Flexible Plug and Play

Quicker and more cost effective connections of renewable generation to the distribution network using a flexible approach - SDRC 9.7

By UK Power Networks

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Acknowledgement

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## Definitions

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<tr>
<td>Active Network Management (ANM)</td>
<td>Autonomous, software-based control system that monitors grid conditions and issues instructions to distributed generators or other field devices in order to maintain the distribution network within operating limits.</td>
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<td>Automatic Voltage Control (AVC)</td>
<td>A substation level system that is used to maintain the substation voltage at a constant value and within the statutory limits.</td>
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<td>Business-as-usual/unrestricted generators</td>
<td>Generation equipment that is connected to the network that has the ability to export at all times of the year up to 100% of its capabilities.</td>
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<td>CiC</td>
<td>Competition in Connections (CiC) is the term attributed to the opening up of the connections market for the design, procurement and installation of new assets necessary to accommodate a new or modified electricity connection. Customers have the option to have some of the connections work, referred to as Contestable Work, carried out by an ICP who must be accredited with Lloyds Register.</td>
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<tr>
<td>Combined Heat and Power (CHP)</td>
<td>Co-generation or use of a power plant to simultaneously generate electricity and useful heat.</td>
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<td>Communications platform</td>
<td>The communications platform installed and commissioned in the FPP trial. It is based on radio frequency wireless mesh technology.</td>
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<td>Distributed Generation (DG)</td>
<td>Electricity generation connected to the distribution network, as opposed to the transmission network.</td>
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<td>DNO</td>
<td>Distribution Network Operator.</td>
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<td>Dynamic line rating (DLR)</td>
<td>A system for calculating real-time ratings of overhead lines based on actual weather data, or measurements on the conductors.</td>
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<td>Feed-in-tariff (FIT)</td>
<td>A subsidy for the generation of renewable electricity for generators under 5 MW.</td>
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<td>Flexible Connections</td>
<td>DG customers connected to the distribution network whose generation output can be controlled by the DNO for operational purposes.</td>
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<td>FPP</td>
<td>Flexible Plug and Play.</td>
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<td>Intertripping</td>
<td>Turning a customer’s generation equipment off at times when the electricity network requires it.</td>
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<tr>
<td>Term</td>
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<tr>
<td>Levy Exemption Certificates (LECs)</td>
<td>Certificates that exempt the owner of the DG equipment from paying the Climate Change Levy, as the energy produced is renewable.</td>
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<td>Low Carbon Network Fund (LCNF)</td>
<td>A funding mechanism introduced by Ofgem to promote research and development for smart distribution networks.</td>
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<td>Micro-PV</td>
<td>Small scale solar schemes, e.g. solar panels on top of residential houses.</td>
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<td>Modern Protection Relays</td>
<td>Protection devices which were trialled by the FPP project to overcome the limitations associated with the use of directional overcurrent schemes for protection of grid transformers.</td>
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<tr>
<td>Photovoltaic (PV)</td>
<td>Solar Panels.</td>
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<tr>
<td>Point of connection (POC)</td>
<td>The interface between UK Power Networks’ equipment (main fuse, energy meter) and the consumer’s equipment (supply panel).</td>
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<tr>
<td>Quadrature-booster</td>
<td>A specialised form of transformer used to control the flow of real power on a three phase electricity transmission network.</td>
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<tr>
<td>RIIO-ED1</td>
<td>The first electricity distribution price control to reflect the new RIIO (Revenue = Incentives + Innovation + Outputs) model for network regulation.</td>
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<tr>
<td>ROCs</td>
<td>Renewable Obligation Certificates offer a subsidy to renewable generators for generating low carbon electricity.</td>
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<tr>
<td>S16</td>
<td>A section 16 (of the Electricity Act) quotation as described in the Standard Licence Condition 15A Guidance Document. This covers the cost of all works associated with completing the connection. This can be requested instead of or in addition to a CiC quote.</td>
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**Flexible Plug and Play**  
Quicker and more cost effective connections of renewable generation to the distribution network using a flexible approach
Executive Summary

There has been continued significant growth in Distributed Generation (DG) across distribution networks from 2008 which has resulted in very limited generation capacity being available for new customers across the Eastern Power Networks network area. This has resulted in a large increase in connection requests in a relatively short space of time and has led to several challenges for UK Power Networks and other DNOs. DNOs have an obligation to offer the cheapest viable connection to a customer, also known as the minimum cost scheme; therefore each connection request is assessed to find the closest suitable point of connection. The availability of accessible and affordable capacity for generators to connect to the electricity network is continuously decreasing, due to network capacity already being fully committed to existing or planned generation projects or unless extensive and costly reinforcement works take place, paid for either by DG customers or the DNO. The closest suitable point of connection can subsequently be much further away, usually requiring lengthy cable routes or connecting customers to a higher voltage level of the network. These are both expensive options and as a result can often mean that the DG scheme becomes financially unviable.

In 2011, UK Power Networks was awarded £6.7 million in funding from Ofgem via the LCNF to undertake the FPP project, which aimed to overcome some of the issues mentioned above for DG. A further £2 million was invested from UK Power Networks, with the final £1m provided by the FPP project partners making a total budget of £9.7 million; invested in an area of the electricity network in the UK Power Networks eastern region. The project was established to manage the influx of generation applications and connections to an area with a number of technical challenges preventing connection by integrating a number of smart devices and developing novel commercial arrangements.

The project was the first to explore the use of flexible connections through innovative commercial arrangements in mainland Great Britain. Flexible connections are a concept whereby DG customers can be connected to the distribution network on the basis that their generation output can be controlled by the DNO for operational purposes. A similar concept had been used on the Orkney Islands but had not been used with schemes with a lower capacity factor (i.e. wind schemes based on Orkney are expected to generate 50% of their peak capacity over the year, whereas the assumption is that schemes in the East of England generate 30% of their full capacity over the year). The lower capacity factor of wind schemes in the East of England had the potential to make the flexible connection offer less economically viable; however, this has not been the case.

Since the introduction of flexible connections in the trial area in March 2013 there has been significant interest, which has seen the project achieve the following:

- Receive 45 DG connection requests;
- Issue 39 connection offers for 176MW of generation;
- Receive 14 customers’ acceptances of the flexible connection for 35.88MW of generation.
- As of 12 December 2014, the project has commissioned four customers, totalling 2.75MW, which has given the project the opportunity to generate and implement new learning for future flexible connections that are to be commissioned.

Offering flexible connections have been made possible by:

- Utilising 24 smart devices installed across the trial area, as detailed in Successful Delivery Reward Criteria (SDRC) 9.41, 9.62 and 9.81 – which detail the technical characteristics of the FPP solution as well as specific smart devices, such as the Quadrature-booster, and;
- Developing two commercial arrangement methods of curtailment, Last in First Off (LIFO) and pro-rata. The two curtailment approaches have different methods of implementing a curtailment scenario, which see the additional capacity made available by the smart devices, shared differently amongst DG customers.

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Prior to the development of the commercial arrangements the project undertook an extensive stakeholder engagement study with key industry stakeholders, generators and UK Power Networks departments, as detailed in SDRC 9.1 – Stakeholder Engagement4, to fully understand the key technical and commercial challenges of the project. As part of this work, UK Power Networks tested the market to see if a curtailment level of 5.3% per year would be manageable, key stakeholders indicated that this would be an acceptable level of curtailment. This formed the basis of the commercial offering and network assumptions. Through offering flexible connection offers in the FPP trial area, the project has subsequently seen three of the fourteen accepted DG customers accept flexible connection offers with ~9% annual curtailment estimates. As highlighted in Section 2.3.5, there are different scenarios that will see DG customers accept higher levels of curtailment than the initially indicated 5.3% which was deemed acceptable.

Initial assumptions for the growth of DG in the trial area had been based on all wind generators connecting, this was due to the subsidies available, as well as historic generators in the area, who were mainly wind. This assumption also made for the worst case when assessing the estimated curtailment levels of generation schemes. However, there has been a significant growth in the application for PV (photo-voltaic) schemes in the last year, which has meant a more diverse mix of generators wishing to connect within the trial area. This has had a positive impact on the resulting curtailment analysis, which is now as low as 0.59% in some cases.

The flexible solution gives the customer an option for a different type of connection, which is at a cheaper price, but with the likelihood of generation curtailment at peak times. The customer must then assess this against the business-as-usual alternative and decide which option provides the best solution for their project. FPP has shown that when taking account of the calculated level of curtailment the flexible connection is a viable option for the majority of customers. In total the project has saved accepted DG customers within the trial area approximately £38 million on their connection offers, or £32 million, when including the cost of the ANM and curtailment.

Through the trials, the project has successfully designed and implemented a methodology for offering flexible connections that have provided DG customers within the FPP trial area a cheaper and faster alternative method of connecting to a heavily constrained area of the distribution network compared to the normal business-as-usual approach. As highlighted in section 5, the flexible connection has enabled an average connection cost saving of 8.7% for DG customers in the trial and reduced connection lead times by over 59%, or an average of 29 weeks. This has also led to higher acceptance levels for flexible connection offers, compared to business-as-usual offers.

The success of FPP in creating and utilising additional capacity in an area where the distribution network is heavily constrained has led to extensive interest from DG customers on the wider roll out of flexible connections. As a result, UK Power Networks has committed to incorporate flexible connections in other areas of the network as an alternative within the portfolio of options available for DG customers by Q2 2015 and has since further accelerated the rollout by offering flexible DG connections in the Norwich area from November 2014.

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1.1 Report Purpose
This report completes a suite of reports that explain the evolving principles of access and commercial customer connection offer. The previous reports are:
- SDRC 9.1 – Stakeholder Engagement
- SDRC 9.2 – Principles of Access

This report follows on to show how the principles of access have worked in practice and the development of the commercial offer. Specifically, this report meets the criteria to show that FPP has facilitated faster and cheaper connection of renewable generation to the distribution network, compared to timescales and costs of connection utilising traditional approaches.

1.2 Document Structure
This report summarises the work associated with the commercial solution trialled in the FPP trial area and the completion of SDRC 9.7 (Facilitation of cheaper and faster connection of distributed generation to the distribution network, as compared to timescales and costs of connection utilising traditional approaches).

The successful completion of the SDRC is evidenced by making a flexible connection offer to a DG customer and demonstrated that the connection offer to that DG customer is cheaper and faster than traditional business-as-usual methods that require reinforcement. The connection offer has proven popular and as such we have issued 39 connection offers and connected four customers.

In addition, the report provides an insight to the learning available to other DNOs when designing and offering a similar solution to DG customers.

The report is structured as follows:

**Section 1** explains the background to DG growth in the trial area, giving an overview of why the trial area was chosen and what the project set out to achieve.

**Section 2** is an explanation of the innovative commercial arrangements used in the project, explaining both the LIFO and pro-rata principles of access and analyses their benefits within the project.

**Section 3** details how the connection offer was developed in order to send out a consistent offer to all customers. The additional documents relating to the project that customers have received are explained and the key learning is discussed.

**Section 4** describes the projects that have accepted the FPP connection offers, particularly in terms of the project savings over a conventional connection approach, as well as the learning and experience from connecting customers using the FPP connection methodology.

**Section 5** revisits the business case for the project, detailing the benefits of flexible connections, particularly when compared to business-as-usual alternatives and proves that the FPP methodology provides a faster and cheaper connection for DG customers.

**Section 6** focuses on the roll-out of the flexible solution to other areas of the UK Power Networks’ distribution network.

**Section 7** provides a number of options that need to be analysed to clarify the treatment of reinforcement for flexible connections and indicates the preferred approach. As flexible connections do not replace the requirement for reinforcement, there needs to be a clear method for reinforcing the network for this scenario.

1.3 Background - DG Growth
Historically, electricity distribution networks have been built to support demand for electricity from households and businesses. The introduction of electricity generation on to
Figure 1 – Total distributed generation (DG) enquiries for UK Power Networks (2008 – October 2014)

The distribution system complicates the supply of electricity, changing the direction of the power flows in some cases i.e. from end to customers to the electricity grid rather than from the electricity grid to the end customer. Government initiatives to incentivise ‘greener’ sources of power generation have given rise to the increased number of generators wanting to connect to the distribution network in more recent years. Some of these incentives include Feed-in-tariffs, ROCs and LECs for renewable generators.

Over the past seven years, UK Power Networks has seen a significant increase in the volume of DG requests, as shown in Figure 1, with 2013 enquiries being 44 times greater than 2008. In the four years from 2008 to 2011 (when the project business case was calculated), UK Power Networks had seen the DG enquiries across the three licence areas increase by ~20 times.

This large increase in connection requests in a relatively short space of time has led to several challenges for UK Power Networks and other DNOs, as the availability of accessible and affordable capacity for generators to connect to the electricity network is continuously decreasing, unless extensive and costly reinforcement works take place. DNOs have an obligation to offer the cheapest viable connection to a customer; therefore each connection request is assessed to find the closest suitable point of connection. Increasingly, generators are unable to connect at their nearest connection point, due to network capacity already being fully committed to existing or planned generation projects. This has resulted in the closest suitable point of connection being much further away, usually requiring lengthy cable routes or connecting customers to a higher voltage level of the network. These are both expensive alternatives and as a result can often mean that the DG scheme becomes financially unviable.
UK Power Networks needs to treat all connection requests as per the Standard Licence Condition 15A and the Distributed Generation Standards Direction Guidance Document, which includes responding to generators with a connection offer, within a set period of time depending on the voltage level they wish to connect at. The dynamic and fast moving nature of generation projects on a network with limited generation capacity requires a full understanding of the existing and potential projects in the network area and the impact any new generation connection requests will have upon these. As the customer has 90 days to accept a quotation offer, there can be a requirement to provide the customer with interim updates to inform their business decisions in this dynamic market.

The changing nature of generation connections for both the DNO and the customer means that alternative solutions must be sought; this is where FPP can provide an alternative, through the introduction of smart solutions and innovative commercial arrangements to enable more generation to connect.

1.4 FPP project and trial area

In 2011, UK Power Networks was awarded £6.7 million in funding from Ofgem via the LCNF to undertake the FPP project. A further £2 million was invested from UK Power Networks, with the final £1m provided by the FPP project partners making a total budget of £9.7 million; invested in an area of the electricity network in the UK Power Networks eastern region. The project was established to manage the influx of generation applications and connections to an area with a number of technical challenges preventing connection by integrating a number of smart devices and developing novel commercial arrangements.

1.4.1 FPP Trial area

The 700km² area of the distribution network between March and Peterborough in the East of England was chosen for the FPP trial area as it had a number of characteristics which made it a suitable area for testing FPP:

- This rural Cambridgeshire area had 90MW of connected wind generation, mostly connected at 33kV;
- Other generation technologies were already connected, such as the existing Wissington Sugar generation plant (Combined Heat and Power);
- An additional 57MW of generation was in accepted offers, 34.5MW of generation had been requested and enquiries for a further 97MW of generation had been received;
- Finally, existing network assets were reaching their operational limits.

To support the DG community to understand the potential available capacity on the distribution network UK Power Networks publicises a heat map to show the generation utilisation levels of the network. The FPP trial area was the first area of network within the UK Power Networks footprint to become constrained for capacity at 11kV, 33kV and now at 132kV, as shown on the map in the heat map, in the blue hashed area. This issue has now been replicated across areas of UK Power Networks South-Eastern network.

The resulting lack of capacity for generators to connect is due to a number of different technical constraints, which are also prevalent within the FPP trial and provide a platform for the project to trial different techniques to manage these constraints. The key constraints within the trial area are as follows:

- Thermal constraints – high levels of DG at times of low demand can increase the power flows on already over utilised networks resulting in thermal overload within the FPP trial network;
- Reverse power flows – distribution networks were historically built for demand customers, meaning power always flows one way from National Grid’s network to the distribution network to the customer. Generation can cause reverse power which can affect the control systems used on the distribution network;
Flexible Plug and Play
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• Limited generator control – intertripping has been used previously, which stops the generator exporting electricity onto the network at certain times. This has generally been via a simplistic communications system which either ramps the customer’s generation down to zero or trips the breaker to turn their supply off/on. This can have an added risk to the network with step voltage change. This solution does not provide a generator with the most efficient connection. Having increased generator control enables generators’ output to be controlled dynamically, enabling greater utilisation of the network, without compromising network safety;

• Lack of a commercial framework for flexible connections – a framework was needed to enable UK Power Networks to offer flexible connections and legally bind customers into the arrangement.

The DG connections heat map for the Eastern region can be viewed here.

The FPP trial has allowed additional generation to connect in the trial area without the requirement for costly reinforcement works to take place. Since the project began offering connections in March 2013, FPP has facilitated an additional 35.88 MW to connect in the trial area. As of 12 December 2014, 2.75 MW has connected, with the final 33.13 MW scheduled to connect over 2015. This is an additional 39% of generation capacity due to connect compared to 2013 levels when the project began offering connections, as shown in Figure 2.

The trial area was designed around Peterborough Central and March Grid sites and their ten feeding primary substations,
where these technical issues were prevalent. The FPP communications platform was installed to provide coverage across the ten feeding primary substations and clearly defines the FPP trial area, as shown in the red hashed area in heat map.

1.4.2 FPP project – Technical and Commercial solutions

To overcome the prevalent constraints in the trial area, a number of technical and commercial solutions were developed to improve a customer’s ability to access the spare capacity. Flexible connections are subject to curtailment at times when capacity to generate onto the network is limited due to the existing unrestricted generators already exporting on to the network, thermal line limits and voltage rise exceeding allowable limits.

A number of technical trials have taken place in the trial area to test the ability and functionality of different smart devices to aid more generation to connect to the network. The smart devices that have been trialled are:

- Active Network Management (ANM) – the ANM system utilises inputs from measurement points across the network, smart devices and from customer generator control systems to determine a level of generation that can be accommodated in real time. This is communicated with the customer generator control system to enable greater utilisation of the network, without affecting the integrity of the electricity network;
- Dynamic Line Rating (DLR) – the DLR system monitors the local environmental conditions i.e. wind speed and temperature to provide a real time rating for overhead lines. This enables greater utilisation of existing overhead lines;
- Automatic Voltage Control (AVC) – the latest AVC system includes improvements to mitigate issues with voltage level on networks with large penetrations of generation;
- Novel Protection Relays – modern protection relays are being utilised to trial alternative novel protection philosophies which mitigate network constraints associated with directional overcurrent schemes to create additional headroom for DG connections;
- Quadrature-booster – the Quadrature-booster is a phase shifting transformer that is able to control the flow of power through two parallel circuits, enabling greater utilisation of assets; and
- Communication Platform – this passes the information from the control centre to the smart devices and ANM.

SDRC 9.6 expands on a number of the technical trials by detailing the successful completion of the implementation of active voltage and active power flow management within the FPP trial area, using a centralised ANM system in coordination with a number of smart solutions.
The commercial solution has been developed alongside the technical solution from the beginning of the project and the documents continue to be developed to clarify constraints and the changing nature of the network. The progress of the FPP connection offer has been developed in four broad stages:

Figure 3 – Development stages of the FPP commercial offer

- **Stakeholder Engagement**: Carried out to understand the technical and commercial challenges for the project.
- **Principles of Access**: Focussing on realistic options for access to generation capacity for customers.
- **Flexible Connection Offers**: The first six FPP offers were made on 1 March 2013.
- **Development of Offer**: Update of a number of documents to account for the flexible elements of the connection.
2
Smart Commercial Arrangements
An important part of being able to make the flexible connection offers to generators in the trial area was choosing the best way of allocating capacity to the customer and the order in which generators would be curtailed by the ANM system. It is important for the generator to have confidence in their likely export capacity after curtailment, so that they can undertake a thorough financial assessment of their project. The project delivered SDRC 9.2 – ‘Principles of Access’ report in December 2012\(^6\) which explained the options available for curtailing generators.

Two options were deemed possible under the current regulatory framework; Last in First Off (LIFO) and pro-rata.

### 2.1 Last in first off approach

LIFO arranges generators in a queue and curtails them in the order that they applied for their connection to the network. In this instance the first generator to accept their connection offer at their current place in the queue is insulated against larger curtailment amounts, as generators who apply later on will be curtailed first. This is an approach that has been adopted by other DNOs; Scottish and Southern Energy’s Orkney project had implemented ANM based on a LIFO principle of access during the time when FPP was proceeding through the project bid stages. FPP incorporated the learning from the Orkney project; specifically the way the generator joined the capacity queue based on their application date, as well as using similar ANM technology in FPP to that used in the Orkney project.

The LIFO approach gives the generator a good deal of certainty, as long as confidence can be placed in the curtailment forecasts at the point that an investment decision is made. It is clear that there will be some winners and some losers through curtailing in this way, as the last to connect always bears the most risk of being curtailed. This approach is easy to understand, easy to implement and easy to manage in most instances. There may be some areas where this approach does not work, mainly, where there are a number of constraints on the network that affect the customer in a different way depending on where they connect and how these constraints interact.

### 2.2 Pro-rata approach

Pro-rata is an approach that curtails generators connected to the network based on each generator’s proportional export contribution to the constraint at a moment in time. When the constraint is prevalent, the curtailment is then shared amongst all generators that are exporting onto the network at that time.

Pro-rata uses a predefined highest ‘acceptable’ level of curtailment that a generator would be willing to accept, but still ensures the DG scheme can be viable. For the FPP project this was set at 5.3%, which was sense-checked by DG developers, and then tested via FPP. The percentage of curtailment is as a reduction in generation over the generators yearly output, based on the profile of wind generation in the East of England. As long as there is still a significant saving on the business-as-usual connection offer, including the lost revenue from curtailment, the flexible connection offer will appear more attractive than the business-as-usual alternative.

#### 2.2.1 Capacity quota

In order to apply a pro-rata approach, a capacity quota must be designed to ensure that there is a limit on the capacity of generation allowed to connect to keep curtailment levels at a reasonable level for the generators within the quota.

Applying a quota in the March Grid area provided a different principle of access for capacity to similar turn-down schemes run by other DNOs. In this case the FPP project harnesses the learning benefits of implementing the pro-rata right of access, whilst importantly also providing generators with a simple, credible and certain set of principles on which they are connected and curtailed.

The technical assumptions used to calculate the quota also underpin the curtailment assessment reports and the analysis carried out early in the project by Baringa Partners LLP on the revenue loss or the cost of curtailment which supports the financial assumption used in the quota calculation.

The assumptions used to underpin the quota calculation and the curtailment reports rely on data from UK Power Networks’ own network configuration, demand growth, the growth of micro-PV (Photo-Voltaic – small scale PV installations that do not require permission from the DNO) and more specific data relating to the generation type, which was taken from information provided by generators already connected to the distribution network in the area.

The quota calculation is based on the point at which the £/MW cost of curtailment over the projects lifetime was equal to the £/MW cost of reinforcement, this is shown in the graph above.

This was agreed with the initial stakeholders as an acceptable approach. The quota was set at 33.5MW of generation and the first flexible connection offers were issued with an expected curtailment level of 5.3%, which was perceived to be a manageable curtailment level by customers.

As customers continued to request connection offers once the 33.5MW quota was filled with open and accepted offers, the decision was made to continue offering flexible connections on a LIFO basis.

### 2.3 Pro-rata vs LIFO

The pro-rata approach was applied to the March Grid connections in the trial area. Most of the initial stakeholders that the project engaged with had projects that fed into the March Grid constraint; this is detailed in SDRC 9.1 – Stakeholder Engagement report. March Grid currently has two 45MVA 132/33kV transformers and an interconnected 33kV network supplying 33/11kV primary substations. The constraint is the
reverse power flow capacity, which is limited by the maximum settings of the transformers. This has been exhausted by generation already connected and exporting to March Grid.

The LIFO approach has been implemented at the Peterborough Central grid site. The constraints at Peterborough Central grid are more complex than the constraint at March Grid and include overhead lines reaching their thermal rating limits, reverse power flow reaching operational limits and step voltage change exceeding statutory limits.

The sections below detail the initial criteria that the principles of access were measured against, the initial thoughts around each principle and an explanation the FPP experience of offering connections to customers based on LIFO and pro-rata rules of curtailment.

2.3.1 Network Utilisation

Network utilisation is the criterion that focuses on maximising the amount of generation that can be economically connected to drive the efficient build-out of the distribution network. This is important, as being able to ensure our assets are fully utilised means a more efficient network for both the customer and UK Power Networks. The principles of access report, made some initial assumptions regarding the network utilisation of the LIFO and pro-rata approaches which are summarised in table 1.

The pro-rata approach leads to more customers being able to accept a connection offer based upon an expected level of curtailment that still makes the project financial viable. This is due to the reduction in the connection cost and the shared risk associated with the curtailment methodology.

The increased network utilisation from this method is shown in Figure 5 overleaf, which demonstrates that more generators are able to connect under the pro-rata approach.

The sharing of curtailment under the pro-rata rule means that whilst early generators to connect will accept a higher curtailment level than they would under a LIFO approach; they are agreeing to a curtailment level that is acceptable to them and as such sharing the curtailment levels to enable later connections. This could be the difference between having a viable and a non-viable project for later DG customers wishing to connect.

It is clear that pro-rata offers an efficient way of allocating curtailment for specific types of constraints. However, LIFO has a wider application that can be applied to more constraint types.

Initially the project made the assumption that all wind generation would connect under the FPP project. The main reason for this assumption was to ensure that customers would receive the ‘worst-case’ curtailment estimate for their project, which could be used when arranging financing. The generation mix for the area is outside the control of the DNO and there is no way of anticipating in what order generation applications will come in, what generation types these will be and what impact this will have on the rest of the customers within the March Grid quota. This has led to a trade-off between ensuring

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<tr>
<th>LIFO</th>
<th>Pro-rata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not ensure greatest volume to connect to the network as high curtailment levels could block more generators from having a viable scheme to connect.</td>
<td>Provides maximum efficiency by driving the greatest volumes of generation capacity to viably connect in a constrained area.</td>
</tr>
</tbody>
</table>
optimum network utilisation and offering customers certainty in their curtailment estimates. The resulting generation mix at March Grid has not allowed the best possible utilisation of the network as the quota could have accepted more generation with the current technology mix at a higher curtailment level of 5.3%. The position of accepted customers has become much more favourable than initially estimated since the generation mix has changed, resulting in the most economic network utilisation not being achieved but there have not been issues with customer’s financing their projects.
Flexible Plug and Play
Quicker and more cost effective connections of renewable generation to the distribution network using a flexible approach

The graph above shows the difference in the expected curtailment rates for the accepted generators and outstanding generation quotations in the March grid trial area.

Although the most efficient generation mix has not been achieved, by utilising the quota approach, the project has allowed an additional 5.8MW of generation to connect over a LIFO approach. LIFO allows 27.7MW to connect at a curtailment rate of less than 5% by using this approach. The pro-rata principle of access, allows 33.5MW of generation to connect to the network at an average curtailment of 2%, with the added benefit of linking generators to the potential reinforcement of the network, as will be discussed later in this report.
It is possible that using the idea of a more dynamic quota, would ensure that the most efficient use of the network is provided based on the DG types in the queue for capacity. By giving all customers a curtailment rate of 5.3%, the capacity quota could be capped differently depending on the make-up of the current schemes applying for connection, ensuring the most optimal output, whatever the generation mix. SDRC 9.2 – Principles of Access, details the approach but this was not undertaken as part of FPP as it would be more difficult to manage due to the amount of capacity within the quota changing every time a customer did not accept a flexible connection offer, as other DG schemes would then enter the quota. This could positively or negatively affect the previous quota amount and provides the customer with less certainty of their curtailment estimate for securing finance for their project.

2.3.2 Certainty
Certainty assesses each principle of access depending on how accurate the long term level of curtailment can be when the project applies for a connection. The principles of access report, made some initial assumptions regarding the certainty of the LIFO and pro-rata approaches which are summarised in table 2.

Since the project outset there have been changes in the understanding of the certainty that pro-rata provides. Customers have indicated that pro-rata provides a more certain set of principles for their DG scheme because the approach shares the risk of curtailment across all DG schemes within the quota. The importance and reassurance that sharing risk provides, should not be underestimated. Customers indicate that a pro-rata scheme is more likely to be financed than a LIFO scheme due to the risk sharing element.

Due to the changing mix of generation in the capacity quota over the project, the expected levels of curtailment have reduced from the expected worst case of 5.33% to as low as 0.59% in some cases, as such it is likely that the project could have set the capacity quota at a higher level (~40MW). However, this was not possible as the quota could have reverted back to all wind connecting and these customers would then be given non-viable curtailment estimates at a quota size of 40MW.

In addition to this, a customer accepted a flexible connection offer with a curtailment estimate of 9.16%. This is due in part due to the project already having been financed based on 100% utilisation of their generation within their existing factory building. It was identified that there was the additional capacity to export some electricity generation, this required an export agreement, which could be offered via FPP. This shows that depending on the DG scheme characteristics, some schemes can accept higher curtailment levels than initially thought, particularly where the scheme has already been financed.

| Table 2 – Assumptions on the certainty of LIFO and pro-rata principle of access |
|---------------------|---------------------|
| **LIFO**            | **Pro-rata**        |
| There is a good level of certainty for the customer in LIFO, each customer in the queue is unaffected by any generation applications that apply after them, as the type of generation technology does not affect their likelihood of curtailment. This option gives the customer a clear understanding of the order in which they will be curtailed. | There are additional uncertainties with this method compared to a LIFO approach due to the impact that future generation types to connect will have on the initial customer. This can be mitigated upfront by using a conservative approach to setting the quota cap. |

7 Named ‘Reflexive’ Quota in SDRC 9.2 – Principles of Access
Figure 7 shows the changes in the curtailment estimates issued between the times that the customer accepted the FPP connection offer and December 2014 when more customers had accepted their FPP offers and the generation types in the capacity quota at March Grid became more defined. On average the curtailment levels have decreased by ~55% between the customer accepting an offer at a curtailment level and the current expected curtailment.

Although the curtailment level for every customer has improved from the connection offer to the connection acceptance or connection offer expiration, the sometimes frequent movement of a DG scheme in the capacity queue and the associated changes to the curtailment estimate can be difficult for the customer to keep up with. This can put an additional burden on the customer to revise their business case a number of times to see whether the current estimated levels of curtailment are manageable.

Under the LIFO approach there were not any changes to the customers’ expected curtailment levels except where the customer has given us additional information that has changed the initial assumptions in the report. This is because the queue has consistently remained the same and the

Figure 7 – Curtailment levels for accepted projects from acceptance to project close at March Grid
constraints associated with the two accepted projects are independent of each other.

Although FPP does not replace the requirement for the network to be upgraded to allow future unrestricted generation to connect, it can facilitate this. The use of the reinforcement quota defines the point at which it becomes feasible for generators connected on a flexible basis to pay for the network reinforcement rather than continue to be curtailed i.e. the cost of curtailment for all customers exceeds the cost of reinforcement. Once 33.5MW of generation have connected, there becomes the incentive for FPP generators to pay for this reinforcement work. Reinforcement at March Grid was initially budgeted at £122,000 per MW and the feedback from some of the generators the project engaged with, indicated that although the contribution to reinforcement was at a reasonable level, the uncertainty it provided added an additional risk. If reinforcement works were to be included as part of the customer offer, it provided an additional uncertainty around when reinforcement would take place (as there was no understanding of when the quota was likely to fill up) and when the funds would be required. This added an additional element of risk to the connection offers that could have deemed the schemes unviable.

2.3.3 Simplicity
Simplicity explains how easy each approach is to implement and understand for the customer. The principles of access report, made some initial assumptions regarding the simplicity of the LIFO and pro-rata approaches which are summarised below:

At Peterborough Central Grid there were issues with voltage rise being outside of statutory limits and thermal constraints on one of the overhead lines into the grid site. In this case a LIFO approach was the best approach as there are different constraints on different parts of the network and therefore not all generators would feed into the same constraint, but a curtailment order needed to be set up in case all the generators fed into a new constraint at some point in the future.

The pro-rata approach works well at March Grid, due to the simplicity of the constraint. At March Grid the constraint was the same for all customers feeding into any of the primary substations that feed into March Grid, which made it simple to form a queue for the capacity. The constraint could be reinforced by replacing the existing transformers with two 90MVA transformers to increase the reverse power flow capacity.

By the very nature of what is being implemented – a new process and a new type of connection – the outcome is a more complex solution than the conventional approach. There is a trade-off between trying to offer a transparent approach, showing the benefit, that is simple to understand and the right balance must be met in order to make the best offer available to customers. Although both principles of access have a similar level of added complexity, the additional burden on the customer to understand the capacity quota at March Grid, as well as changes to their curtailment report as a scheme moves up the capacity queue can be burdensome. The amount of information sent to the customer with the connection offer is designed to give the customer all the

<table>
<thead>
<tr>
<th>LIFO</th>
<th>Pro-rata</th>
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<tbody>
<tr>
<td>Easy to understand and implement for most constraints.</td>
<td>The pro-rata approach can be more complex, particularly in setting a quota level to allow the maximum network utilisation.</td>
</tr>
</tbody>
</table>
Flexible Plug and Play
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information they could require to be able to fully analyse the profitability of their DG scheme. There may be too much information sent out with the connection offer, this will be reviewed as part of a roll out of the solution.

2.3.4 Fairness
The fairness criterion looks at the equitable allocation of curtailment costs between generators connecting to the same area of the network. The principles of access report, made some initial assumptions regarding the fairness of the LIFO and pro-rata approaches which are summarised in table 4.

To connect an infinite number of generators under a pro-rata rule would not be providing the initial customers with a fair approach to connection, as the more generators to connect, the higher the curtailment level shared amongst all generators would be. Therefore it was decided that implementing a quota was a method of reducing the risk and limiting the estimated curtailment levels to within an acceptable limit for the generator. This provided customers with a consistent approach, as all customers were able to accept a connection offer at a curtailment level that ensured their project was still viable, whereas LIFO could have meant that customers received different curtailment estimates dependent on where they were in the queue, meaning some projects that could have been viable under the quota approach would not be based on the LIFO approach. With LIFO, the DG customer market effectively decides when curtailment is too high for any more schemes to accept a flexible offer in a particular area, as the schemes become financially non-viable at higher levels of curtailment. Using the pro-rata method means that the DNO decides what level of curtailment generators receive and the capacity at which no more generation will accept (outside of the quota).

A DG scheme’s position within the capacity queue is based upon the date and time that they make their application for a grid connection; this position determines their estimated curtailment rate. This provides the fairest way of allocating capacity: on a first come, first served basis. If a scheme is unable to accept a connection offer currently, due to issues such as planning permission, they will have to allow their connection offer to expire and reapply when the project has progressed. This may mean that the project moves down the queue, potentially behind schemes that are at a stage to progress with connection of their generation.

Table 4 – Assumptions on the fairness of LIFO and pro-rata principles of access

<table>
<thead>
<tr>
<th>LIFO</th>
<th>Pro-rata</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-come first-served basis is not always the fairest way to allocate capacity. The curtailment levels rapidly increase the later the generator is in the LIFO queue, which increases their costs for connection and curtailment far above the first generator in the queue.</td>
<td>Depends on the level of the maximum curtailment. The level of curtailment that determines the capacity quota cap may not suit all generation types to enable a viable project.</td>
</tr>
</tbody>
</table>
2.3.5 Learning

The project and specifically the implementation of the principles of access have provided significant learning for future use of the principles for UK Power Networks and other DNOs, as shown in this chapter.

Pro-rata offers a more efficient and certain means to connect by allocating capacity levels, which in turn maximises the amount of generation that connects to the network compared to LIFO. The drawback with using pro-rata is that it cannot be applied to all constraints, which is why the project has not been able to use pro-rata in the Peterborough Central grid area.

Significant savings in terms of cost of connection and time taken to connect can be seen for all projects that have requested a connection under FPP, the amounts of saving are significant and do not depend on the principles of access in the area, this is detailed further in section 5. However, the level of acceptance is different for each principle of access, with more connection offers being made and accepted in the March Grid area. This is partly due to the reduction in risk and lower curtailment rates in the March Grid area due to the pro-rata approach, which provide a much more financeable approach for the customer.

Table 5 – Assumption on the learning of LIFO and pro-rata principles of access

<table>
<thead>
<tr>
<th>LIFO</th>
<th>Pro-rata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited additional learning over SSE’s Orkney project, however, by using a similar offering in the Peterborough area, the project could see if the lower capacity factor of wind turbines in the East of England had an impact on the acceptance rate.</td>
<td>An innovative, ambitious and widely applicable approach that will create a great deal of learning.</td>
</tr>
</tbody>
</table>
Development of Connection Offering
The connection offering for FPP was based upon the current connections offer process for Section 16 (S16 – contestable and non-contestable works) and Competition in Connections (CiC – non-contestable works only), with FPP project support for the specific additional elements. Due to the innovative commercial offering of the flexible connections under FPP, a number of key documents required alterations before they could be sent to DG customers to take into account the changes to the customer’s connection and access to export electricity to the grid. There was also the requirement to create additional information to support the customer to understand the offer they had been given.

The documents that were updated are:
- the connection offer; and
- connection agreement.

There were different versions of each, depending on whether the customer was a LIFO only customer, a quota customer or a LIFO customer joining once the quota was filled (March Grid).

3.1 Overall Approach
FPP offered its first flexible connection in March 2013 to DG customers that had previously received a business-as-usual connection offer in the trial area, but were interested in the benefits of a flexible connection. Any customer requests received for DG connections within the FPP trial area were given the option to have a flexible connection offer instead of or in addition to the business-as-usual connection offer. This gave the customer the opportunity to compare the connection types and the implications for their DG scheme.

To be eligible to receive a flexible connection offer, the customer must meet the following four criteria:

1. Have requested a connection offer through UK Power Networks’ Projects Gateway;
2. The project is located within the FPP trial area;
3. The generation capacity is greater than 200kVA;
4. Their closest, logical point of connection (POC) is within the trial area and the constraint can be managed by the ANM equipment.

The connection offer gives a price for connection, an estimated date of connection based on the customer accepting immediately and references the terms of connection. In the FPP offer we also add the adapted connection agreement for the customer to view prior to signing (this will be further explained in section 3.3).

3.2 Connection Offers
The connection offer is made to the customer once the generation connection request has been assessed against the current network availability and work required to enable connection (contestable and non-contestable).

Four key aspects of the connection offer were modified in order to make the FPP offers to actual customers. These were:

1. The quotation letter from the Project Manager has been adapted in order to make it clear that the offer is for a flexible connection;
2. The key differences between a business-as-usual offer and an FPP offer are highlighted;
3. A termination notice if planning is not approved within six months is included, to ensure that developers are in a position to build and connect their projects quickly;
4. Additional information, projections, data, estimations and forecasts of levels of curtailment are sent with the connection offer.

The provision of a flexible connection via FPP is subject to three conditions:

1. The customer entering into the (flexible) connection agreement;
2. The installation of an ANM scheme on their premises to enable UK Power Networks to issue instructions to their generating equipment to curtail their export of electricity.
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3. UK Power Networks curtailing the export of electricity to
the distribution system in accordance with the Notice and
the Connection Agreement.

3.2.1 Additional Information provided with the
Connection Offer
A number of assumptions provide the basis for the curtailment
forecasts, therefore, four additional documents, to the usual
quotations letters are provided to the customer to support and
explain the FPP offer, and particularly how the quota capacity
and curtailment figures had been calculated.

Cover Letter
This is a letter explaining what information is part of the
FPP additional documents and giving contact details for the
team dealing with queries on these connections.

Additional information booklet
The additional information booklet explains the project in
detail, covering information on:
- Purpose and objectives;
- The trial area;
- Description of constraints and solutions;
- ANM;
- Principles of Access;
- Curtailment assumptions.

Curtailment Report
The curtailment assessment report outlines the estimated
curtailment levels that the customer could experience over
a year by taking into consideration the generator’s proposed
capacity, it’s place in the capacity queue, the commercial
arrangements method (LIFO or pro-rata), POC location in
relation to other DG schemes and network constraint(s). The
curtailment level takes into consideration an error factor of 10%,
which is utilised within the ANM configuration and detailed in
SDRC 9.6 (called the safety margin) which aids the curtailment
figure to be the worst-case scenario. The information within
the report is used to support the business case or due diligence
to enable the customer to understand whether their DG
scheme is financially viable. Individual curtailment assessments
are completed and issued to each customer.

The curtailment report details the input assumptions
underlying the analysis, these are:
- The demand profile of the customer on the local network
  behind the local constraint;
- The capacity factor of the generator (the yearly production
  percentage for that generator type) and the export profiles
  of unrestricted and flexible generators, shown in table 6;
- The expected level of micro-generation export growth,
  which is not controllable via ANM;
- Network configuration and operating conditions; and
- Capacity limit of the relevant circuit and its relationship to
  wind speed or other climatic effects.

<table>
<thead>
<tr>
<th>Generator Type</th>
<th>Uncurtailed Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>30%</td>
</tr>
<tr>
<td>PV</td>
<td>11.16%</td>
</tr>
<tr>
<td>Micro-PV</td>
<td>11.16%</td>
</tr>
<tr>
<td>Always On</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 6 – Un-curtailed capacity factor used in
curtailment assessment

Historical profile data, in the form of a time-series, has been
used as a basis for the analysis with a range of different
scenarios studied. The time-series data has been used to
tailor the curtailment report to either a Wind, PV or CHP
generator. The different scenarios look at the impact of Micro-
PV, operating margins being just below their true limits and
assuming zero demand growth as a worst-case (demand
growth would create more capacity for generation). The
different scenarios give the customer an indication of how curtailment will vary with different conditions.

**Capacity Quota Calculation**
The projects connecting to March Grid receive an extra document, explaining the underlying assumptions and the calculation of the capacity limit for the capacity quota.

### 3.3 Connection Agreements

Once a customer is connected to the electricity network using traditional methods, the National Terms and Conditions of Connection⁸ apply. Although due to the infancy of flexible connections the National Terms and Conditions do not take into consideration the flexible element of the connections, amendments have been made to the connection agreement in order to reflect the terms of the flexible export.

Two connection agreements have been developed, one for each commercial approach developed and the templates are available to view by request. This agreement is signed by the customer and UK Power Networks prior to commissioning to ensure that the flexible terms are contracted. The connection agreement details the way in which the customer will be curtailed over the lifetime of the generation equipment. It is important to outline this in the document as it offers the customer certainty on their connection and indicates expected levels of curtailment. This flexible connection agreement is also more specific to each customer’s site, including the flexible export and unrestricted import capacity, should the customer have an incoming load.

Some specific terms have been modified in the connection agreement document to make it more relevant to the flexible connections and ensure the customer is fully aware of their requirements. This is specifically detailed in the document with the customer’s obligations and subsequent owners of the generation equipment. The customer obligations include:

- Maintenance of their connection and any aspects of the ANM that they are responsible for;
- Not changing any part of the ANM system without agreement from UK Power Networks;
- Notifying UK Power Networks before undertaking any maintenance of those parts of the ANM scheme that they are responsible for maintaining;
- Subsequent owners of the generation equipment must be aware of and comply with the connection agreement on the site generation.

The connection agreement lists a number of different schedules; the information in the schedules is tailored to the specific DG details. Schedules 1 and 2 of the connection agreement detail the individual connection point and the flexible arrangements.

### 3.4 Learning Outcomes

**Future changes in ownership**
The role of the developer and the role of the owner of the project evolves and their interaction with UK Power Networks changes throughout the flexible connection process. In a number of cases a project is developed by a company and is sold prior to the scheme being built. Therefore the flexible connections process needs to take into account changes in ownership to the project; this can take time due to the legal documents that are required to update the ownership. This process could be updated to ensure that ownership changes can be accounted for in the faster flexible connection delivery, particularly by accepting the documents electronically and reducing the requirement on legal colleagues to deal with this scenario.

In order to ensure that all connection agreements contract the flexible arrangements for export for current and future customers, it is important to ensure that the National Terms of Connection reflect these arrangements. Work is underway

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to include a clause within the National Terms of Connection within the next few years; all customers will have to pass on the details and specific constraint of their electricity connections to any future owners so that they are bound by the same terms of connection.

The time implications of setting up and deploying alternative commercial arrangements
Implementing a new commercial offering to customers requires additional time and effort to set up to ensure that it is implemented smoothly and to a high standard of customer service. The key elements that need to be adapted are the processes and policies surrounding the offers. This requires extra resource in order to spend time setting up new processes, training and supporting the new elements, reviewing constraints, engaging on the new aspects with customers and producing the right legal documentation to support the offer.

Whilst the set-up of the new commercial offering has required time to organise and prepare for, there is also a continued element of management required in order to ensure customers understand the flexible offer, as well as the queue for capacity. Additionally, updated curtailment reports are issued when customers move position in the capacity queue.

Provide the customer with sufficient time to review and sign the connection agreement
The draft connection agreement is sent to the customer with their connection offer letter, to allow the customer enough time to review, understand the purpose and the individual clauses that have been amended for the flexible connection. This allows enough time and avoids potential delays, as flexible connections cannot be commissioned without a signed connection agreement.

Challenges of putting the connection offer and agreement together
In order to begin offering new flexible connections to customers, the offer letter and connection agreement required amendments to account for the different offer type that was being made compared to conventional generation connections. One particular issue was the length of the document that was sent out to customers, as this was already a fairly long document which had to include the Connection Agreement as an Appendix, making the offer letter around 50 pages. This issue was raised, but the decision was made to issue offers of this length to ensure that customers were fully aware of the type of offer they were accepting and the connection offer that they would be required to sign up to should they wish to go ahead with their project.

The connection agreement was an important part of the offer as this offered clarity that the DG was being connected on the basis that the whole capacity would be interruptible if the distribution network required the generator to be turned off. It took time to make sure that the Connection Agreement was simple for customer’s to understand but also legally robust to ensure the responsibilities of all parties were clear.

Treatment of other onsite generation
A number of schemes connecting under FPP already have exporting and non-exporting generation on site. This needs to be captured under the connection agreement as theoretically the customer can generate from any piece of generating equipment as long as the site generation does not exceed the export capacity that has been approved. The other onsite generation needs to be controllable, if this is the case, so that if the distribution network is unable to accept generation, all onsite generators can be switched off until it is safe to generate.
Flexible Plug and Play Customers
4.1 Customer and Stakeholder Engagement

The popularity of FPP has seen the project engage with a number of interested parties, as customers have seen that FPP could be a viable option for their generation sites inside and outside of the trial area in the future. In a relatively small area of the East of England the project has engaged with forty-four customers with projects in the trial area.

Initially the project engaged with a number of stakeholders as part of the stakeholder engagement report. This was used as a starting point for the provision of flexible connections as the offers had to meet customer and other key stakeholder requirements for the project to be successful in achieving the number of customers that have requested FPP connection offers.

Stakeholder and customer engagement has continued throughout the project and has seen all of the key pieces of information, such as reports and key documents produced by the project published on the UK Power Networks innovation website. The FPP trial area is outlined on the Eastern region heat maps (available from the UK Power Networks internet page) and these have raised the profile and sustained interest in the project. The FPP team also regularly speak at relevant conferences to share the learning from FPP and speak to different stakeholders.

The close relationship between the FPP team and the Connections directorate has ensured that key information regarding the project has been disseminated to key external stakeholders via the customer engagement workshops or the DG mailing lists. The workshops provide an excellent opportunity for both UK Power Networks and FPP to engage with the DG developers to understand the key issues and concerns affecting the DG community, whilst disseminating key learning generated to the industry. These methods will continue to be used to roll-out the project, as well as the DG webpage on the UK Power Networks website.

4.2 Project Acceptance and Savings

As described in Section 2 of this report, the initial assumption for the curtailment analysis for the FPP project was that all generators connecting under the scheme would be wind generators. This was due to wind providing the worst case scenario for the curtailment assessments and also reflected that the predominant demand for generation in the area prior to 2012 had been for wind turbines; therefore the March Grid quota was set at 5.3% curtailment per generator for 33.5MW connecting. There has been a significant shift away from wind applications during 2013/14 with solar PV becoming far more prominent. The mix of PV, wind and CHP connecting in the trial area, means that curtailment levels in the quota have decreased, making the offer even more attractive. This is reinforced by the level of savings that can be seen in section 5; savings over the unrestricted approach are between 45% and 98% with an average saving of 87%. The majority of projects have saved over 80%, even with a number of the latter quotes charging the customer for the ANM equipment, as the first eight pieces of ANM equipment covered by the project had been utilised.

A number of customers withdrew their connection offer requests prior to quotation, this was mainly in areas where an FPP alternative could not be offered due to the local constraint or the positioning of a site, such that the FPP alternative would still be expensive because of the cabling routes required. These customers were given feedback on their options early in the process and as such decided to withdraw their requests.

To date 12 December 2014, Peterborough Grid has had four FPP connection requests, totalling 28.20MW, two of these customers have accepted the FPP alternative. One of these accepted offers, a 0.25MW PV generator, was connected via the ANM system in April 2014.

March Grid has seen larger levels of interest, mainly due to the available agricultural land in the area. Thirty-six FPP
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offers have been made in the March Grid trial area, with an additional six being re-offered to the same customers when their projects had progressed with planning. Twelve generators have accepted the offer. These generators total 27.63 MW of capacity, and all sit within the capacity quota, although four projects accepted the offer when they were in the LIFO part of the queue (after the 33.5MW quota) and subsequently moved up and into the quota, due to projects within the quota dropping out. Three customers have connected in the March Grid area during November and December 2014, with a total capacity of 2.50MW.

Not including the offers that are currently valid, the acceptance rate for FPP connections is an average of 37% compared to a UK Power Networks average amongst DG customers of ~20%. This shows that on an increasingly constrained network, flexible connections have proven to be a viable alternative, particularly where the risk is shared, as shown in the pro-rata approach. The rates of acceptance over the last seven years are shown in Figure 8.

The percentage of accepted offers in 2008 is much higher than in other years as the grid in the East of England was not so constrained. Due to generation connections in 2008 from then on there was less generation capacity available to connect at a reasonable cost and timescale. The trend of decreasing grid capacity has continued over the following five years.

Through choosing to accept the flexible connection offers rather than the business-as-usual offers, the accepted DG customers have saved £38 million in total on the upfront cost of connection. This shows that the loss in earnings from curtailment is low enough to make the FPP offer

Figure 8 – Total quotations made compared to offers accepted for business-as-usual and FPP commercial offerings
more attractive than the cost of accepting a business-as-usual connection, which would have been impossible as the business-as-usual costs have deemed the majority of generation schemes unviable.

4.2.1 Learning Outcomes

**Acceleration of connections, provided by FPP can have an additional cost benefit**

FPP has attracted the connection of mainly renewable generators. These generators are highly dependent on subsidies from the Government to ensure that their projects make a profit for the next 20 years. These subsidies take the form of the ROCs, Feed-in-tariffs, and LECs. Changes to Government policies or subsidy levels can make previously viable projects unviable. This has particularly been seen recently with the proposed changes to the ROCs for PV schemes which are larger than or equal to 5MW. FPP is a significant aid in this respect, as the connections can be provided faster than the business-as-usual alternative, therefore a customer with an FPP connection offer is more likely to achieve a connection before changes in pricing or funding rules.

4.3 Post Acceptance

There are several additional requirements with flexible connections over and above a business-as-usual DG connection that are required by UK Power Networks and the customer. A key aspect of this is to allow UK Power Networks to design the ANM system in order to meet the specific customer requirements, whilst also being able to effectively manage the network constraint. There are a number of different control systems on the open market for generators to procure, each has a different configuration and can accept different information from the ANM, therefore it requires time to understand what the customer system can and cannot deliver to meet the needs of the flexible connection. However, in order to provide an FPP connection, the customer’s control system must meet a minimum standard and specification.

The following actions take place with the customer and FPP team input, in addition to the usual process from other business departments:

1) The customer is made aware early on of the high level additional requirements of the ANM system;
2) The kick-off meeting is an initial opportunity for UK Power Networks and the customer to understand the project works required in more detail, to set a schedule and to set the customers’ expectations. This then leads on to further detailed discussions;
3) The initial communication interface meeting is arranged following the kick-off meeting. The purpose is to understand what information can be sent and received by the customer’s local control system, which informs the way in which the ANM is configured. More than one communication meeting may be held depending on the complexity of the system(s) involved.

4.3.1 Learning Outcomes

**Flexible connection installations has led to an improved process for future connections**

At the first customer commissioning there was an issue with the customer’s PV plant control system and UK Power Networks ANM control equipment communicating correctly. The issue was resolved, with the following key learning points generated and implemented for future customer commissioning:

1) To minimise the possibility of technical issues that could affect commissioning, bench testing or cold-commissioning of all interfaces should be carried out prior to final commissioning on site with the generators.
control unit. This can be completed remotely, and could identify any potential issues that could be fixed prior to the full generation commissioning day;

2) To ensure any potential technical issues that are raised during the final commissioning day can be resolved on the day, the DG customer’s control system engineer needs to be present on site for the whole commissioning day; and

3) There is the need to standardise the communications protocols that are used for interfacing with the generators control system to ensure that UK Power Networks have a consistent approach. This can be achieved to a certain extent but as there are a large number of different control systems supporting different protocols, standardisation will take time.

Further challenges resulting from the interface design have been detailed in SDRC 9.6
5

Business Case
This section reviews the benefits of offering FPP for UK Power Networks, other DNOs and DG customers, particularly focusing on how the FPP connections are more financially viable and faster to implement.

5.1 Benefits from implementing flexible connections

Over the past three years UK Power Networks has seen an increase in the amount of DG wanting to connect onto the distribution network, meaning that without significant network upgrades taking place, unrestricted capacity will continue to be sparse, and this increases the strength of the business-case that flexible connections are a viable way to extend the life of existing assets. At the current rate of growth FPP has proven that flexible connections are a popular and viable alternative where an unrestricted connection is too expensive, such that UK Power Networks are receiving requests for the availability of flexible connections to be rolled out to other locations.

The design and delivery of flexible connections has enabled UK Power Networks to improve the service provision to the customer, through offering a viable connection for DG schemes. As part of this alternative method of connection the project has been working very closely with DG customers to ensure they can make well informed decisions, whilst also gathering feedback to ensure that flexible connections are truly a viable alternative to business-as-usual connections.

All of the work being undertaken by the FPP project has enabled UK Power Networks and DNOs to support the Government targets to reach an 80% cut in carbon dioxide emissions by 2050 from 1990 levels\(^3\). By enabling the growth of energy from renewable sources, UK Power Networks will make a significant contribution to aiding the green agenda and this demonstrates one of the company visions to be a respected corporate citizen.

5.2 Comparison of the Flexible Plug and Play Method to the Conventional Connection Option

FPP set out to make flexible connections a viable alternative offer to generators wishing to connect to the distribution network in the trial area. The two key objectives of the FPP project were to enable cheaper and faster connections compared with the traditional business-as-usual offers. The information gathered from the 45 flexible connection offers, 14 accepted customers and the four customers connected using FPP methods, as of 12 December 2014, has demonstrated and proved the project has delivered against its two objectives.

5.2.1 Flexible Plug and Play offers a cheaper way to connect to the network in the trial area

The flexible connections quotations issued to DG customers in the trial area since March 2013 have proven to be a cheaper alternative than the business-as-usual alternative. As shown in Figure 9, the flexible connections quotations issued to customers have provided savings of a minimum of 45% compared to the traditional business-as-usual offer, with over half of the flexible connection offers providing a saving over 90%. Across all of the projects this is an average saving of approximately 87%, which equates to a reduction of approximately £6.5m per project.

As part of the project budget and agreements with project partners a provision was made to finance the on-site ANM/communications equipment, installation and commissioning cost for the first eight customers to accept the flexible connection quotations. Initially, when providing DG customers with their flexible connection quotations, no allowance or charge was made for the ANM, installation and commissioning costs, which were made for generators after the initial eight. Figure 9 only shows the cost saving between the quotes that have been issued to customers. In order to provide a true comparison between flexible connections and the business-as-usual offer, whilst also understanding if the projects would still be financially viable,\(^3\)

the total cost of the project needs to be calculated, which includes the expected level of curtailment and the ANM and communications equipment.

Before accepting the flexible connection offers the DG developers would undertake financial due assessment, as part of this they would take into consideration the impact of curtailment. Figure 10 below shows the net present value of curtailment over the scheme’s connected lifetime (assumed to be 20 years) based upon the level calculated in the curtailment report and the S16 quotation cost including the ANM costs. This is then compared with traditional business-as-usual costs.

The FPP costs are made up using the following components:
- 7.2% discount rate;
- Curtailment rates based on capacity factors that are representative of the East of England; 30% wind, 11.16% PV and 100% CHP;
- Curtailment rates are taken to be the current curtailment rate if the project has accepted the offer or is still valid or the last curtailment offer made to a project that has expired;
- Full costs and installation of the ANM equipment at the customers site: the ANM box, cabling and interface design; and
- A number of the accepted connection offers have requested a local demand connection with their export connection, where this has been requested the cost has been included in the figures below, as the additional cost of including a demand connection is negligible.

The FPP costs do not include:
- A contribution to the central communications infrastructure provided by FPP, which would be paid by a generator connecting on a flexible basis in the future;
- Operation, maintenance and licence charges have not been added to the customer cost as these have been covered by the FPP project in this instance.

Taking into consideration all the ANM and communication equipment costs and curtailment over a 20 year period all but two of the flexible connection offers still were more financially viable than the business-as-usual offers with an average saving of ~65% or £5.4m per project. This further reinforces that flexible connections do not only provide a
Flexible Plug and Play is quicker and more cost-effective for connecting renewable generation to the distribution network using a flexible approach.

Short-term benefits, but even after 20 years of curtailment, they provide a long-term viable alternative.

The two flexible connection offers for Generator 04 and 15 become more expensive than the traditional business-as-usual option when taking into consideration the cost of curtailment and the ANM/communication equipment costs. This is as result of the low business-as-usual connection costs quote, when the FPP trial area was not so congested and thus the business-as-usual offer was lower than would presently be the case.

The full costs shown in Figure 10 for Generator 15 in terms of cost of ANM and curtailment were not paid for by the generator. They were one of the first eight customers to accept a flexible connection offer, so the offer cost did not include the ANM and communication equipment. Generator 15 also had the ability to utilise the majority of their generation on-site so they would not see the same curtailment levels as outlined in the curtailment report. Both of these factors made the flexible connection offer a more financially viable alternative to the business-as-usual offer which is not reflected in Figure 10.

Generator 07 has not accepted the FPP offer and is unlikely to, based on their current position in the capacity queue. This project sits behind the capacity quota at March Grid and has a current curtailment rate around ~20%. Unless some projects ahead of this scheme in the queue drop out, this project will not be able to accept as the FPP offer is not financially viable due to the high expected curtailment level.

The majority of the cost for flexible connections is the physical works that are required to take place before the DG scheme can be connected to the network. However, as mentioned above, the customer, particularly in the roll-out of any solution, will have to cover the cost of the ANM and communications equipment, as well as taking into account the cost of curtailment over the lifetime of the project. The graph below shows the proportion of the overall cost shown in Figure 10, split by the three main cost sections for the accepted customers.

On average the total FPP cost is made up of 50% S16 base connection cost, 25% ANM and communications equipment and 25% cost of curtailment over 20 years. Whilst 50%
uplift on the normal cost of the closest connection may seem expensive, when compared to the conventional offer alternative, this has proven to be the only viable alternative.

Cost Per MW
As part of the Stakeholder engagement report, DG customers indicated that a grid connection of less than £200,000/MW would indicate a profitable scheme. The project has seen flexible connection offers accepted between £53,000/MW to £486,000/MW excluding curtailment, with an average price of approximately £311,000/MW. Five DG customers accepted flexible connection offers over the £200,000/MW threshold, with an average price of £247,000/MW, which indicates that the price per MW threshold is higher than originally indicated, or it is at least different depending on the technology type. The cost including curtailment ranges from £92,000/MW to £796,000/MW, the higher end of this range are a number of CHP projects, CHP may have a different tolerance due to the generator being ‘always-on’ and as well as PV plant that does not plan to export so will not see the likely curtailment. A more realistic average cost per MW based on the experience of FPP is likely to be around £340,000.

It is likely that customer’s see the FPP scheme as a way of connecting to the network within a time frame that secures current support tariffs. This provides additional security to accepting an FPP offer as the works required for a flexible connection are quicker than the business-as-usual alternative. This reduction in risk of accepting an FPP offer could also account for the reason why customers have accepted the FPP connection offer at a higher cost per MW than initially anticipated.

It could be suggested that some of the customers accepted their flexible connection speculatively: with the higher levels of curtailment and thus a higher cost per MW and were doing so to secure their current place in the queue for capacity, whilst also hoping that their project would move into the March Grid quota rather than staying within the LIFO section of the queue. There are, however, other reasons why projects would be able to accept at a higher cost per MW as they affect the financial model of the generators. These can include; whether the
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A generator owns the land for the generation equipment to be installed upon or whether the generation equipment is already installed and therefore has already been financed. The cost per MW of the scheme is larger for the smaller projects, this is due to the subsidies provided by central Government, for example the Feed-in Tariff for small wind generation is larger than the ROC/CfD for larger wind schemes, and the same is true for PV. The ANM is charged on the same basis for all parties so will appear more costly for smaller projects.

5.2.2 Flexible Plug and Play offers a faster way to connect to the network in the trial area

To date four FPP schemes have connected to the distribution network, with another ten schemes expecting to connect during 2015.

**Faster Connections**

The significant difference in the time taken to connect a DG customer to the distribution system following acceptance of a business-as-usual connection offer, compared to a flexible connection offer, is that there is no more available capacity for unrestricted generation on the network. This has resulted in customers requiring a business-as-usual DG connection in the FPP trial area, having to connect to Walpole grid, which is approximately 40 km from the trial area, where capacity will become available from 2017.

Each customer quotation for either a business-as-usual or a flexible connection is tailored to meet both the customer’s and the DNO’s requirements to connect them safely to a point of the distribution network at minimum cost. The connection offer letter sent to a customer, details the high level components of work required to be undertaken by the DNO and the customer. These components and the work

![Figure 12 – Accepted Flexible Connection Cost per MW](image_url)
required to complete them, determines the time that it will take to connect the customer to the distribution network.

The comparison of the time taken to connect for business-as-usual connections and flexible connections, in Figure 13, is based on time spent specifically relating to the project, removing any time spent waiting for planning consents, land rights and wayleaves. The timings only focus on the physical work taking place to connect the scheme.

Although, there are relatively small number of projects that have and will connect under the FPP project, as shown in Figure 13, flexible connection projects are able to be completed quicker. The average connection time saving is approximately 29 weeks. This is mainly due to the reduced cable route lengths to the POC, which under the business-as-usual offer is a number of kilometres away from their site.

Generators 14 and 15 are existing load and generation customers situated in an area of the network that at the time of application was not as heavily constrained as other areas. The work required to connect these customers to the distribution network was minimal so the main difference between the business-as-usual option and the flexible connection option for these customers was the cost to connect.
6

Roll out of Flexible Distributed Generation Connections
The success of the FPP project to date has shown that flexible connections are a viable and attractive alternative to generators who are otherwise unable to connect to the network using their closest and generally cheapest point of connection. In the UK Power Networks RIIO-ED1 business plan submission, there is a commitment to:

*Integrate Flexible Plug and Play connection offers (as per our Low Carbon Network Fund Project) into business as usual by Q2 2015*.

UK Power Networks has since accelerated the rollout of flexible DG connections with the area of Norwich being the second zone where flexible generation requests have invited since November 2014.

This section presents a summary of the key areas that require consideration as part of the implementation into business-as-usual.

### 6.1 Power systems analysis and solutions

As part of the roll-out for the solution, UK Power Networks is defining the technical scope by identifying the technical constraints on the network and the technical solutions that can enable generators to connect.

In order to do that, an initial review of the Eastern and South Eastern networks has been completed focusing on ranking the grid supply points and grid sites in terms of level of demand for connections, complexity of constraints present and cost of connections issued.

The understanding of the power system problems that need to be solved has driven the prioritisation of areas in terms of the roll out and also determines the overall architecture and solutions used to implement flexible connections.

Different solutions might be employed for different types of constraints or different size generators. It is however important to ensure interoperability if these different solutions sit within the same network.

A risk-managed gradual introduction of the flexible plug and play methods to the network is currently being planned. It recognises both the high-demand for such services and the need for further trial results and refinement of the method.

#### 6.1.1 Telecommunication strategy

FPP has implemented a radio frequency mesh network that provides the communication system for the project. There are a number of alternative methods that can be used to provide the communication solutions required to support the ANM. The FPP method and the alternatives are being analysed using the cost and benefit for each scenario against the requirements that are drawn up as part of the technical analysis. It is envisaged that a suite of solutions that meet different requirements and performance levels will be made available to enable flexible DG connections.

### 6.2 Commercial Framework

To complement the technical offer with the roll-out of flexible connections, a thorough approach to the commercial assessments is also being undertaken. This will ensure that the customer is offered a clear and consistent flexible connection offer that is replicated in other areas of the distribution network.

#### 6.2.1 Principles of Access

The principle of access to the flexible capacity will be decided upon based on the area and the constraint before any flexible connection offers can be made. This links to the technical constraint and the associated technology to manage this constraint. The two options that will be analysed are pro-rata via a capacity quota and LIFO.

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Pro-rata: The FPP capacity quota was set using the point at which the cost of curtailment and the cost of reinforcement per MW are equal. An alternative approach would be to utilise the FPP experience, which has shown that in some cases a tolerable level of curtailment has proven to be up to 10%. However a figure needs to be set that will prove viable for the majority of projects. From the FPP experience and discussions with developers, a lower figure of between 5% and 6% is likely to be more acceptable for a quota that has a variety of technology types. A generation mix has to be assumed (most likely to be solar dominated in the current environment).

Based upon the experience from the FPP project a dynamic quota is an interesting way to manage the pro-rata curtailment. The change from the initial FPP assumption of all wind connecting to a mix of wind, PV and CHP has seen the estimated levels of curtailment per customer reduce significantly. Thus if the FPP quota was dynamic, more generation would have been able to connect as the size of the quota would be based on the generation mix at the time. However, this idea could make the quota element of the offer much more complex to manage.

LIFO: A LIFO principle of access is the best solution where there are specific constraints, such as local feeder or overhead line constraints on networks and for interconnected networks.

The use of Pro-rata and LIFO principles as best identified for each case to ensure efficient utilisation of the network while reducing uncertainty to customers.

6.2.2 The Connection Offer Process

It is important that the connection offer process is fully integrated into the usual business practice of making connection offers. This includes the ownership of different aspects of the connection offer by business teams.

UK Power Networks’ Asset Management directorate already play an important part in the offering of connections to customers. This is continuing for flexible connections as this is the department which holds the knowledge, expertise and history about different network areas.

There are a number of documents that have been developed as part of FPP, detailed in section 3 of this report. These documents will need to be adapted for the offering under the roll-out of the solution.

6.2.3 Capacity Register

Management of the capacity register is vitally important for the flexible offers, as there needs to be a transparent process and order for customers entering into the capacity register (which shows the status of customers requesting flexible capacity in a given area). This also means the customer expectations can be managed by giving them an idea of the approximate levels of curtailment they would expect at an early stage in the connection process. The capacity register information needs to be available to both Connections and Asset Management in order to support their work on a connection offer.

There are several elements to managing the capacity register that need to be decided prior to flexible connection offers being made:

- How are the projects registered for the quota or LIFO – the general approach by UK Power Networks is to register by the date that the customer makes the application;
- Process of updating the customer – it needs to be decided when an update to the customer will be provided if their place in the capacity register changes, as well as the maintenance of the history and updating of the register is made; and
- Ownership – there must be a responsible owner of the capacity quota who has ultimate accountability for the information recorded.
6.2.4 Active Network Management and Communications Cost Recovery

FPP initially received funding for the ANM and communication platform infrastructure (shared use assets) and the first eight pieces of ANM equipment (sole use assets). As fourteen customers have now accepted the flexible connection offer, six customers have had to pay for their ANM equipment (sole use).

The local on-site ANM and communications equipment required to enable the connection, will be paid for by the customer as well as costs for the equipment installation, control equipment, communications and operation and maintenance, which have to date been provided for by the LCNF project budget. A strategy for charging for the initial infrastructure costs that will be utilised by all flexible connection customers will need to be designed, whilst ensuring that UK Power Networks are not investing ahead of need. There are a number of complexities to this, including the proportionate charging for the communications platform and whether the DNO should pay for some of this cost, which will be considered during the design phase.

6.3 Organisational Transition and knowledge transfer

UK Power Networks have set up an internal business change programme known as the Smart Network Plan, in order to embed the learning and deliver the benefits of Future Networks projects to the business. Rolling out flexible connections is one of the first solutions that will be delivered by the Smart Network Plan. This will include the knowledge transfer and new processes required for delivering the flexible connection solution to customers. Key roles, responsibilities and ownerships are being set up as part of this process.

There are three key areas that require changes to the usual connection process in order to make flexible connections.

These are as follows:

1. Network analysis:
   - The POC that is identified and offered to a flexibly connecting customer needs to be made based upon the available capacity, the specific network constraint and the solution to that constraint. This should prove to be closer to the customers site than the traditional business-as-usual alternative;
   - The curtailment analysis to explain the percentage curtailment that could be seen over a typical year will be carried out in-house and sent out in addition to a connection offer.

2. Making connection offers:
   - The flexible connection terms and conditions, as described in section 3 of this report, that are different to the National terms of connection, are to be integrated into a connection offer template for CiC, S16 and pro-rata or LIFO;
   - The additional flexible terms will be integrated into the connection agreement (separate versions for LIFO or quota customers), which needs to be signed prior to energisation of the customer.

3. Continuous management:
   - Continuous management of the capacity quota is required to keep customers’ informed of their current position within the queue for capacity in their location.

There are a number of important messages and lessons learned for the FPP project that have been documented in the numerous reports that have been published over the project lifetime and available on the UK Power Network’s innovation website. This information needs to continue to be shared in order for the roll out to be an early success. This will be carried out through continuous engagement with key stakeholders within and outside of the business.
Reinforcing the network under FPP
Flexible connections are not a long-term solution to the challenge of the lack of capacity available on the distribution network for DG to connect. It is an interim solution that can provide a DG customer with a viable project until such a time that the network in that area can be reinforced. As flexible connections are being rolled out to other parts of the distribution network in UK Power Networks’ licence areas, there must be a standard approach to reinforcement of the network and how DG connected via a flexible connection are treated. This is an important aspect of offering flexible connections moving forward.

There are three methods under which load or demand reinforcement can currently be funded:

1. **Fully DUoS Funded** – all reinforcement works are paid for by the DNO and the cost of this is distributed to all end consumers via their energy bills;

2. **Part DUoS Funded** – the cost of reinforcement is shared amongst the DNO and the customer. This could be in the case when a local network requires reinforcement; a new customer wishes to connect in this area and pays a proportion of the reinforcement costs;

3. **No DUoS Funding** – the customer pays the full amount of the reinforcement costs.

Ideally, the best option would be for a number of DG customers to come together to upgrade the network in the area where their DG schemes reside, so that the cost of the reinforcement is shared amongst the connecting parties. There are a number of options that have been considered, based on the FPP project, to implement such a long term solution:

1. **Reinforcement takes place once the capacity quota is full** – this is the approach that could have been adopted in the March Grid area. The capacity quota was set at a level where the cost of curtailment for all generators was equal to the cost of reinforcement. This means that the cost of curtailment after the quota is in fully accepted or connected offers, is neutral to the cost of the DG customers coming together to reinforce the network. This provides security in terms of knowing that a conventional connection with full export would be forthcoming and as such, ends their expected curtailment, therefore generators are likely to pay for the reinforcement, particularly where this cost is spread among all the DG customers connecting. This was not originally incorporated into the Connection Offers and Connection Agreement for each customer due to the added complexity this gave to the offer, but customer’s indicated that it could be a viable approach. This approach provides the additional certainty to the customers of knowing the cost of reinforcement upfront, which can be based on the size of the customers DG scheme.

2. **Reinforcement takes place after a pre-agreed number of years** – this is an approach currently being trialled under the SP Energy Networks ARC project. It is an approach that can be used when dealing with the UFO principle of access as it gives customers certainty of when the network will be reinforced and when full export of their scheme will be available. This could strengthen the business case for generation projects. However, it has the added uncertainty of not knowing how many other generators will be sharing the cost of reinforcement as one of the first customers to connect or if, the first customer will pay all of the cost if no other generators decide to connect. A DG developer will not know upfront, the cost of reinforcement for their scheme, without estimating the number and capacity of generators connecting. By ensuring that the network will be updated within a certain time, some DG customers will decide to wait to connect until the necessary reinforcement work has taken place.

3. **Reinforcement takes place once a pre-set estimated curtailment limit is reached** – this option could be utilised
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for both a pro-rata and LIFO approach. Customers would sign up to a flexible connection scheme in the knowledge that they will be required to pay for reinforcement at an undefined time in the future, once enough capacity has accepted/connected to bring the levels of curtailment in the area up to the pre-defined value. The capacity to connect before the curtailment levels are reached could be estimated and this would give DG schemes an early idea of the amount they would be required to pay towards reinforcement. The issue with this approach is the current debate around how curtailment is measured; particularly if it should be via the effective energy not generated through curtailment. This is an important point to resolve before an approach to reinforcement can be finalised.

Under each scenario the fairest way to allocate payment would be by the DG schemes total export capacity and therefore their use of the network once reinforcement has taken place.

Work is ongoing to decide the best approach to reinforcing the network for flexible connections. However, it is clear that the majority of the reinforcement works will need to be paid by the DG schemes connecting in the area; with the potential for them to receive money back should any subsequent schemes connect. This is implemented via the second comer rule, where any additional DG to connect in the area within five years of the reinforcement taking place would have to pay a proportion of reinforcement costs to those generators that paid for the reinforcement.
## Appendix 1

### Accepted customer’s project characteristics

<table>
<thead>
<tr>
<th>Project</th>
<th>Technology type</th>
<th>Customer characteristics</th>
<th>Commissioning date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator 15</td>
<td>0.25MW PV</td>
<td>This large factory was seeking to generate output for their site. Their existing load connection meant that the FPP connection required minimum work. The customer was the first to connect providing valuable learning for the next projects to connect in 2014.</td>
<td>Commissioned April 2014</td>
</tr>
<tr>
<td>Generator 20</td>
<td>1.2MW PV</td>
<td>This large factory had Solar PV installed previously with the expectation that all the generation would be used within its facility. This was not the case and the PV was exporting on to the distribution system. The customer could gain finances through applying for a connection to the network, which will be carried out with minimal work as there is already a site load. This customer was in a usual position, where a 9% curtailment offer appeared attractive due to the excess income they could receive with a relatively small cost of connection.</td>
<td>Currently expected to be commissioned Q1 2015</td>
</tr>
<tr>
<td>Generator 12</td>
<td>0.5MW Wind</td>
<td>This customer was engaged from the start of the FPP project and requested an FPP connection only. The project had received planning consent when the connection offer was requested and was quick to accept the flexible offer. This customer already had 100kW of PV export available, the FPP had to ensure that additional equipment it did not interfere with the 100kW export that the customer was entitled to without curtailment.</td>
<td>Commissioned December 2014</td>
</tr>
<tr>
<td>Generator 10</td>
<td>0.5MW CHP</td>
<td>This anaerobic digester was the first CHP plant to be connected to the ANM system for the FPP project. Further studies on curtailment were required as the initial assumptions were based on wind connecting, so additional analysis was required to understand what impact a generator exporting near to 100% of the year would have on other customers.</td>
<td>Commissioned December 2014</td>
</tr>
<tr>
<td>Generator 05</td>
<td>0.5MW Wind</td>
<td>The large factory already had 250kVA of Solar PV with a non-export agreement. They requested an FPP offer for 1.5MW of wind export. As the customer was already a load customer that could use some of their wind generation, it is clear that the customer will experience lower levels of curtailment than those without a load connection, the more energy it uses in the plant. Extra work was required by the customer to ensure that the ANM was only talking to the wind interface so that the PV generation did not interfere with any readings.</td>
<td>Commissioned November 2014</td>
</tr>
</tbody>
</table>
### Project Details

<table>
<thead>
<tr>
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<th>Customer Characteristics</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Generator 14</td>
<td>4MW PV</td>
<td>This PV generator already has 5MVA of installed (unrestricted) PV capacity. However, the customer wanted to expand their capacity for an additional 4MVA of PV and had approved planning consent to do so. As the customer had most of the infrastructure in place, the business case for additional capacity meant that as long as the connection cost was lower than the additional expected revenue, it made much financial sense to expand their site. The customer did require an additional circuit breaker to ensure that the unrestricted connection was not affected in the event that the 4MW was tripped.</td>
<td>Commissioned December 2014</td>
</tr>
<tr>
<td>Generator 01</td>
<td>8MW Wind</td>
<td>This wind farm started as a 7.2 MW connection, however, due to the final decision on wind turbine supply, requested additional 800kVA of export capacity before accepting their interruptible connection. This project was the first to depend on the Dynamic Line Rating system installed in the overhead line that connects the wind farm to Peterborough Central Primary substation.</td>
<td>Currently expected to be commissioned Q1 2015</td>
</tr>
<tr>
<td>Generator 03</td>
<td>10MW Wind</td>
<td>This large wind farm is an example of a project that would not be connecting without an FPP alternative. Having planning consent since 2010, unsustainable connection costs froze the project development until they had this flexible alternative.</td>
<td>Currently expected to be commissioned Q1 2015</td>
</tr>
<tr>
<td>Generator 06</td>
<td>1MW Wind</td>
<td>This customer was engaged from the start of the FPP project and requested an FPP connection only, due to planning taking longer than anticipated, they allowed their first offer to lapse and re-requested once the planning had been approved.</td>
<td>Currently expected to be commissioned H1 2015</td>
</tr>
<tr>
<td>Generator 17</td>
<td>7MW PV</td>
<td>This solar farm requested an FPP and a business-as-usual offer, receiving a 90% reduction in upfront cost by choosing an FPP connection. The project is still undergoing planning but expects this to be in place prior to connection in March 2015.</td>
<td>Currently expected to be commissioned H2 2015</td>
</tr>
<tr>
<td>Generator 21</td>
<td>0.5MW Wind</td>
<td>This small wind development accepted the smallest saving of the accepted offers with a 60% saving over the business-as-usual Offer; this was still attractive enough despite the 1.7% curtailment that the FPP offer competed with the business-as-usual connection offer for the customer. This project is also going through planning an outcome is expected before the end of 2014.</td>
<td>Currently expected to be commissioned H2 2015</td>
</tr>
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<tbody>
<tr>
<td>Generator 16</td>
<td>0.5MW CHP</td>
<td>This small anaerobic digestion plant re-requested a down-sized connection offer, which was then accepted.</td>
<td>Currently expected to be commissioned H1 2015</td>
</tr>
<tr>
<td>Generator 30</td>
<td>0.5MW Wind</td>
<td>This wind turbine generator requested an FPP only connection, which was accepted. The project is currently undergoing planning permission.</td>
<td>Currently expected to be commissioned H2 2015</td>
</tr>
<tr>
<td>Generator 02</td>
<td>0.5MW Wind</td>
<td>This customer was one of the first to request an FPP offer. Due to the project not being at a stage to connect an offer, the customer came back a number of times with varying curtailment estimates. The project finally received planning permission this year and is on track to be commissioned early 2015.</td>
<td>Currently expected to be commissioned Q3 2015</td>
</tr>
</tbody>
</table>
Flexible Plug and Play: Quicker and more cost-effective connections of renewable generation to the distribution network using a flexible approach.