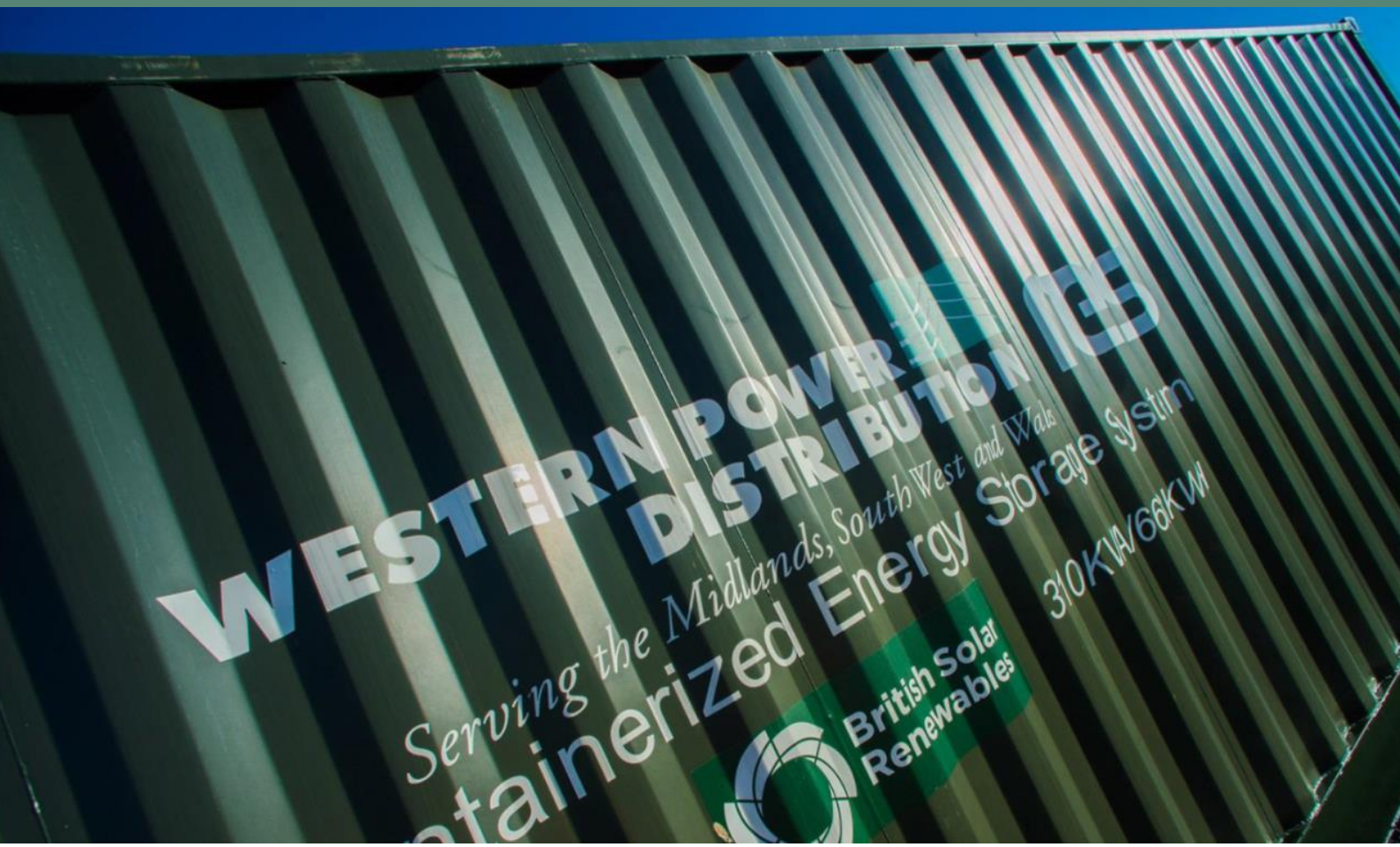
Flexibility Services



Summary

This article describes the different types of flexibility available and explores the possible market arrangements for procuring services. This article also assesses how WPD plans to contribute to the development of regional markets for the deployment of flexibility services.

DSOF June 2018

Note: a glossary and diagram key can be found in the DSOF introduction document on our website

Background

Electricity networks require generation and consumption to be balanced in real time. Even as energy storage solutions become more common, the rate and times which they are charged and discharged will need careful coordination. Flexibility products and programmes are used by the System Operator (GBSO) to balance the overall GB electricity system. Traditionally this came from contracts with larger power stations to turn up or down their output, or the large hydro-electric schemes in Wales and Scotland. As the generation mix has changed, with much more of it directly connected to the distribution networks, their GBSO flexibility products have become more complex. These have allowed participation by smaller Distribution Network Operator (DNO) connected generation and demand customers. However, the actions have been done in a manner that is uncoordinated with DNOs. As DNOs transition to Distribution System Operators (DSOs) such actions will be inefficient and will likely lead to unexpected outcomes.

Flexibility on the electricity system can come from three different sources: large power stations, distribution network smart grids and customer provided distributed energy resources (DER).

Figure 1: Electricity system flexibility

GBSO System Flexibility

Flexibility is the ability of a power system to maintain stability in the face of swings in supply or demand. Traditionally, flexibility was provided in power systems almost entirely by controlling the supply side at large power stations. The GB system has seen increasing shares of intermittent renewable generation requiring additional flexibility to maintain system reliability, as the variations in supply and demand grew to levels far beyond what was originally conceived. This has led to the introduction of additional flexibility programmes by the GBSO for short term reserve and fast acting frequency response services

As larger power stations continue to close and electricity generation becomes much more distributed much more flexibility will be needed across the whole system. This “flexibility gap” will need to be covered by new flexibility options, much of which will be facilitated by a DSO.

Smart Grid Flexibility

Research and Innovation projects have developed a range of new solutions which are changing traditionally passive networks into ones which are much more active. These solutions fall into two categories: smart grid network solutions and smart grid alternative connection solutions.

Smart grid network solutions allow new and existing assets owned by the network operator to be controlled through advanced techniques to provide flexibility.

Smart grid alternative connection solutions allow the distribution network operator to control the network access rights for those connections and provide flexibility through controlling power flows.

Flexibility from Customer's Distributed Energy Resources

Customer connected flexibility can help alleviate both transmission and distribution constraints and contribute to releasing additional capacity on both the transmission and distribution networks.

There is significant value for both active and passive customers connected to the electricity network in maximising the usage of these flexibility sources where it is effective and economic to do so.

Customers with controllable demand, generation or storage can vary their power flows in synergy with the network's needs to provide additional flexibility.

Network Impact

As a DSO, WPD will have our own flexibility and reserve products, for customers to offer their services in return for payment. We will also deploy a range of smart grid technical solutions which will automatically control customer equipment with Alternative Connections and reconfigure the network configuration. GBSO flexibility services will need to be changed to accommodate the increased complexity and dynamic nature of a DSO system.

We have identified four types of smart grid network solution:

- **Automated Load Transfer (ALT)** – Unlike the GBSO, DSO programmes do not need to balance energy volumes. Rather they manage power capacity in discrete network zones. Where one section of a network is at capacity, another may have spare. Thus automated load transfer schemes allow a DSO to move power around to solve constraints.
- **Dynamic Asset Rating (DAR)** – A number of innovation projects have explored how environmental conditions can affect the physical capacity of network components. For example under windy and cool conditions an overhead line can have its rating increased. A number of projects have also investigated the impact on asset health from deliberate (but controlled) overload of cables and transformers. DAR can therefore be used as a source of DSO flexibility.
- **Voltage reduction (VR)** – By slightly manipulating the voltage at which electricity is delivered to customers it has been shown that demand can be increased or decreased. WPD's policy is to operate the system voltage as low as possible as it minimises customer bills. (https://www.westernpowerinnovation.co.uk/Projects/Closed-Projects/Voltage-Reduction-Analysis.aspx).
  However for much of a year there is still sufficient headroom and footroom to use voltage control as a form of demand response for DSO flexibility.
- **Power Electronic Equipment** – Network devices from the Flexible AC Transmission System (FACTS) family have the ability to be dynamically controlled and rapidly adjust system voltage

through the injection or absorption of reactive power. Similarly devices such as Flexible Power Links (FPL) can be used as sources of flexibility, delivering either real or reactive power flexibility.

Alternative connections have become commonplace for WPD's distributed generation (DG) customers. These allow quicker and lower cost connections than conventional reinforcement.

Our innovative solutions allow customers to connect their distributed generation at reduced cost, with quicker timescales but will contain some form of curtailment to avoid expensive reinforcement costs.

There are four variants:

- **Active Network Management (ANM)** – this solution is the most complex and used mainly with larger new generation connections. Customer control equipment is installed into a WPD control solution which allows for full dynamic control of the network, generation and demand.

- **Soft Intertrip** – some networks are constrained due to a single upstream asset requiring reinforcement, or a single limit being infringed under certain conditions. This solution has an on-site soft-intertrip RTU (Remote Terminal Unit) which provides two normally open contacts for the customer's control system to monitor; Stage 1 and Stage 2. When both sets are open, the connection will be free of constraints. The levels of curtailment corresponding to the operation of the Stage 1 and Stage 2 contacts are defined at the planning stage.

- **Timed** – this solution is a simple timer-based device that monitors the connection agreement with the customer, which will include some form of curtailment based on times of day. The customer's connection agreement will include an operating schedule which will define the times and levels of capacity available to them. The solution is supplied by the customer's equipment and does not require any additional investment from WPD to implement.

- **Export Limited** – this type of connection enables customers to cap their import from or export to the distribution grid. This often allows customers to connect renewable generation or storage beyond their meter whilst protecting the distribution network. Measurement and control equipment is used to automatically adjust the customer equipment to ensure they comply with their connection agreement.

The DSO will develop flexibility products which customers with controllable demand or generation will be able to provide services against. These are likely to be reserve services for real power or voltage control (rather than fast acting products such as frequency response – which remains the responsibility of the Transmission System Operator).

The smart grid flexibility solutions described in the previous section will be mostly used in operational timescales. Customer DER flexibility services will be taken in investment decision timescales to reduce, defer or negate conventional build. Identifying, contracting and operating such non-network solutions are at the centre of the DSO transition. WPD has recently launched five Constraint Managed Zones (CMZs) which will deploy non-network solutions. Our Flexible Power product (www.flexiblepower.co.uk) is aimed to offer simplicity and certainty to customers with flexible DER wishing to offer a service. Unlike the GBSO reserve products, Flexible Power will offer locational products that can deliver improved reliability to the DSO.

Detailed Assessment

Flexibility services can be called upon to reduce network stress at summer (distributed generation) and winter (demand) peaks by adding and removing the volume of power or time shifting energy. It can be delivered through active control of smart grid network solutions, or customer provided Distributed Energy Resources (distributed generation, energy storage or active demand). It can also be delivered more passively in nature, through Time of Use Tariffs (TOUT) or time dependent connection agreements.

On a typical summer day, in a solar PV dominated network, demand will be low throughout the day and generation output will peak during the midday hours. Negative power response is required, through either demand turn up or distributed generation curtailment (turn down).

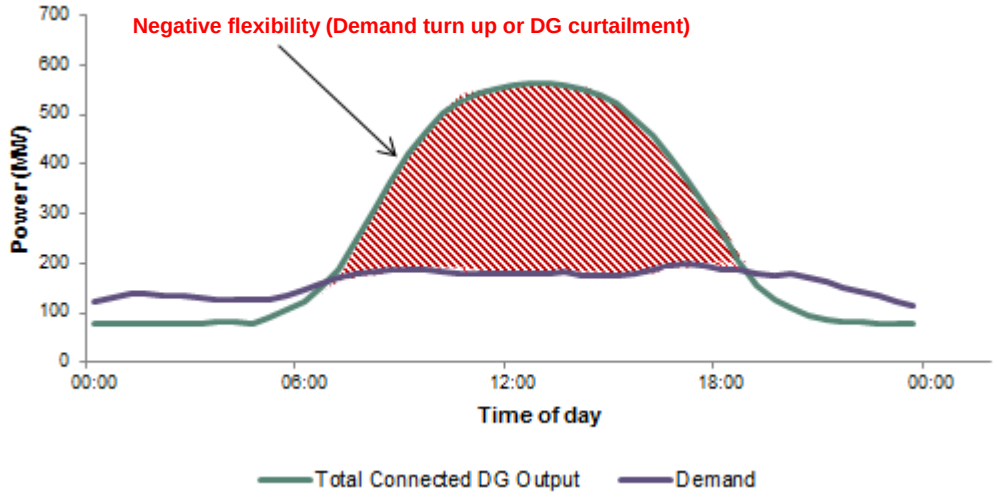


Figure 2: Typical summer solar PV generation-dominated day

On a typical winter day, in the same solar PV dominated network, demand will peak towards the early evening, which is outside the output window of the generation. Positive power response is required, through either demand turn down or distributed generation despatch (turn up).

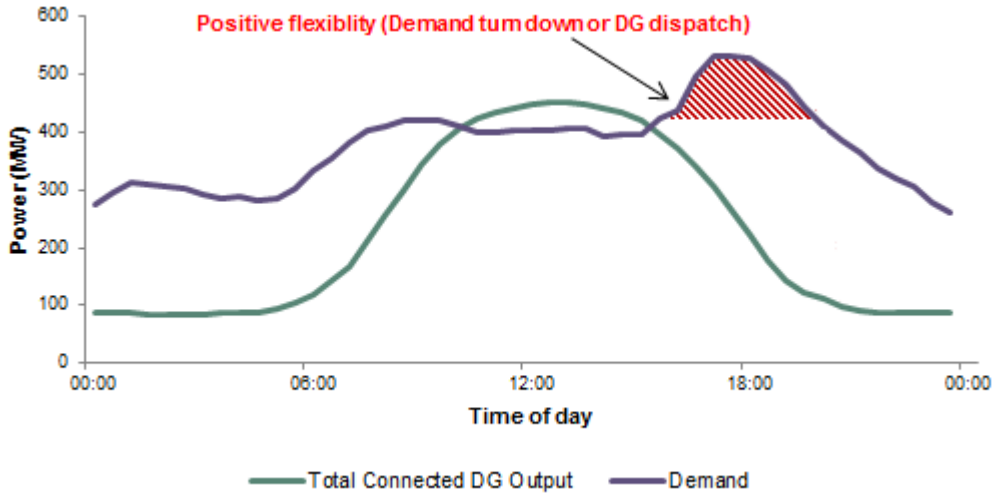


Figure 3: Typical winter peak demand day

By utilising flexibility to reduce or eliminate the peak network conditions, reinforcement requirements can be reduced or deferred. If the cost of utilising the flexibility is less than the savings from the reinforcement deferral, then this may be an enduring solution. If the flexibility requirements increase, or if the cost of providing that flexibility increases, then the business case for completing the reinforcement will be bought forward.

Having the option to utilise flexibility in an area may also allow better investment decisions to be made, particularly if there is significant uncertainty over local growth scenarios.

Short Term Mitigation and Solutions

The increased number and capacity of distributed energy resources connected to the electricity system is leading to an increase in the level of active management of demand and generation seen on the distribution network. This changing system is driving an increase in the interactions between the transmission and distribution networks and there is a growing need for parties to move away from the current market model.

Moving away from traditional roles will allow new markets to be created and accessed by a wider number of participants, helping both existing and new market participants to support network and system operation.

WPD strongly believes that customer connected flexibility and distribution network smart grid flexibility can help alleviate both transmission and distribution constraints and contribute to releasing additional capacity on both the transmission and distribution networks. There is significant value for both active and passive customers connected to the electricity network in maximising the usage of these flexibility sources where it is effective and economic to do so.

In order to economically achieve this, the greatest number of participants must be able to provide services across a number of market procurers.

In order to cost effectively achieve this, there must limited conflict between various procurers of flexibility and network capacity must be sufficient to facilitate the services provided by market participants.

WPD believes there are four key principles to achieving this:

1. **Facilitating accessibility to markets** - Customers will expect level playing field access to a wide range of revenue streams and DSOs will have a key role in facilitating neutral markets. Multiple paths to market could ensure competition remains, but must not lead to conflict or complexity. Customers will expect the complexity to be designed out by Industry. Ultimately, the efficiency of the route to market will be reflected in the commercial revenues passed through to participants. Distribution network operators will increase their usage of non-build solutions, creating new markets for new and existing participants.

2. **Increased T-D Co-ordination -** Clear coordination processes and common methodologies for procurement and dispatch of services will aid efficient local/system wide usage of resources. Principles of access and rights for access will also need to be considered from a whole system viewpoint. Increased information exchange across the transmission and distribution interface will enable conflicts to be managed on an operation timescale. Evolving the existing roles and responsibilities to have a more co-ordinated approach to system resilience, which can take advantage of new forms of flexibility on the system.

3. **Product/Service convergence** - Convergence at a design stage of the products and services which utilise flexibility across both transmission and distribution system requirements will reduce the likelihood and impact of any market conflict. Co-ordination across market procurers to define consistent methodologies and principles will help support level playing field access. Providing information to customers on the pre-requisites for service delivery will enable them to assess the suitability of connection types and ensure they can benefit from potential revenue streams. Convergence of services and connection types will aid the simplification of customer offerings and improve the customer experience.

4. **Signposting for services** - DSOs will publish more information on the availability of capacity across their networks for power delivery. They will also publish information to assess ability of the network to transmit power and understand the utilisation of assets. Proactive information publishing will provide leading signals on where to connect to maximise system efficiency and charging methodologies will be changed to provide lagging indicators to reduce network congestion. This visibility of the existing and future network will help markets deliver the services required. DSOs will further stimulate markets by the signposting of markets for non-build solutions, opening new revenue streams for participants.

Long Term Solutions

Whole system flexibility will be delivered through markets with multiple routes, enabling customers to choose which procurers to provide to and allowing multiple revenue streams to be stacked.

Co-ordination of these services and products will be essential to ensuring conflicts are minimised and the electricity system remains efficient. Currently, the existing market model relies on a passive distribution network offering unlimited capacity. There are, however, different models of operation and the responsibilities for system operation can lie between full GBSO control and full DSO control, with a co-ordinated market model providing a third market model sharing those responsibilities.

Ensuring the market model(s) employed across areas are delivering economic system behaviours will be crucial to realising the biggest benefits.

Current Market Model

The existing market model for procuring services to resolve transmission issues has no direct link with DNO constraint management. This has no effect when solely transmission connected energy resources are utilised, or when the distribution network capacity is assumed to be infinite. However, as DNOs are increasingly actively managing the network, curtailment due to constraints can cause conflicts and reduce in the effectiveness of services delivered. As the number and level of constraints increase, the likelihood and consequence of the conflicts will become more apparent.

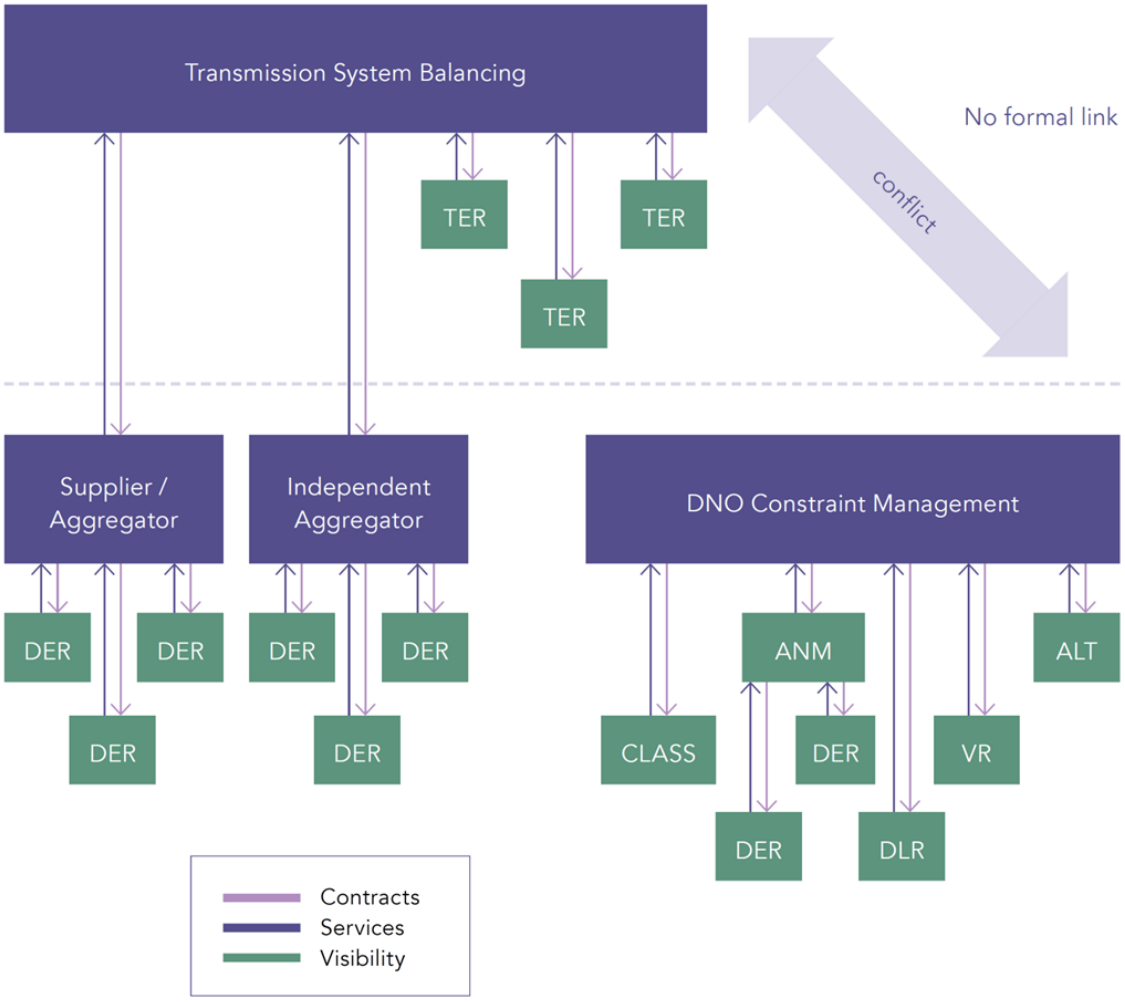


Figure 4: Current market model

Unmanaged conflicts between services will result in a more inefficient whole system outcome.

GBSO-led Market Model

The GBSO-led market model preserves the same arrangements as the current market model, with the GBSO directly contracting with distribution connected DER for services. A visibility link between the GBSO and DSO enables the GBSO to have oversight of any conflicting actions DNO constraint management may undertake, such as curtailment under ANM systems. It is also able to call upon distribution network smart grid flexibility through commercial contracts with the DSO.

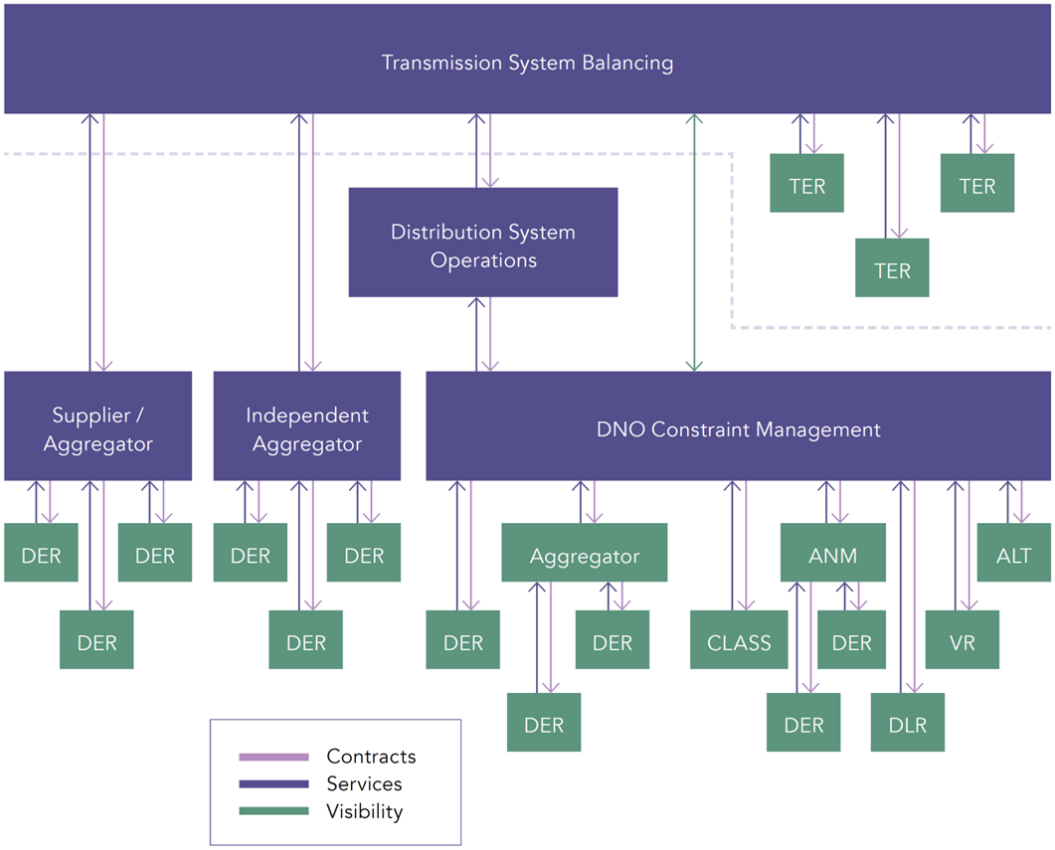


Figure 5: GBSO-led market model

Although this model allows conflicts to be managed and/or mitigated by increasing the visibility between the GBSO and DSO, the complexity of this process increases as the number and curtailment of those constraints increases. Supplier and/or aggregator managed DER within or adjacent to ANM zones will be affected by DNO constraint management and so the GBSO will need to inform the DSO of any potential conflicts in order to ascertain the impact. The nested nature of distribution constraints and the interactivity of meshed networks vastly increase the complexity when assessing the effectiveness of DER to deliver services, meaning a full network impedance model with connectivity is required, as well as historical and real-time load flows for real-time and forecast curtailment studies. Any planned network running arrangement alterations the DSO takes or any unplanned outages will potentially undo the contracted service position.

Customers in constrained distribution networks may be disadvantaged as the GBSO calls on flexibility services in unconstrained areas ahead due to the uncertainty and risk associated with non-delivery of contracted services due to DSO actions.

As the smart grid flexibility is embedded within the DSO operations, the GBSO may not maximise its usage of the resource, preferring to utilise more expensive contracted flexibility which will be able to commit to operating much further ahead.

However, networks with few constraints or smaller numbers of distribution connected energy resources may be simpler to describe and result in an acceptable level of inefficiency due to unplanned or uncoordinated actions.

Multiple Party Co-ordination Model

The multiple party co-ordination model develops a dual procurement approach, which enables both DSO and GBSO to directly contract with distribution connected DER through a variety of aggregator and supplier paths. Visibility of contracts placed would be exchanged between the DSO and GBSO, enabling conflicts to be understood and managed.

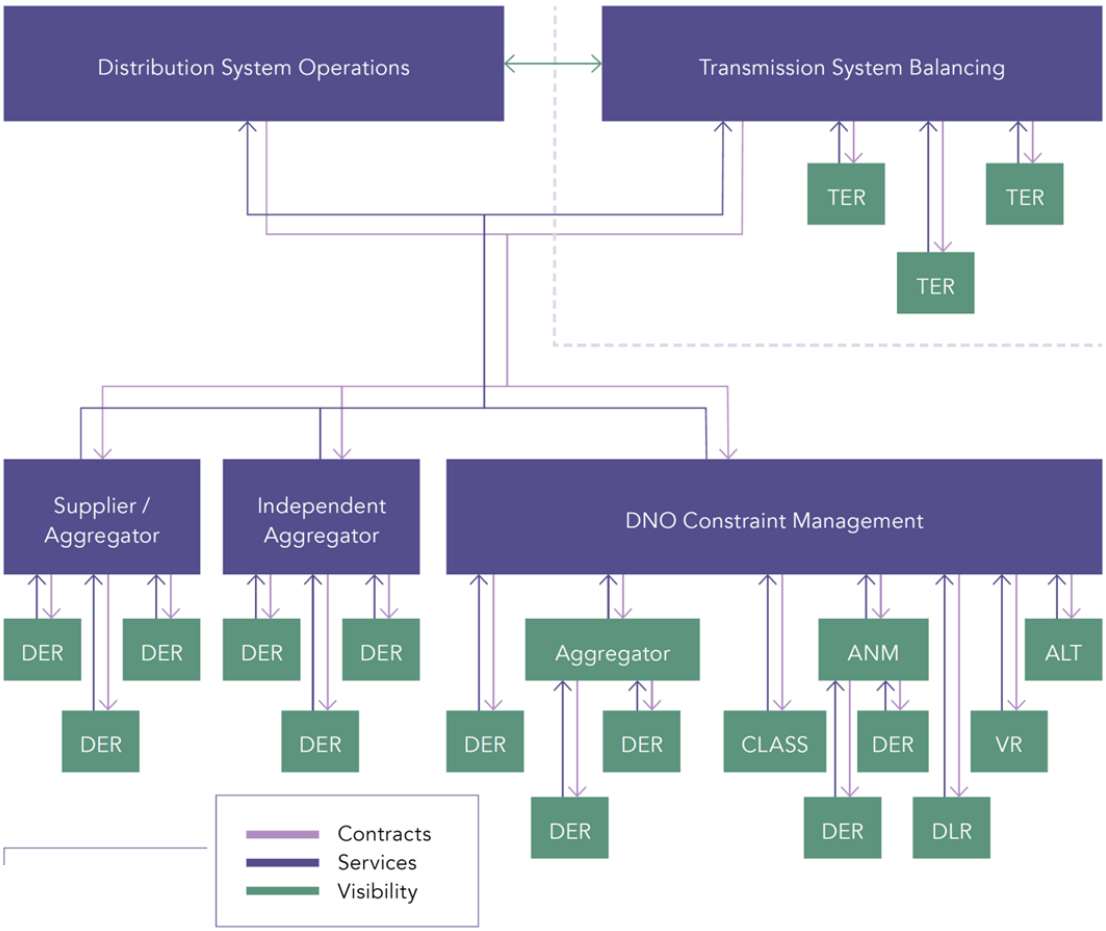


Figure 6: Multiple party co-ordination market model

This model allows equal access to flexibility services from a number of market procurers, but requires a sharing of roles and responsibilities, which would need frameworks, principles and methodologies to be developed and agreed prior to operation.

Again, the complexity of the visibility platform between DSO and GBSO increases as the number and curtailment of the distribution constraints increases. Traditional reinforcement, charging signals and proactive signposting of services can all be used to minimise the likelihood of conflicting actions occurring and help simplify the visibility required between operators.

Market mechanisms and incentives that place responsibilities on all parties to ensure visibility of services is maintained and penalties or balancing mechanisms to ensure the results of unplanned conflicts are equitably shared may help this model run efficiently.

DSO-led Market Model

The DSO-led market model changes the hierarchy of the commercial frameworks and allows the DSO to co-ordinate the prioritisation of flexibility services with respect to the constraints on the distribution

network. By operating the model this way, the services offered up to the GBSO will inherently be co-ordinated across the transmission-distribution boundary.

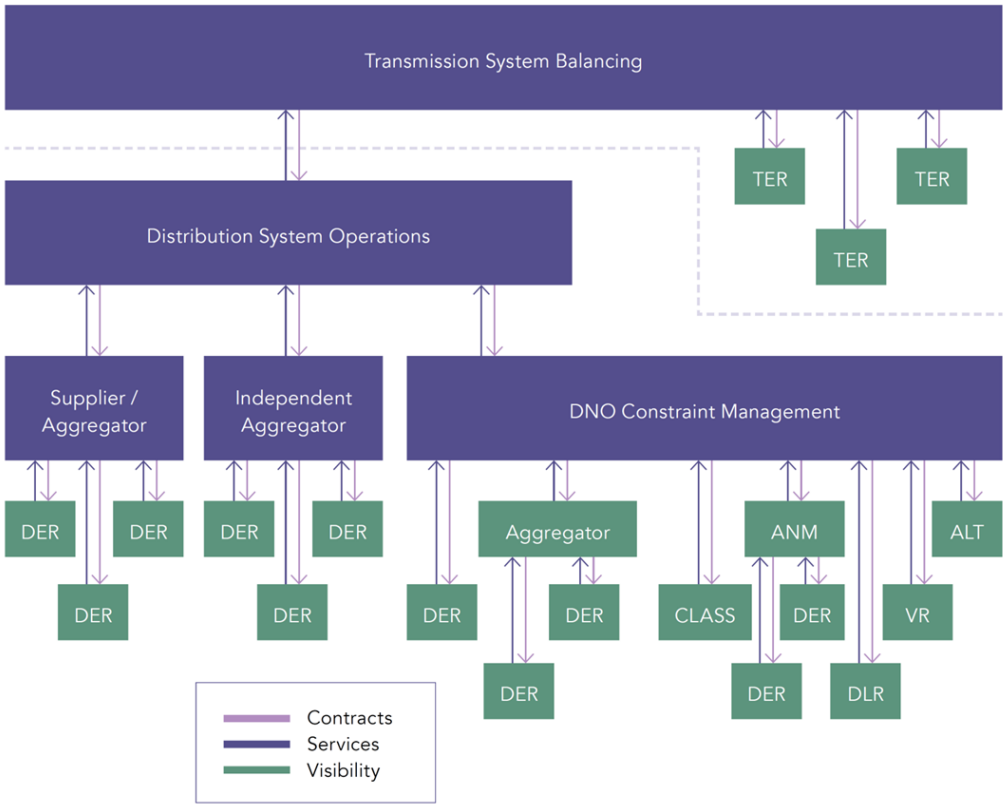


Figure 7: DSO led market model

The DSO is able to assess not only the effectiveness of services within the distribution network and factor that into the economic cost, but also the impact of running those services on future optionality. By optimising the dispatch of those services based on a holistic impact on the local distribution network, the whole system outcome will be most efficient and cost-effective.

The GBSO will be able to take balancing actions on a national level within a pool of services competitively procured through a number of DSOs, without adversely impacting localised network constraints. The DSO will be responsible for ensuring the requested response is efficiently delivered through fully range of flexibility services at their disposal.

Customers in constrained and unconstrained distribution networks will have their flexibility services called upon equally by the GBSO as the DSO would take on the risk associated with non-delivery of contracted services due to DSO actions, which the DSO would be uniquely placed to best assess.

Market Model Transition

In some areas of WPD's network, it may be acceptable to operate the system using the existing market model where there are no or few conflicts between distribution network constraints and distribution network connected services.

The GBSO–led market model maintains the same system hierarchy and enables all commercial services to be agreed and settled using existing mechanisms. As distribution network constraints increase, curtailment and service conflicts will increase across a number of voltage levels and the GBSO will not be able to optimally manage the dispatch of conflicting services deep within the distribution network.

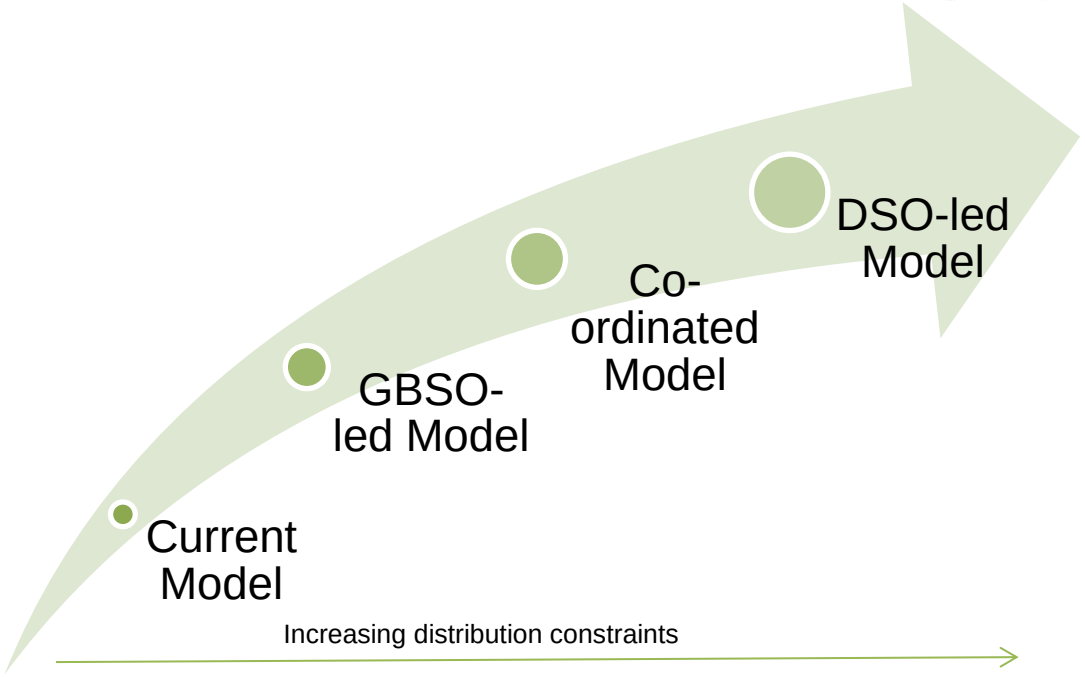


Figure 8: Progression of DSO market models

The co-ordinated market model allows both GBSO and DSOs to share a single procurement model but requires complex market design and effective visibility of operations to ensure the model provides efficient outcomes. WPD will work with the GBSO to facilitate shared procurement activities in areas where the level of constraints is beginning to increase.

The DSO-led market model requires a significant shifting of responsibilities for system balancing operations and commercial contract activities, but will result in the most efficient whole system outcome for distribution networks with multiple complex constraints. Where distribution constraints are impacting on service delivery through existing market models, WPD will work with the GBSO and move towards a DSO-led market model.