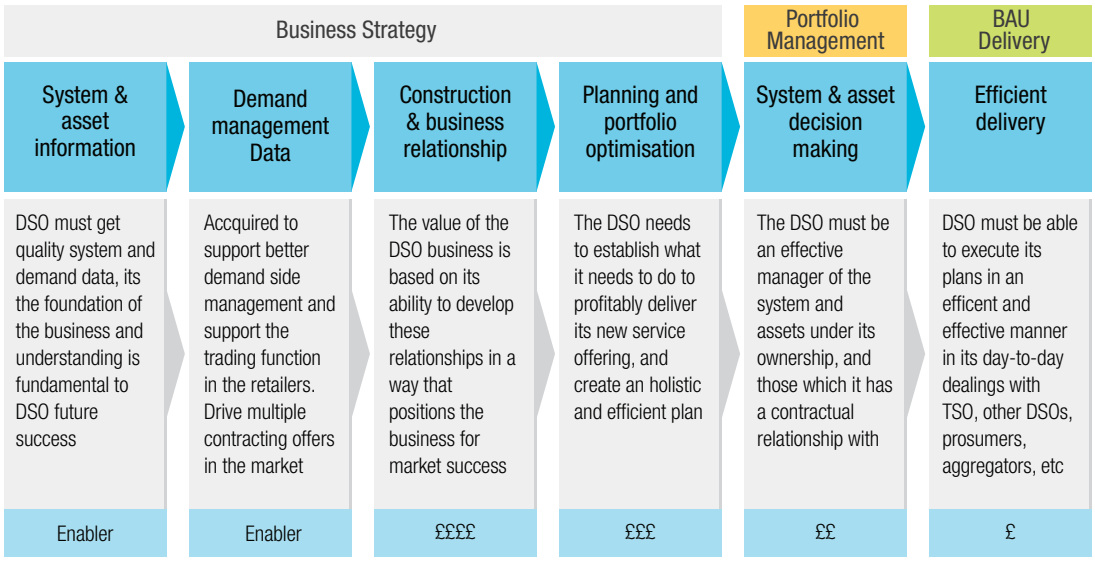
DSOs may even go beyond trading in flexibility to helping to create it. In areas of low DER penetration there will be opportunities to identify projects that will create DER capacity. The DSO would be well placed to appraise these projects for their ability to reduce overall generation costs, or serve the needs of distribution system flexibility. It could even invest or enter into joint venues (potentially with other DSOs). This might involve providing capital investment for the development of DER installations or CHP units.

Other commercial services which the DSO could get involved with include ownership of Electric Vehicle (EV) charging points and charging a fee for use. However, this is a problematic proposition due to increasing numbers of EV charge points increases the demand for EVs, which drives demand for EV charging points and therefore investment. The type of self-driving demand for capital investment makes the business case more difficult to reconcile.

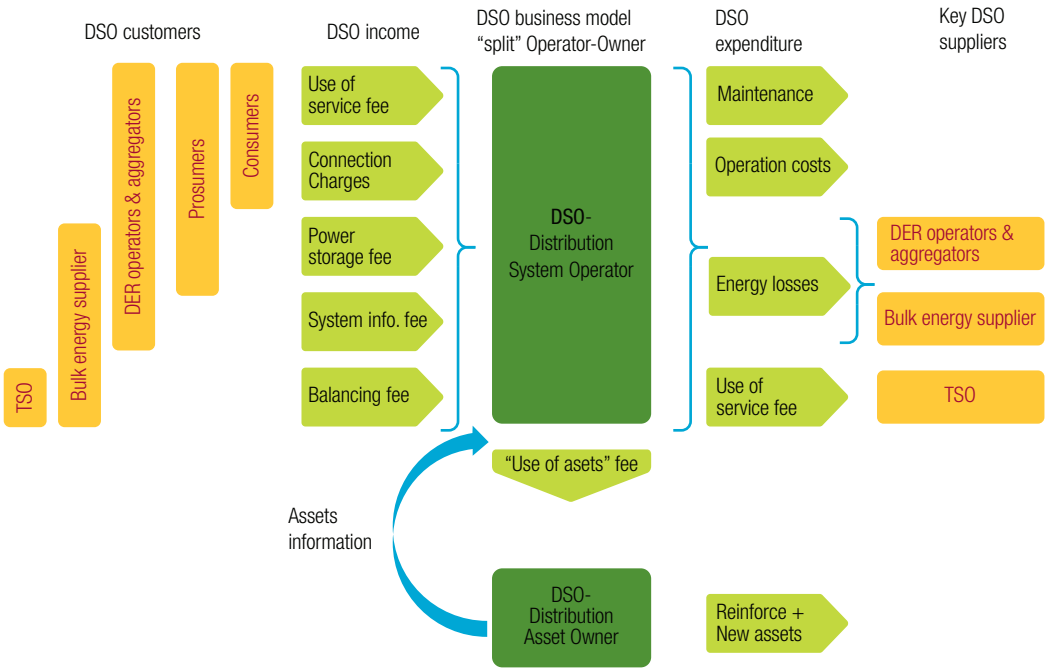
Regardless of the activities the DSO chooses to enter into it will need to understand where value is created in the organization, which will require thinking about the value chain.

The above value chain model demonstrates that if the new DSO is to create value, the opportunities are greatest at the business strategy end of the spectrum. Under the DNO model this has traditionally been at the regulatory funding end so it is clear that new skills and business thinking will be required. It will be imperative that the DSO has clear information about the system and assets (not necessarily directly owned) at its disposal. It will need to set out its contractual and business relationships in such a way that it can extract value from them when operating the system and it must be clear about what services are in its portfolio and how precisely they will be delivered.

If any of these things are not in place then effective system/asset management and efficient delivery alone will not create the necessary value. However, should all of the first three links in the chain be properly developed, it will enable the value created to be released into the DSO business.



What is the business model that UK DSO should adopt?



'There are a number of things that the DNO should be putting in place now to make the upcoming journey successful.'

As can be seen from the value chain above, asset information and the ability to manage contracts and portfolios are the key enablers to creating a profitable organization. Therefore there is a potential advantage for the future DSO to separate into two entities: System Operator and Asset Owner. An illustration of how this separated DSO Operating Model would look and should interact with the market is illustrated below, with the DSO entities shown in green.

The main advantage of the above structure is that the System Operator is free to contract with privately built assets as well as its own area distribution assets. In addition, the DSO may choose to have more than one System Operator geographic business unit to allow it to most effectively manage the range of relationships and interactions driven by the changing market. This allows the DSO to deliver flexibility using the exchange of real-time system data. The range of new technologies that are becoming available to interact with the DSO customers, such as Smart Meters and the wider Smart Grid, offer the possibility to make the above model work commercially.

This model would mean no change to current ownership of network assets and the Distribution Asset Owner could take on DER ownership if advantageous (and permitted by regulation) and become a supplier as well as a customer to the System Operator. The System Operator would remain familiar with its own geographical area's power system, but it would need to be separated in such a way that it would be free to become an operator in other areas (controlling more than one physical network) without causing a conflict of interest. In addition, a single existing DNO could separate itself into a single Asset Owner and a number of System Operators to manage the power markets locally and create more flexibility to enter into contracts and joint ventures.

What is the journey to the business UK DSO model?

Many DNOs have limited visibility of the operation of their current network due to poor data. In addition, there is limited existing capability to control and execute balancing. This means that the starting point for the journey is some way from the destination, even from a functionality perspective. In addition, interaction with customers is currently not high – as most of this is done by the energy retailers – so customer experience is at an early maturity level. There are a number of things that the DNO should be putting in place now to make the upcoming journey successful.

First 24 months – operating as a DSO 'Demand Balancing'

The DNO will need to develop a commonly agreed vision for the customer propositions it wants to offer to identify the capability, capacity, IT, process and knowledge gaps in its organization. This will provide a view of the size of the transformation to be undertaken.

As part of this transformation it will be essential to develop techniques to model the whole-system behaviour of the network and its new business interfaces. Given the increasing rise of DER and the rollout of Smart Meters there is already greater interaction and variety within the key processes such as operations, new connections, DER access, customer services and planning. This will require new skills, processes and systems to effectively manage and benefit from.

Out in the network, increasing amounts of DER will require investments to physically connect all new resources. SCADA, actuators and Intelligent Electronic Devices (IED's) will need to be deployed as part of the journey to creating a truly Smart Grid to manage the increasing volatility of net and peak demand. However, this investment should be offset by reducing the enhancement of existing facilities which are economic barriers to the integration of DER. So it is clear that asset planning and strategy will require a major review at an early stage of the journey.

Of course the Smart Grid in itself is only an enabler to operating as a DSO and, in order to operate the network more successfully, the DSO will require a control centre that works with embedded predictive analytics and AI. This centre should be able to take the data and information coming from the system and make automatic changes as necessary to balance the system. In addition, it will need to provide relevant and timely management information to allow manual adjustments as necessary. This will require multi-way links to interface with the DER network, the TSO and other DSOs to manage the multi-exchange of balancing power. In addition, this centre will need to be the 'brain' that supports the DSO in making relevant market trades.

Remaining RIIO1 period – thriving as a DSO

Two to three years from now the DSO should look to separate the System Operator and Asset Owner businesses. There would be clear strategic and organizational steps to undertake in order to make this a reality:

Strategic steps

- Decide where the organization wishes to be with respect to a DSO maturity level, by when, and then clearly define a strategy/roadmap to get there and any innovation projects needed to support the journey.
- Set out the approach for regulatory engagement and driving regulatory change to support the vision, including incentives modifications and social equitability strategy.
- Agree the approach for industry engagement, including licences, code modifications, and how DSOs can work together and with the TSO for wider industry advantage.
- Design the internal organizational boundaries encompassing the role and relationships of the System Operator and Asset Owner for day one separation.

Organizational steps

- Define the target operating models comprising the organizational scope or the separation and executive reporting lines and structure.
- Design the external organizational boundaries with external interfaces, including shared services, for day one separation.
- Develop the business case for both entities including the markets to enter and avoid now and in the future; e.g. electric vehicle charging, CHP ownership, street lighting, consultancy and modelling.
- Develop the market model and contractual framework regarding how the new entity will address the market and what contractual terms it wants to promote.
- Develop the capabilities required to operate the new model such as new contractual, commercial and asset management/operation capabilities will be critical.
- Design the information architecture to operate the new model, including systems and data flows/usage.
- Develop the future service offerings, e.g. Demand Side Response.
- Develop a model of socio-economics and demographics against energy intensity/use to identify and target interaction with likely Prosumers.
- Develop customer-focused views of some of the key processes with high customer interaction, such as provisioning of new connections.

Of above tasks, the one which should be planned and executed first is the regulatory strategy. In order to create the landscape required for a successful transition, DNOs will need to work with the regulatory bodies to ensure that regulation is updated so the existing business model is not negatively affected by the proliferation of DER over the next 24 months. In fact, DNOs should push for incentives that promote the integration of new technologies and generate R&D funding, thereby showing clear system planning and operational benefit from DER as early as possible.

DSOs are certain to remain as regulated organizations well into RIIO2, and their activities could become limited by an overly restrictive regulatory framework. It is therefore important that the DNOs do not try to predict what the exact DSO business model will look like. DNOs should be working to help refine RIIO2 incentives that enable them to design the optimum model to create a profitable business which meets the needs of the customer and the wider electricity system/market and can react to changing technology and consumer behaviour.

What are the challenges?

There are further complications that the DNO will need to understand and manage:

- Access to finance for capital investment.
- Increasing numbers of participants becoming involved in the sector, including potential long term disruptive plays from companies such as of Tesla and Google.
- Changing nature of energy use by both the public and corporations.
- Environmental concerns and regulations.
- Increasing competition for appropriately skilled resources.
- Increasing customer access to information and the increasing data security requirements.
- Resilience and security of supply targets.
- Expectation of greater control and better decision making through Smart Meters/Smart Grid/IOT.
- Regulation failing to keep pace with industry change needed to make the new system work.
- Assets dealing with increasing fluctuations in voltage levels and power quality, leading to shorter lifespans.

All of the above challenges will need to be incorporated and addressed during and beyond the transformation journey to DSO.

How can Capgemini support DNOs in their journey?

As a DNO you need to understand how you can successfully transition from the 'early smart' world to the reality in 24 months' time when the majority of customers will have Smart Meters. Beyond this you will need to have a clear vision of how your organization will need to operate entering RIIO2. Capgemini can help by:

- Framing the challenge through building awareness of the new DSO world within your organization, and defining the start point and target organization design
- Focusing investment by refining the change portfolio and transformation roadmap to meet the desired design and creating the relevant governance model
- Accelerating the speed of change within your organization to achieve and maintain a market-leading DSO position.
- Holding meaningful engagement sessions with key members of the organization to ask the challenging questions needed to maintain the change and drive the necessary cultural change.
- Bringing an understanding and experience of the technological, data and digital landscape into which the DNO will be journeying based upon our experience of working with DSOs across the world.

About Capgemini

Capgemini is working on some of the largest business transformation programmes for DNO/DSO organizations as they make their journey from early Smart, through Smart Grid and onto full DSO services. In addition, we are engaged with the UK national TSO on its current Asset Owner – System Operator strategic separation. This gives us the insight to help organizations at the early part of this journey, through the 24 month transformation and on to their longer term strategic objectives.

As the world's number one provider of smart energy services we are helping major players in the industry to manage all stages of the DSO lifecycle, involving over 43 million utility customers across 30 Smart Grid and Smart Meter programmes. We are also leaders in the application of digital technologies and data to address business challenges, such as the ones facing those on the DSO journey. IDC has given Capgemini Leader Ranking in the Worldwide Digital Transformation Services providers for Utilities

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