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# Unlocking the capacity of the electricity networks

overview

We are publishing this document to give you an overview of the status of constraints across the distribution and transmission networks and the changing interactions between them. In constrained areas, the network does not have the capacity to transport the electricity required or produced from a new connection. Industry is beginning to respond to these challenges, working with the Energy Networks Association (ENA) to improve coordination at the network interface. Distribution Network Operators (DNOs) are drawing on new, more flexible approaches to managing their network and enabling connections, releasing capacity for customers in constrained areas, while Connect and Manage arrangements are speeding up transmission connections for generation.

But there is more to do – new practices need to be embedded into the toolkit of options considered as business as usual. It is also important that practices evolve to remain efficient as the system changes, both for connecting customers and the system overall. In doing this, network operators need to engage constructively with customers to understand how best to meet their needs. We will also need to ensure regulation continues to support the best outcomes and we will consider this as we take forward our thinking on the transition to a smart, flexible energy system, signalled in our recent joint Call for Evidence with BEIS, to enable an efficient low carbon future system.

## Overview

1.1. An efficient process to get connected to the electricity network is essential for the social and economic wellbeing of the country. Large amounts of low-carbon technologies need to connect to our networks to help meet our climate change targets[1] and the economy is supported by new businesses and homes being energised. Timely electricity connections of all types are essential for the efficient and secure low carbon future system.

1.2. Our role is to achieve the best outcome for consumers. This means making sure customers can get connected as efficiently as possible and that costs are allocated to the right customers, to the benefit of both individual parties and the system overall.

1.3. The way we use the electricity system has begun to change. Generation is becoming more distributed and new forms of flexible demand are emerging. Some parts of the distribution network now have limited spare capacity, meaning that connection customers can face a long wait to connect and higher costs because of the work required to accommodate them. We have published this document to give an overview of the

[1] The UK is committed to reducing greenhouse gas emissions by 80 per cent relative to 1990 levels by 2050. The UK also has a shorter term target under the EU Renewable Energy Directive to achieve 15 per cent of final energy consumption from renewable energy sources by 2020.

status of constraints across the transmission and distribution networks and how the interaction between them can have an impact.

1.4. In our 'Quicker and more efficient connections' (QMEC)[2] publication in 2015, we outlined some of the issues customers face in connecting to the distribution network and consulted on ways to make this process easier. We want to highlight the improvements the industry has begun to make since then and outline our expectations for continued progress. In this document we also describe the transmission access regime arrangements ('Connect and Manage')[3].

1.5. DNOs must continue to improve how they respond to their customers' needs, while stakeholders should engage proactively with the DNOs, including using the RIIO-ED1[4] Incentive on Connections Engagement (ICE)[5], to signal their priorities. The industry must build on progress so far to ensure customers benefit from a responsive connections process, based on efficient use of the network and approaches to new investment to benefit the whole system.

1.6. Our recent joint Call For Evidence[6] with the Department for Business, Energy and Industrial Strategy (BEIS), on a Smart, Flexible Energy System considered how the management of the networks may need to evolve to meet the changing system needs. New technologies and approaches that enable efficient and flexible use of the network help to manage distribution network constraints and can support an efficient wider system. We will consider any next steps on distribution constraint management and the interactions with the wider system in the context of our forthcoming Spring Plan[7] publication.

## Background

1.7. Historically, generation connected primarily to the transmission network, exporting power to demand concentrated on the distribution network. Additionally, patterns of demand tended to be relatively predictable, generally with enough spare capacity on the network to accommodate changes in network usage.

[2] The QMEC consultation and subsequent publications can be accessed here.
[3] The 'Connect and Manage' regime was introduced in 2011 to improve access to the electricity transmission network. It is designed to allow earlier connections to the network for new generators, but can result in additional network constraints.
[4] The RIIO-ED1 price control set the outputs that the 14 electricity DNOs need to deliver for their consumers and the associated revenues they are allowed to collect for the eight-year period from 1 April 2015 to 31 March 2023.
[5] We expect DNOs to provide good service to customers that are seeking to connect. In RIIO-ED1, we have introduced an incentive to encourage DNOs to provide good service to customers that are seeking to connect. DNOs must provide evidence that they have engaged with their larger connection stakeholders and responded to their needs. If they fail to do this, they could incur a penalty. Further detail on the ICE can be found here.
[6] The joint Call for Evidence with BEIS on a Smart, Flexible Energy System can be accessed here.
[7] This refers to our plan for enabling a smart, flexible energy system which we intend to publish jointly with BEIS.

1.8. Recent growth in connections for new generation to the distribution network has outstripped industry forecasts in certain technologies such as solar, as shown in Figure 2 below[8], with some regions experiencing a particularly high take-up of generation. The six DNO groups and their 14 licensee regions across GB are shown in Figure 1, below.

1.9. At the end of 2011, generation connected to the distribution networks was estimated to be around 13% of total generation capacity in GB. By the end of 2015 this proportion had approximately doubled to 26% - around 24GW[9].

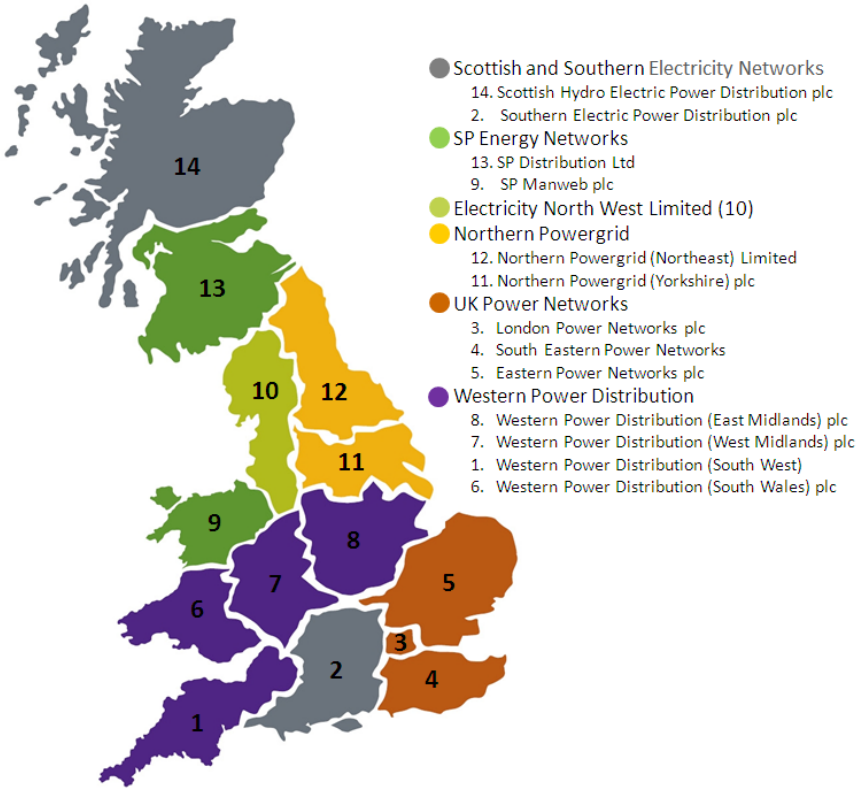


**Figure 1 – DNO location and ownership**

1.10. Overall, DNOs report around 27 GVA of distributed generation[10] connected to their networks as of May 2016, with a further 20 GVA waiting to connect[11]. It is therefore

[8] Figures for solar deployment are published here; 'forecast level for 2020' overlay line derives from industry estimates
[9] This data was reported from DUKES 2016 – chapter 5
[10] This figure reflects the amount of reported generation connected by DNOs and may not be comprehensive, for instance will not capture microgeneration. Some DNOs do not include lower voltage levels in their queue reporting. VA is the unit of apparent power. Electrical engineers use this when designing and operating power systems because it takes into account active power (W) and reactive power (VAr). Even though reactive power does no real work it still heats conductors and produces losses so it has to be taken into account in sizing and running the electrical system.
[11] The totals 'waiting to connect' are reported by DNOs as those in the connections queue with an

increasingly important that DNOs efficiently and flexibly manage, both the generation that is already connected as well as those who are waiting to connect.

1.11. While generation is becoming more distributed, local consumers are changing their patterns of demand and customers are looking to connect more low carbon technologies such as storage and electric vehicles. It is not clear exactly how quickly these technologies will appear and how they will be used[12]. But an increase in customers wanting to connect can lead to congestion, creating or exacerbating network 'constraints'.

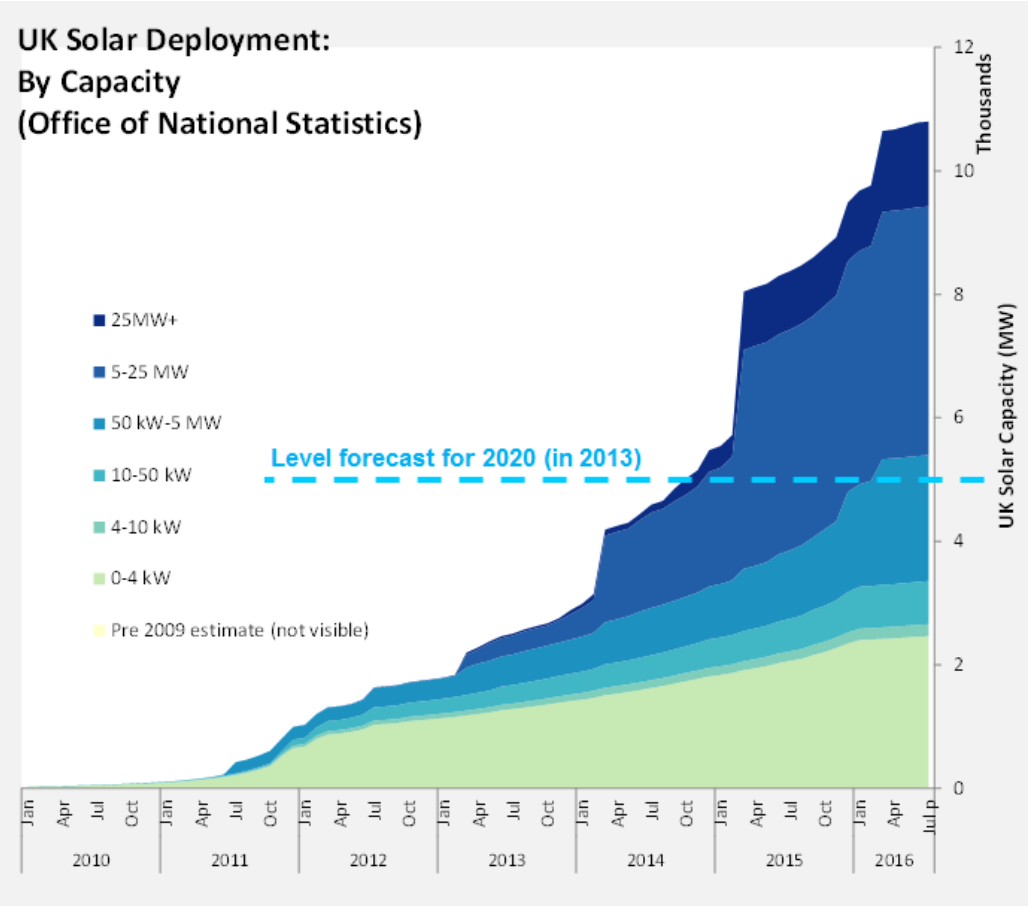


**Figure 2 – Solar PV deployment (solar deployment source ONS; forecast level indicated derived from industry estimates)**

1.12. Constraints are driven by technical limits on the network: broadly thermal, voltage, and fault-level[13]. DNOs and the Transmission Owners (TOs) and the System Operator (SO) plan and build the networks taking account of these physical limits,

offer accepted, at time of reporting in May 2016. Further to this, a significant amount of generation, not included in this figure, has received a connection offer but has not accepted it.

[12] For example, storage technologies have recently begun to develop very quickly, which has led to a significant increase in the number of connection application requests. Though in some cases, these technologies also offer the potential to change how the network is used and may help alleviate some constraints.

[13] Further detail on each of these is provided in the accompanying document.

various technical standards, the operation of their network, and the capacity already reserved for other parties through existing connection agreements or live connection offers in the 'queue'.

1.13. Some level of network constraint is healthy and part of the normal reinforcement cycle - a network that has excess spare capacity is likely to be oversized and underutilised, meaning we would all be paying more than we need to. If constraints are not efficiently managed, they can have negative impacts, both directly on parties looking to connect and more broadly on the costs of the electricity system overall.

## What are the impacts of network constraints?

1.14. As the use of the local network changes, constraint levels for new generation have risen, making it more challenging to manage them. In turn, interactions with the transmission system are also changing and actions or congestion at distribution level are more able to affect the operation of the transmission system and vice versa.

1.15. The impact of these physical constraints is that new customers may be unable to connect in areas where the network can't transport more power[14]. This has implications for the amount of investment required – by DNOs and connecting customers – to accommodate new connections, and/or for the value of the connection for the customer (if they cannot export power when they want to).

1.16. These impacts may be felt by connecting customers and wider consumers in a few ways:

- On the transmission system there is a clear and direct cost for consumers of managing congestion through the SO's system balancing actions, including constraint payments to generators associated with the Connect and Manage regime. In the accompanying document we describe the regime, as well as the Network Options Assessment process the SO follows to try and manage future constraint costs.

- On the distribution system constraints may mean customers can't connect to the network when and where they would like. This can occur even if the network isn't actually full, by customers who are ahead of them in the connection queue holding on to allocated capacity even when their project is not progressing, or if customers that are connected don't fully use the capacity they have been allocated. This can increase costs for connection customers and may mean new developments are delayed, have to move to another location on the network or don't proceed at all.

- The interaction between transmission and distribution constraints may also cause inefficient outcomes. Transmission constraints can restrict generation connecting to the distribution network. Where the energy exported from the distribution

[14] The process for connection to the distribution network and associated policies is described here.

network is constrained at the transmission level, the SO's actions (eg constraining generation elsewhere/carrying out work on the transmission network to accommodate new generation) may lead to a sub-optimal solution for the system overall if not coordinated. Equally, it is important that locally connected providers are able to access markets and provide services efficiently to parties elsewhere on the system, including potentially to the SO.

## How are constraints being managed?

1.17. Supported by our innovation funding[15], DNOs are now offering flexible and innovative arrangements which are enabling faster, cheaper, connections and may lead to reinforcement being deferred or ultimately avoided where future demand is uncertain[16]. They are beginning to increase the available capacity through using the existing network more efficiently and exploring new approaches to deliver investment where needed.

1.18. In our QMEC work, we set the DNOs the challenge of delivering a plan to make best use of existing capacity, including offering these new, innovative techniques as part of their business-as-usual range of options and make best use of existing capacity. We also invited DNOs to come forward with trials that could justify building new capacity in advance of need.

1.19. Flexible connection schemes are now a feature of many areas on the constrained networks and have released a significant amount of network capacity, with more schemes planned. DNOs report around 3.7 GVA[17] of connection offers have now been enabled through a combination of flexible connection arrangements and more active management of existing and new capacity. This is being achieved through different approaches across the networks.

1.20. Figure 3 shows the flexible schemes that have been implemented and are planned to be deployed across 5 DNO groups (corresponding to 13 of 14 DNO regions). ENWL is not shown on the chart as it is the only DNO group not to report any constrained areas

[15] The LCNF innovation funding mechanism in the previous price control supported testing of a range of innovative approaches. This is continued by the NIC and NIA in RIIO-ED1. Further information on current network innovation mechanisms can be found here.
[16] SSEN tendered for flexible alternatives to network investment in their Constraint Managed Zones – further information can be found here.
[17] Most DNOs report 'capacity made available' through flexible connection arrangements as the extent to which the combined maximum (non-firm) export capacity of the generation connected or for which offers have been made to date exceeds the firm capacity of the network. For SPEN and SSEN "capacity made available" shows the capacity made available to the customer(s), ie the capacity offered, which includes some firm capacity. UKPN notes its ANM schemes may be able to offer more capacity than reported, depending on the technology type and constraint level.

of its network which would require 'significant' reinforcement to connect generators of certain sizes.[18] [19]

1.21. The ENA has produced a Good Practice Guide for implementing Active Network Management (ANM).[20] This guidance also begins to highlight key considerations which network companies need to take account of to ensure efficient implementation of ANM, and these approaches may need to evolve to ensure they deliver benefits going forward.

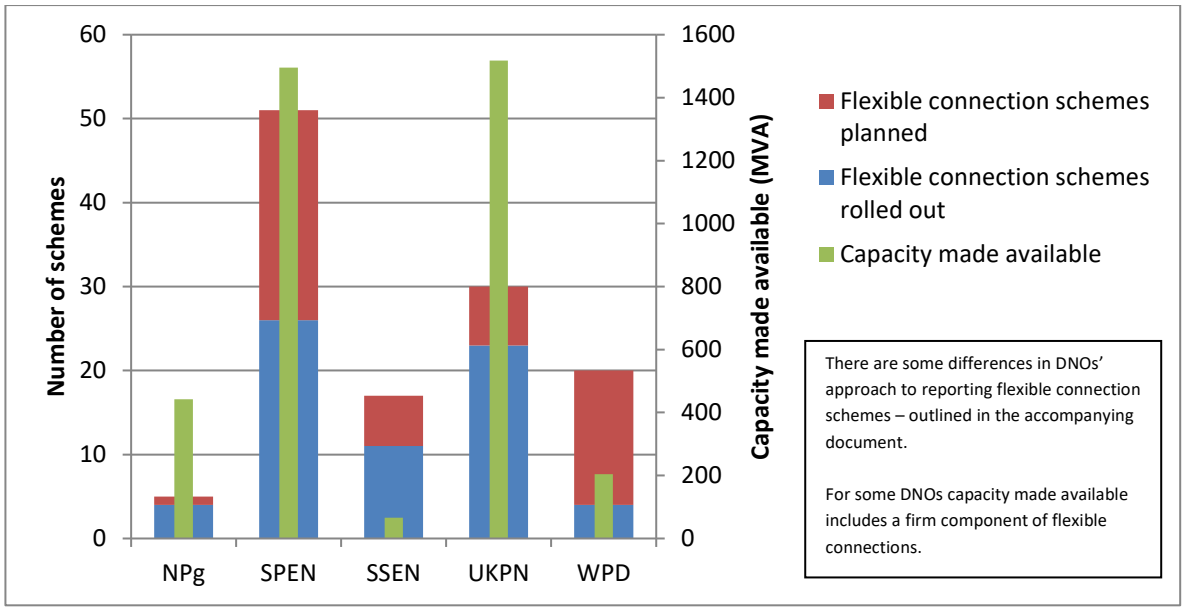


**Figure 3 – Flexible connection schemes implemented, with capacity released, and schemes planned as of May 2016.**

1.22. Half the DNOs have now conducted trials of approaches to anticipatory investment and the Scottish DNOs have recently had success in leading consortia to do so. SPEN has reported it led four consortia developments totalling almost 700 MW of contracted or connected projects - their mid-Wales development[21] making up almost 500 MW of this figure, plus two other developer-led consortia schemes totalling 90 MW. SSEN reported a number of smaller consortia now being progressed as well as Grudie Bridge (28 MW

[18] In seeking to assess the scale of constraint, we asked DNOs to indicate areas of their network where significant reinforcement would be required to connect generation of 5 MW and 25 MW, and where they would be able to make a flexible connection offer. Further detail is provided in the associated document to this overview.
[19] ENWL currently does not report the same need to manage congestion through flexible arrangements, but stakeholders say they experience constraints locally. ENWL says it expects to be in a position to offer ANM to customers in approximately 18-24 months following installation of a new network management system with the appropriate functionality, but does include the ability to curtail in abnormal system conditions in its standard connections.
[20] The ENA's Good Practice Guide for ANM can be accessed here.
[21] Further information is available here.

equating to 70% of the hydro capacity due to connect in Scotland in 2016), detailed in the accompanying document.

1.23. A similar approach has been initiated on Orkney with 64 developers having indicated an interest in sharing the reinforcement costs required to connect an additional 434 MW of generation on the islands.

1.24. Collectively, the industry (through the Energy Networks Association (ENA)) has established a new TSO-DSO Transition Project, which replaces the previous Transmission-Distribution Interface group[22] that looked at areas which need coordination between distribution and transmission. This work aims to address the increasing need for coordination across all aspects of system and network operation, including in managing congestion, facilitating connections and coordinated active management of the system.

1.25. Particular areas the group are considering under the four workstreams include principles for the co-ordination and management of TSO and DNO constraints, ANM principles of access, high level commercial agreements required between SO, DNO and the customer for sharing of flexibility services, whole-system charging, consistent customer experiences, statement of works process, storage and the potential models for the distribution utilities as they transition to DSOs. In addressing these issues the project aims to ensure maximum benefit to the customer, facilitation of renewables and low carbon technology and a resilient and secure network.

## Our expectations

1.26. As we decarbonise, DNOs will need to provide timely connections to the network at an efficient cost, whatever the future trajectory of new technologies looking to connect. DNOs must be proactive in their approach to planning and forecasting and the choice of flexible connections they make available. They must understand what constitutes best practice, they must listen and respond to their stakeholders' changing needs and they must manage their investments efficiently.

1.27. Recent progress suggests the industry is beginning to respond to these challenges. However, new arrangements can bring their own problems and stakeholders indicate that more progress is needed. For example:

- A lack of information about network availability can hinder customers' assessment of options when planning their projects.

[22] For further detail please see the ENA website: http://www.energynetworks.org/ . Particular areas the group are considering include principles for the co-ordination and management of TSO (Transmission System Operator) and DNO constraints and ANM principles of access, high level commercial agreements required between SO, DNO and the customer for sharing of flexibility services, whole-system charging, consistent customer experiences, statement of works process, storage and the potential models for the distribution utilities as they transition to Distribution System Operators (DSOs).

- Alternative connection options are not always readily available in those areas of the network that are (or are likely to become) most constrained.
- If a connection customer has high or uncertain curtailment levels and is unclear over whether further reinforcement is planned, they may be prevented from accessing markets or providing services. This may limit the benefits they can offer to the system and ultimately the value they create for consumers.
- If the interaction between transmission and distribution constraints is not effectively coordinated it may contribute to inefficient outcomes through restricting network access or other potential impacts of local actions in actively managed schemes.

1.28. There is uncertainty about the exact growth rate of different technologies and when the future challenges will become most pressing. But the pace of change is rapid and it is important that the progress made by the industry is equal to this and can support changing requirements as they emerge. We consider further progress will be needed in these areas:

**An efficient connections process including use of flexible approaches**

- DNOs now have many options, including flexible connections, which they can draw on to manage their networks efficiently. By identifying where there is likely demand for new connections, DNOs should also be able to identify when and where to roll out flexible connections or other innovative approaches.
- At this time, we believe that each DNO is best placed to identify the most suitable approach to deploying flexible connection arrangements for its customers and local network conditions, within the regulatory framework. To do so, however, DNOs must engage constructively with their stakeholders, including on new or innovative proposals and understand the range of approaches taken by other DNOs and stakeholders. They should identify and embed best practice, building on the considerations outlined in the ENA's earlier work on good practice in ANM, and more recently on transmission-distribution interface issues to consider in particular potential impacts on the wider system[23].
- Whatever approach they take, we expect consistency in outcomes. Customers, wherever they are, should be offered an appropriate choice of connection options, with the necessary information to help them make informed investment decisions, based on locational signals. It is important that DNOs provide sufficient information about network availability, capacity and connection options to give customers the early opportunity to locate in areas where capacity is available. As the system continues to evolve, DNOs should review and develop their approach

[23] Relevant points in the ENA's Good Practice Guide for ANM include the importance of certainty, triggers for reinforcement and approaches to curtailment.

and use of the range of solutions available to ensure they remain efficient, being flexible in how they meet the needs of their stakeholders.

- DNOs must embed into business as usual, the good practice stemming from work under QMEC to manage the connection queue better, working with customers to understand how they can meet their requirements. This may involve developing a better understanding of their customers' different needs and the issues they face when they want to connect, such as in the planning process. As an example, if a DNO can demonstrate that other customers in the queue can benefit from storage being connected in an area, through enabling quicker and less costly connections, they should promote storage in that context, providing more information on where it should connect, for example within their heatmaps[24].

- They must address the challenges involved in providing a common characterisation of the levels of constraint across their network, and customers' requirements for network capacity, to ensure DNOs and their stakeholders can build a clear understanding of how capacity is being managed, where spare capacity is available and where more can be done to manage constraints and their impacts.

- Stakeholders should take the opportunity created by incentives such as the Incentive on Connections Engagement (ICE) to engage proactively with the DNOs in shaping their connections offerings.

- In integrating these approaches into business as usual, DNOs are becoming more active in managing power flows on their networks, a key part of the transition to DSOs, which we signalled the importance of in the Call for Evidence[25]. DNOs should build on enhanced monitoring, forecasting and planning, proactively assessing and anticipating the changing requirements of their networks and ensuring they are ready to respond.

**Efficient and coordinated use of available capacity**

- The value customers put on network access can change over time – both their long term requirements and short term fluctuations. DNOs should explore further new ways of allocating capacity more effectively and dynamically and highlight any barriers to doing so.

- In doing so, network operators and the SO should try to understand and manage interactions between the distribution and transmission networks and the needs of customers. It is increasingly important that DNOs, TOs and the SO work together to plan their networks efficiently, including in enabling new connections, as is

[24] Further detail on the arrangements relating specifically to storage is given in the Call for Evidence referenced above.
[25] Chapter 5 of the Call for Evidence focuses on the roles of parties in system and network operation.

recognised by the TSO-DSO Project and in the ENA's Good Practice Guide. Congestion should be managed at the most efficient point on the system, with the costs and value of actions across transmission and distribution considered in the design of flexible connection arrangements.

- DNOs, TOs and the SO should consider their work from the QMEC trials and in the TSO-DSO project, as well as how their approaches can enable efficient access to markets, and ensure flexibility is valued across the system.

**Efficient investment signals and processes to bring forward new capacity as required**

- Locational signals should be based on a robust and holistic view of options across the networks and used to let required investment be identified and delivered where flexible arrangements are no longer efficient. This should be informed by a coordinated planning process and clear view of stakeholders' requirements.
- Good practice in identifying and implementing new approaches to anticipatory investment needs to be embedded into business as usual across all DNOs.

## Further work

1.29. The industry has made a promising start in initiating work to address these areas. However, it must make further progress to ensure customers benefit from a responsive connections process, built on efficient use of the network and approaches to new investment, that produces benefits for the system as a whole. We envisage constraint management will need to form part of the 2017 progress review on the DSO transition we describe in our Call for Evidence[26]. It will be important to demonstrate continued improvement in these areas, considering system-wide efficiency and the benefits and any impacts of DNOs' approaches.

1.30. We need to ensure the regulatory arrangements support efficient and responsive constraint management. This must include developing these new approaches, considering them as options to be deployed as efficient, business-as-usual practices, in a coordinated way, taking account of potential wider impacts.

1.31. We must also understand whether current arrangements will remain fit for purpose in the long term, as the system evolves, or whether any aspects could pose a risk to wider efficiency. We are soon to publish our Spring Plan, joint with BEIS, outlining next steps in our plan for a smart, flexible energy system.

[26] In the Call for Evidence we signalled that further progress is necessary over the coming year in addressing the requirements outlined. We noted we envisage a progress review will be needed by the end of 2017 at the latest on the DNO-DSO transition and SO-TO-DSO coordination.

## More information

1.32. We have published this paper to help you understand more about network constraints, how the network companies are responding and what our expectations are. Alongside this document, we have published a paper, with more detail for those who are interested in:

- **Current status of constraints on the network**
- **How DNOs are responding to constraints**
- **Progress update on 'Quicker, more efficient connections' investment trials**
- **Overview of the Transmission Connect and Manage regime**