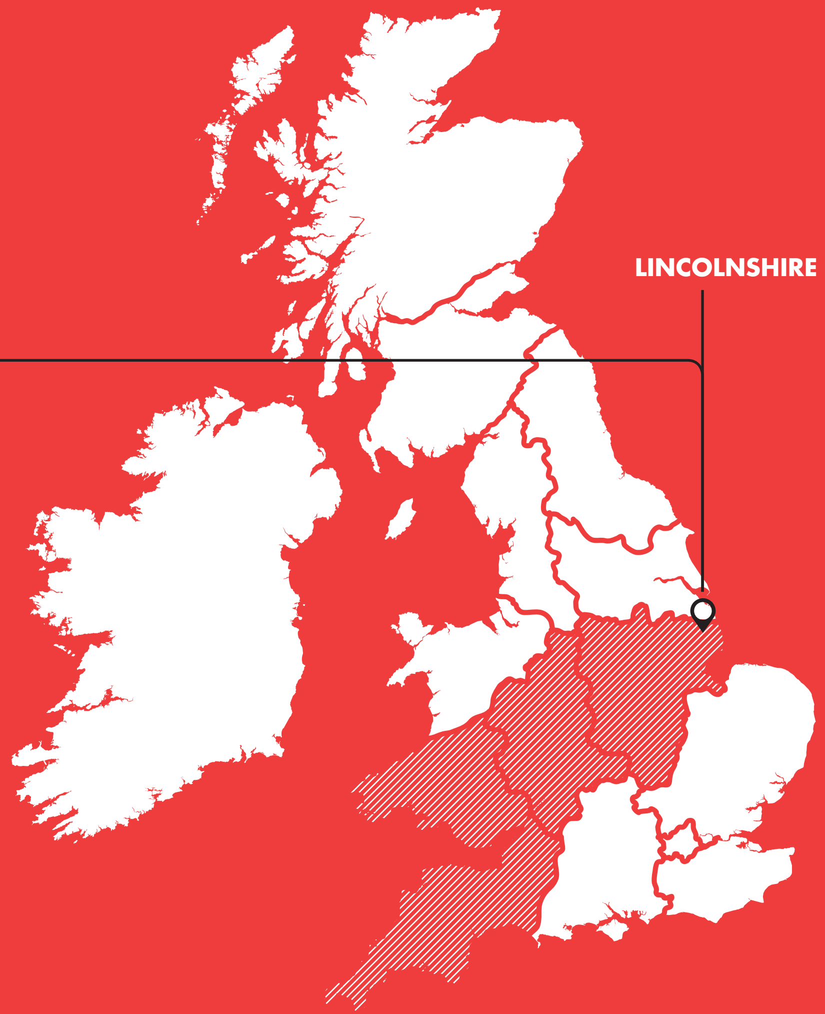
WESTERN POWER DISTRIBUTION

LOW CARBON HUB

CONNECTING RENEWABLE ENERGY IN LINCOLNSHIRE

LOW CARBON HUB
LCN FUND PROJECT CLOSE DOWN REPORT

APPENDICES



LCN Fund
Low Carbon Networks

Contents

Appendix A – Feedback from the DG Developers Workshop

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Below are a range of comments collated by Accent following the DG Developers workshop held on 15th February 2011. More detailed feedback is available on request. Since this survey was conducted Central Networks (CN) has now become part of Western Power Distribution (WPD).

Feedback on LLCH in attendees' own words

It is of great value, however it requires a lot of cooperation from a lot of different competitive parties that might not see to eye to eye to agree to co-operate, it has a value although it is limited. I had seen the slides before so I pretty much knew what was to be discussed.

I think it is a good initiative and quite interesting too. To be honest I wasn't entirely sure what it was about so the workshop gave me a clear idea what the hub was all about.

Yes it is a good initiative for what it is, shall I say, for a technical solution it is good initiative. I can't pretend to have understood fully, [but] before I attended the attended I couldn't pretend to have understood fully what the concept was, but having attended the event I felt I had been informed.

I think it is essential for that area to be able to develop it, so it was perfect.

I was quite impressed by it to be fair, I thought it was quite a good business model really. That whole sort of model I really liked the look of and I actually thought it might even gain more public interest and I also thought that you might even be able to get the planning permission easier as well because of that, so I actually liked the look of that, and it is a pro-type isn't it and I could actually see that model.

Feedback on workshop in attendees' own words

I think the fact that CN (WPD), rather than just making it a straight forward 'death by slide' presentation, made it an interactive workshop there was an opportunity for people from obviously like myself from a suppliers perspective and developers, basically we were asked to consider certain problems and how we would manage them, and obviously I think that was quite refreshing.

I think they were very open, I don't know how it could have been any better, they explained clearly what was going on – it was good.

I thought the group sessions worked well and drew out rather than it just being a one way traffic of being given information it allowed people to become involved and expanded the discussions onto wider issues around what otherwise would have just been a technical solution. It did sort of occupied a full day, but it wasn't necessarily a full days worth, it started a little bit late for me and sort of occupied that mid point of the day that made it impractical to do anything in the morning or afternoon.

The presenters were very precise and clear and knew what they were doing, there were other organisations there which sort of fitted in with that and saw opportunities for themselves, indeed the reasons I was there was to look at what there might have been in it for [name of organisation]. No I thought it was pretty good, there wasn't a massive amount of people there and I would probably have thought there was going to be more people there so I am not really sure how well broadcast it was but sometimes people have got other schedules.

Influence on future development decision, in attendees' own words

You might want to target a certain area but it depends on the landowners willingness to have turbines, the grid plays a part but at the same time you have other constraints for example say aviation if you have got many RAF bases or an airport close by or even natural designations you might be able to consider a certain area and in the case of East Lincolnshire they do suffer from aviation restrictions.

It will definitely influence where we look for developments, [I don't know] whether we will end up changing what we do, but it will change where we look

What influences a developer on a connection other than the wind capture speed is whether we can make a connection within a reasonably cost effective envelope, so if the low carbon hub will enable low cost connections, or lower cost connections what is actually happening is we might be able to have the sites within the Lincolnshire area and I am sure there are lots, but unless the connection route lengths are reasonable regardless of whether the sites are there or not the economics do not stack up, so the LCH has to allow or enable, or ensure the costs of connection is within a reasonable cost so that the wind farm will pay for itself.

We already have developments, I think what they will find is that people already have the sites in that area so possibly it would facilitate sites coming forward, so I think it would be good if CN contacted us or we got in contact with CN pretty soon.

Concerns about LLCH in attendees' own words

Complexity I suppose, especially on the contractual side of things, The technical aspects of it are I am sure feasible it is where it can all be pulled together and get all the different generators e to work with it.

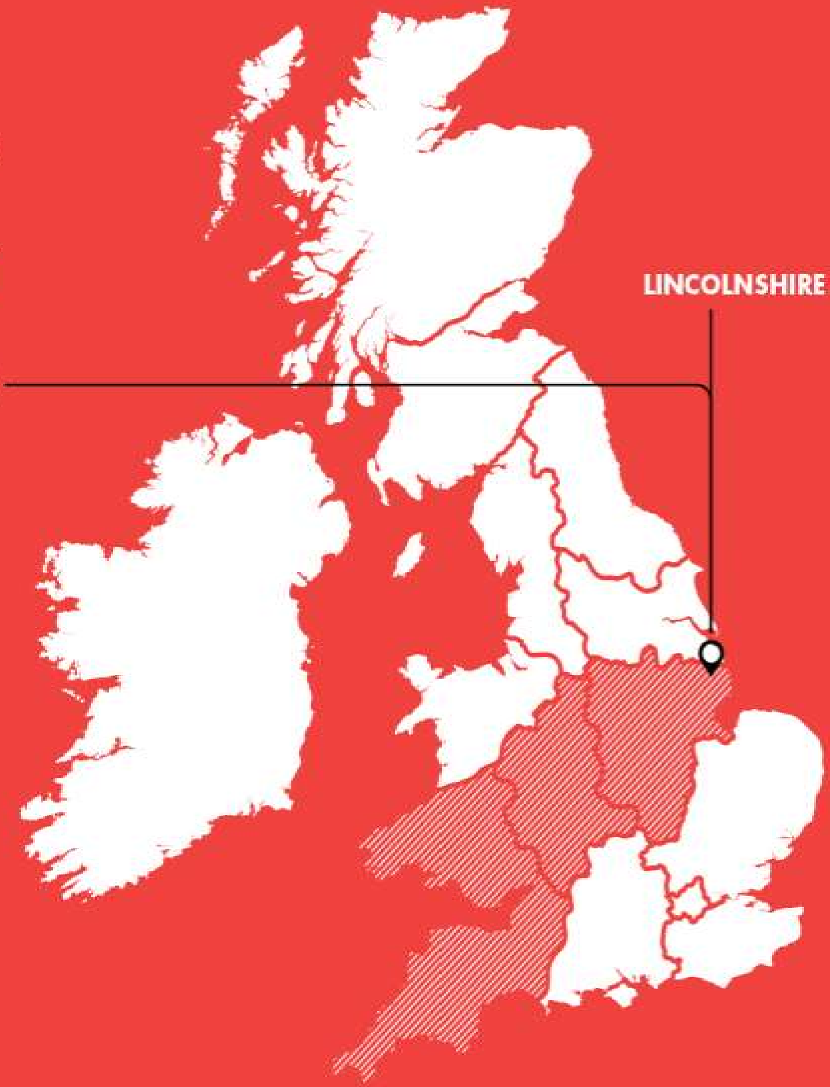
Perhaps the main concern, which is an obvious one, is the lack of local government buy-in as they would see this as a facilitator for wind farm development, and that part of the world is particularly opposed to wind farms, so they might oppose the scheme because of them seeing it as a facilitator to something they are opposed to in the first place.

Appendix B – Connections Commercial Report

WESTERN POWER DISTRIBUTION

LOW CARBON HUB

CONNECTING RENEWABLE ENERGY IN LINCOLNSHIRE



Alternative Connections Commercial Report 11/08/14

Document Control

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Contents

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Glossary

Term	Definition
ANM	Active Network Management
ACSR	Aluminium Conductor Steel Reinforced
AVC	Automated Voltage Control
DG	Distributed Generator
DNO	Distribution Network Operator
DPCR	Distribution Price Control Review
DVC	Dynamic Voltage Control
FACTS	Flexible AC Transmission System
GIS	Gas Insulated Switchgear
HDA	Hard Drawn Aluminium
IFI	Innovation Funding Incentive
LIFO	Last In, First Out
LCH	Low Carbon Hub
PV	Photo Voltaic
RPZ	Registered Power Zone
RTU	Remote Telemetry Unit
RIIO ED1	Revenue = Incentives +Innovation + Outputs Electricity Distribution 1
WPD	Western Power Distribution

Introduction to the Low Carbon Hub

The Low Carbon Hub for East Lincolnshire has been designed to test a variety of new and innovative techniques for integrating significant amounts of low carbon generation on to electricity networks, in an effort to avoid the costs that would normally be associated with more conventional methods.

The project has received £3m of funding from Ofgem's Low Carbon Networks Fund Tier 2. In this project, we are seeking to explore how the existing electricity network can be developed ahead of need. The adaption of commercial arrangements is one technique that can facilitate the connection of more low carbon generation at a cost significantly lower than that of conventional reinforcement or ahead of conventional network reinforcement being carried out.

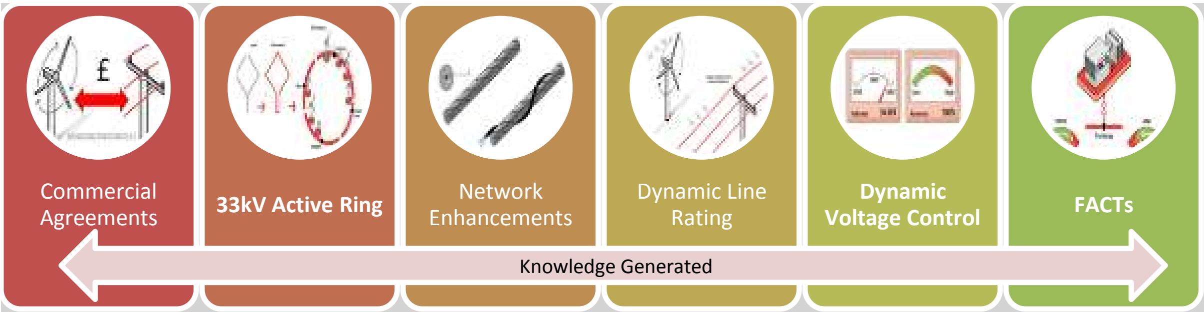

Figure 1– Low Carbon Hub Techniques

Lincolnshire's east coast location makes it suitable for a wide range of low carbon generation types, including onshore and offshore wind farms, large scale solar Photo Voltaic (PV) and energy from bio mass crops. Unfortunately many generators are not connected to the distribution network closest to them due to the effects the connection would have on the network operation during certain times of the year and some network conditions. They are often faced with either a costly connection, declining the connection offer or a long delay whilst conventional reinforcement is scheduled and carried out.

Traditionally the distribution networks have been designed on the assumption that electricity generation is large scale and centralised, and power flow will be unidirectional from the higher voltage transmission system to the lower voltages of the distribution network. The capacity of network circuits and components is dictated by the maximum demand, the fault level rating and the need to maintain voltages within defined ranges. When Distributed Generation (DG) is modelled and connected, the connection is based on a passive connection (i.e. the generation is unconstrained unless under certain N-1 scenarios). This includes assuming all generation could be at full output (100%), as the same time as the minimum demand whilst the network is operating at its upper voltage bandwidth.

The Low Carbon Hub (LCH) will demonstrate new technologies, operating procedures and commercial arrangements that will allow the network to operate actively so as to support more low carbon generator connections, providing cheaper and timelier connection options.

1.1 Connection Generation in East Lincolnshire

New passive generation connections are modelled to ensure the distribution network will remain within its statutory and operational design limits. In weak network areas these connections tend to result in system reinforcement, installing new underground cable to areas closer to Skegness where the effect on the network is reduced, meaning it would allow the network to remain within its design and operation limits. This can be very expensive and prevent generation connections. We have historically received a high volume of connection enquiries from developers which makes the location ideal for this project.

When a generator is connected to the distribution network power flow often becomes bidirectional, fault level is increased and voltage control becomes more complex. Conventional design solutions can be used to counteract changes in fault level, voltage control and capacity however, they can be prohibitively expensive. This can mean that in areas which have abundant renewable energy resources, the offered connection design means locating distributed generation is uneconomical for new DG sites

1.2 The Low Carbon Hub methods – Commercial Arrangements

The Low Carbon Hub has a commercial project component that will be trialled together with new technologies and operating procedures.

New commercial agreements

The new commercial arrangements will facilitate more affordable and timely connections to networks considered “Full” using traditional connection assumptions. DG customers will be given the option to use the spare capacity in the network when it is available, curtailing their generation output when the network has reached its design or operation limits.

New commercial arrangements have required developments in three main areas:

1 **Demonstrating Active Network Management, installing hardware for:**
   - Monitoring the thermal limits of network assets,
   - Monitoring the voltage at key network nodes
   - Controlling the output of new Distributed Generation connections when voltage or thermal limits are reached.

2 **Developing Alternative Connections**

Researching and developing a set of commercial mechanisms to allow the Distribution Network Operator (DNO) to offer generation connections using the spare network capacity, constraining the generation output when the Distribution System cannot accept any further Distributed Generation. These commercial mechanisms have been developed in conjunction with the Distributed Generation community with both the DNO and DG developer’s requirements in mind.

3 **Estimating the level of constraints**

The amount of spare capacity within a network depends on many factors, including the location of the new DG Site, the distribution system demand profiles, the network impedance and the export profile of other DG sites. In order to accept new commercial arrangements the DG Developer must be able to understand how the network will operate with the additional generation, understand estimated level of constraints it could experience, the factors that influence this and likely hood of them changing. Western Power Distribution (WPD) have developed two constraints analysis tools to help support this process. The first is for customers to use themselves, hosted on a dedicated internet page, and another for WPD planners to support the process of offering Alternative DG connections.

1.3 The Low Carbon Hub methods – Technology

The Low Carbon Hub has two technology project components that will be trialled together with the commercial and operating procedures as outlined below:

Network Enhancements

When network assets are being replaced based on condition or load reasons DNOs replace assets with the minimum cost scheme. This project will test if additional functionality should be either designed or built, recording the increase in cost and further functionality these assets could provide in the future. This increased functionality will include installing assets with a larger capacity rating that have the provision for fibre communications to be installed.

In this project, sections of our existing 33kV network are being replaced due to age and condition reasons. These circuits will be upgraded to increase capacity and have optical fibre communications installed for the first time. This work is in addition to investment already funded through the current distribution price control (DPCR5) settlement.

The standard design when replacing rural 33kV Overhead lines is to install 150mm^2 Aluminium Conductor Steal Reinforced (ACSR), the circuits being replaced in the LCH area will have 300mm^2 Hard Drawn Aluminium (HDA) installed with the provision for optical fibre both at the construction phase and as a retrofit activity.

DStatcom

In creating an active network with multiple in feeds from generation, a high degree of variability (both in terms of demand and generation) can result in unwanted voltage fluctuations and harmonics on the electricity network. A Flexible AC Transmission (FACTs) system device can rectify these issues automatically. High costs and modest connection of DG to distribution networks means historically FACTs technology have not been deployed on distribution networks. In this instance, the FACTs device, also referred to as a DStatcom, will be connected in parallel with the electricity network at Trusthorpe and will operate as a controllable current source (an arrangement often referred to as ‘shunt compensation’). This allows reactive power to be generated or absorbed by altering the capacitance or inductance and is a means of controlling power factor or voltage. The solution will be designed in such a way to maximise the amount of generation that can be connected.

1.4 The Low Carbon Hub Methods – Operating Procedures

The Low Carbon Hub has three operating procedure project components that will be trialled together with the commercial and technology procedures as outlined below:

Dynamic AVC – (DVC)

Building on the principles of one of our previous Innovation Funding Incentive (IFI) projects, the voltage on the network will be actively varied. This technique, known as Dynamic Voltage Control, will be carried out in real time using measurements coming from demand and generation sources. Dynamic Voltage Control should allow us to further increase the capacity of the network whilst maintaining the system voltage within the statutory limits.

The primary network voltage is regulated through the Automatic Voltage Control (AVC) relays at Skegness. The AVC relays ensure the network voltage remains within statutory limits at all times. As networks are increasingly no longer just supporting demand, the connection of generation makes the process of regulating voltage with a static AVC set point increasingly more difficult.

33kV active network ring

Creation of the 'active network ring' involves installing additional switchgear, disconnectors, new telecommunication links and new protection relays. Once complete, the network will run as a closed ring with greater controllability enabled by increased visibility of power flows and voltage profiles. This arrangement will allow us to reconfigure the system based on the real time status of the network. It also requires a more complex power system protection scheme to protect the system from damage in the event of a variety of different fault scenarios.

Dynamic system ratings

The Skegness Registered Power Zone (RPZ) delivered cheaper connections to offshore wind farms by giving Western Power Distribution a facility to adopt dynamic ratings for overhead lines. This method, which has already been widely disseminated within the industry will be further developed to test new techniques for calculating plant and equipment ratings and the subsequent operating limits based on real time data.

1.5 Researching Constrained Connections

Engage Consulting researched constrained connections to inform the decision as to which method of allocating curtailment would be most appropriate for the Low Carbon Hub.

Of the academic literature around this topic, the most directly relevant is probably the work of the Electricity Policy Research Group at the University of Cambridge[1] .

The paper "Experience of the use of smarter connection arrangements for distributed wind generation facilities"[2], Karim Anaya and Michael Pollitt, December 2012, provides valuable international case study material and other background.

The presentation *"Flexible Plug and Play"*[3], given by Michael Pollitt and Karim Anaya at the IET in March 2013, sets out three most popular allocation rules for curtailment – last in first off (LIFO), pro-rata and market-based. The presentation looks at the "social optimality" of these different approaches, presents some domestic and international case-study material, and draws some broad conclusions. The presentation identifies some pros and cons for each approach, but does not come out formally for or against any of the three methods.

The paper *"Understanding best practice regarding interruptible connections for wind generation: lessons from national and international experience"*[4], Karim Anaya and Michael Pollitt, May 2003, builds on the above presentation. The conclusions of this paper include the following comments on the pros and cons of the three methods:

> *"LIFO, Pro Rata and market-based each have pros and cons. All of these options represent different alternatives of how the DNOs could address the need for connection of more wind to the existing distribution system. LIFO makes economically efficient use of the available capacity in the short run, however it transfers increasing risk to the last in generator connected, and it may also compromise dynamic efficiency by making it more difficult to get agreement to increase network capacity when this becomes socially valuable. The Pro Rata approach has the advantage of reducing risk to the marginal generator, but this comes at the cost of potentially connecting too much generation behind a constraint. Setting the right capacity limit is crucial yet difficult as it needs to consider both short run and dynamic efficiency. Finally, market-based approaches – such as CM - have the advantage of allowing generators to optimally turn down their wind farms according to their costs of doing so. This has the dual advantage of encouraging generator investment in flexibility and of creating the opportunity to have system operator incentives to reduce curtailment. The problem with market-based approaches is deciding who pays the generators for curtailment – this is usually a combination of the system operator and the customer. In this scenario, risk is being transferred which requires a mechanism to absorb this risk transfer via the regulatory settlement. Additional problems are those related to the lack of competition, high*

[1] http://www.eprg.group.cam.ac.uk/category/home/
[2] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Flexible-Plug-and-Play-(FPP)/Project-Documents/Cambridge_FPP_International_Experience_Report_final.pdf
[3] http://www.eprg.group.cam.ac.uk/wp-ontent/uploads/2013/03/EPRG_Presentation_18_03_2013_Finalweb.pdf
[4] http://www.eprg.group.cam.ac.uk/wp-content/uploads/2013/05/1309-Final.pdf

transaction costs that may affect small generators and the administrative burden for a DNO to set up bidding mechanism."

These conclusions are helpful in identifying clearly the main pros and cons of each method, but they do not rule out any of the three methods, or identify one method as being clearly superior to the other two.

Karim Anaya and Michael Pollitt have since produced another paper - "*Finding the Optimal Approach for Allocating and Realising Distribution System Capacity: Deciding between Interruptible Connections and Firm DG Connections*"[5], October 2013, which was too late to influence our choice of method for the Low Carbon Hub, but may be of interest to others.

[5] http://www.eprg.group.cam.ac.uk/wp-content/uploads/2013/10/1320-PDF-v21.pdf

1.6 Stakeholder Workshops

We were conscious of the need to take stakeholders with us in the development of the ideas behind the Low Carbon Hub. We hosted an innovative connections workshop, with support from Engage Consulting, on 13th June 2013. A selection of key stakeholders from the DG community was invited. These included DG trade associations, DG developers with recent connections in the East Midlands and DG developers that expressed an interest in innovative commercial connections at our Revenue = Incentives +Innovation+ Outputs Electricity Distribution 1 (RIIO ED1) business plan workshops. In total, ten stakeholders attended the workshop.

We introduced the Low Carbon Hub, explained how DNOs traditionally planned networks with DG connections under the fit and forget methodology and how, if we offered connections using innovative techniques, it could allow developers to make an informed choice between a traditional connection and an Alternative connection.

The feedback from the workshop was very helpful in shaping details of the commercial arrangements developed for the Low Carbon Hub. The key outputs and findings from the workshop have been disseminated to the parties attending the workshop and made available on the project website

The following summarises the main points made by stakeholders at the first workshop:
These were correct at the time of the workshop and are subject to change as Alternative Connections evolve.

	Feed Back from the DG community	How has influenced our development of Alternative connections
1.	DG developers enquired whether we can share information on requests for interactive connection offers that require upstream reinforcement, to developers when they enquire about connection.	Where possible, this information is shared with DG developers when initial contact is made. Often locations will become interactive part way through or even after the connection offer has been made. The Alternative connection offers have a fixed queue position for the duration of the validity period to provide a period of certainty.
2.	Some DG developers shared that they have some constrained connections in Ireland. N-1 1st Circuit outage conditions have measured availability, limiting generation export. This is normally a single scenario and single generator interface.	The Lincolnshire Low Carbon Hub will look to incorporate multiple constraints at different voltage levels under normal and abnormal running arrangements, providing an option for additional generations to connect without influencing generation connections already connected.

3.	Some developers would prefer to have stipulated constraints rather than follow circumstances, for instance only ever 80% of full capacity at night rather than see when the circumstances dictate they reduce generation.	WPD will research to see if this is applicable within its innovative commercial arrangements. If this is possible, it will be discussed with developers on a site by site basis.
4.	Any constrained offer needs to be very clear in terms of any dependency or interactivity with other connections. This needs to be covered within the commercial agreement.	Constrained connection offers include an anonymous table detailing the DG already in the queue. Confidentiality issues have prevented WPD from sharing future generation connectivity.
5.	What happens if a generator retires? How do others move up in the queue? Also what if they are only shutting down to rebuild?	If a generation site is decommissioned, the generators will retain the same LIFO queue number, but their constraints would be reduced. Any developer looking to replant would retain their existing LIFO position for the original site capacity. Any additional capacity would require a new LIFO queue position.
	A number of DNO's have requested the ability for direct control of a Distributed Generators Power Factor Control. DG developers enquired whether the control loops required for innovative connections need to be in real time or can occur in a longer time frame.	This is an option DG developers may wish to explore as a method to reduce their constraints. It is not mandatory as part of the alternative connections to have direct control of a sites power factor.
	Accurate data is the biggest/most important issue for developers. Will the TNEI tool be enough by providing the answers or will they want the data	WPD has used historical load data, outage data, fault data and profiles for new and existing generators to provide an estimated level of constraints for this connection under three different scenarios.

	themselves. The tool should have 2 scenarios accepted offers and offers not yet accepted to give greater clarity and reliability of the likely constraints. Also requested, would the TNEI tool be able to convert to GIS for generators to use in plans.	For the avoidance of doubt, WPD does not guarantee any level of duration or frequency of curtailment or constraints. The Customer is strongly encouraged to conduct their own assessment of the potential curtailments / constraints and risk associated with an alternative connection. The current version of the Constraints Analysis tool cannot be converted to GIS, however this is being considered for future Constraints Analysis tools.
	Information regarding constraints is most valuable when detailing the level of constraints in in monthly or quarterly time periods. An overall % level of constraints with a tolerance may be acceptable but is not as useful.	The LLCH constraints analysis tool will detail both the monthly and the annual constraint figures. All generation developers have been offered a meeting with the modelling team to discuss which network components lead to the greatest constraints.
	The significant issue highlighted with innovative connections revolves around the ability for generators to raise finance. Any significant deviations from the standard connection template will make accepting a connection more difficult.	The Alternative Connection offers have been based on the WPD EHV and HV Section 15 and 16 offer letters.

	The constrained and or innovative commercial arrangements need to highlight the assumptions in both the offer letter and the connection agreement. This may be best captured using the offer as an appendix in the connection agreement.	The Alternative connection offer contains details of the network limiting factors and the historic Curtailment studies where WPD has used historical load data, outage data, fault data and profiles for new and existing generators to provide an estimated level of constraints for this connection under three different scenarios. The connection offer letter will be included as an appendix to the Connection Agreement,
	Developers requested further information on how the system would work to ensure any offers remained valid, i.e. if the DNO had numerous enquires at the same time how do we reserve a place in the connection queue and ensure that the position remains valid when they do come to connect, depending on how long it takes to start generation etc.	A process for securing a position in the LIFO queue is detailed on the project is detailed on the project website www.westernpowerinnovation.co.uk/Lincolnshire-Low-Carbon-Hub/Connecting-to-the-Low-Carbon-Hub.aspx The LIFO queue position is assigned when the minimum information has been received from the Generation Developer. The Alternative Connection offers mirror the standard connection offers key milestones and deadlines. Failure to meet these key milestones or evidence the progress being made could result in a connection offer being retracted. When an alternative connection offer is accepted, the LIFO queue position will not change.
	Through round table discussions it was agreed that LIFO is most desirable constrained connection, but generators are clear that this should protect those further up the queue and they should not be open to further constraints based on those who connect later.	The Last In, First Off LIFO principle will be trialled in the LCH. This will ensure that new connections do not adversely affect the constraints of existing generation developers.
	If DG developers are more aware of when constraints are likely, through the use of on demand load profiles the	All Generation developers receiving Alternative Connection Agreements are offered a Single Line Diagram, network impedance data and the historic demand

	data can be used to better estimate the number and duration of constraints e.g. after dark constraints wouldn't affect solar generators. Advanced information on planned outages would support a distributed generators ability to operate most effectively.	profile data. WPD has a responsibility to notify our customers of planned work, and we do this as early as possible.
	If an innovative connection including power factor correction is required, a developer would need to know during initial discussions. If this information is known it is possible for most generation technology to operate within a 0.95 leading or lagging power factor. Studies would need to be conducted to show what the power factor was at the point of common coupling.	This is an option DG developers may wish to explore as a method to reduce their constraints. It is expected that any long term power factor correction to reduce constraints will be from unity to 0.97 leading at the point of common coupling.
	Generators support the idea of charging for connection enquires/offers to reduce the excessive workload of the connection teams and dissuade lots of speculative enquires.	The Electricity Act prevents Distribution Network Operators from charging for new generation and demand applications. A change in legislation would be required before a DNO could consider charging for connection studies.

1.6.1 Summary

Where possible, knowledge captured at the workshop was used when developing our detailed proposals for the Low Caron Hub Alternative connections. This stage of the work included confirmation of our choice of the LIFO method for allocating curtailment, consideration of the rules that would surround the LIFO queue, etc. and preparation of a draft model connection offer letter and connection agreement for 'Alternative Connections'.

Our choice of the LIFO method for allocating curtailment was based on several factors, including:

- The relative simplicity and clarity of the method;
- The broad acceptance of LIFO by our stakeholders;
- Our wish to protect existing generators from any impact of later-connecting generators; and
- The efficiency of the underlying economic signals.

We recognise that a limitation of the LIFO approach is that resolution of constraints on the network remains unfunded by connecting generators, and that there may be little incentive for early-connecting generators to contribute to any later reinforcement. This is an issue which will probably require some form of resolution by the regulator in the longer term, and we will discuss this with Ofgem.

Conclusion of this stage of the work was marked by a dissemination event held at the East Midlands Hilton on Thursday 3rd October2013, attended by some seventy people, including DNOs, suppliers, manufacturers, trade bodies and generation developers. The event provided a general overview of the Low Carbon Hub techniques and updated stakeholders on our progress with each technique. In addition to the technical elements of the project, details of the proposed alternative connection arrangements and constraints forecasting were disseminated to a wide audience.

1.7 Alternative Connection Offer

In common with the other electricity distribution companies, WPD's traditional approach has been to provide robust DG connections that allow generators to feed electricity into the network under all reasonably foreseeable circumstances. This 'Standard' approach has provided reliable connections that do not require on-going active management by WPD. However, such connections can be very expensive, particularly where there is a requirement to reinforce the existing network, and this up-front cost sometimes deters generators from connecting.

We recognise that the standard approach may have prevented the connection of low carbon generation to some extent and that, for a large proportion of the time, there is a significant amount of unused network capacity. The aim of the LCH project is to unlock this unused capacity and offer it to the DG community.

We have decided to make two separate connection offers to generators that request connection in the LCH trial area - one based on the standard 'fit and forget' approach outlined above, and another based on 'Alternative Connection'. The choice of which offer to accept will be entirely down to the generators' assessment of the relative merits of the two offers.

Alternative connection will be associated with an agreement that WPD may, from time to time, curtail the generator's ability to export electricity. WPD's expectation is that alternative connection will provide significantly cheaper generator connections, in exchange for curtailment. Generators earlier in the LIFO queue are modelled to show relatively insignificant periods of curtailment. As the queue extends the modelled curtailments can increase substantially.

Alternative connections will typically involve little or no reinforcement of the wider network, and the connection charges paid by the customer will therefore generally be lower than those for traditional 'firm' connections that include reinforcement.

Offers for active constrained connections will be supported by separate, non-binding, estimates of the likely levels of curtailment in each specific case. These estimates will be based on sets of assumptions about network demand, generator output, etc. WPD will also provide network information that generators can use to take independent specialist advice should they want to before accepting any alternative offer.

Curtailment may take the form of reduced electrical output, or adjustment of generators' power factor. Instructions to curtail will be effected via communications with generators. In many cases communication will be via dedicated interface equipment, giving WPD the ability to curtail generators directly. In other cases it will be via media such as email or phone, as appropriate. In the event that a generator fails to respond to an instruction to curtail, WPD will have the right temporarily to disconnect the generator from the network.

Where a number of generators are subject to the same network constraint, any necessary curtailment will be undertaken on a 'last in, first off' basis, with reference to the date of their acceptance of the connection offer, and subject to connection works commencing within one year and generation commencing within 18 months.

We will give generators the reassurance that curtailment would only be instructed when necessary and would last only as long as necessary, in WPD's reasonable opinion. No compensation will be paid to generators that are curtailed in this way.

Timeline of Constrained connections

WPD commissioned Engage Consulting to assist it in accelerating the commercial arrangements progress. Project deliverables and milestones are identified, and high level plans were set out as below.

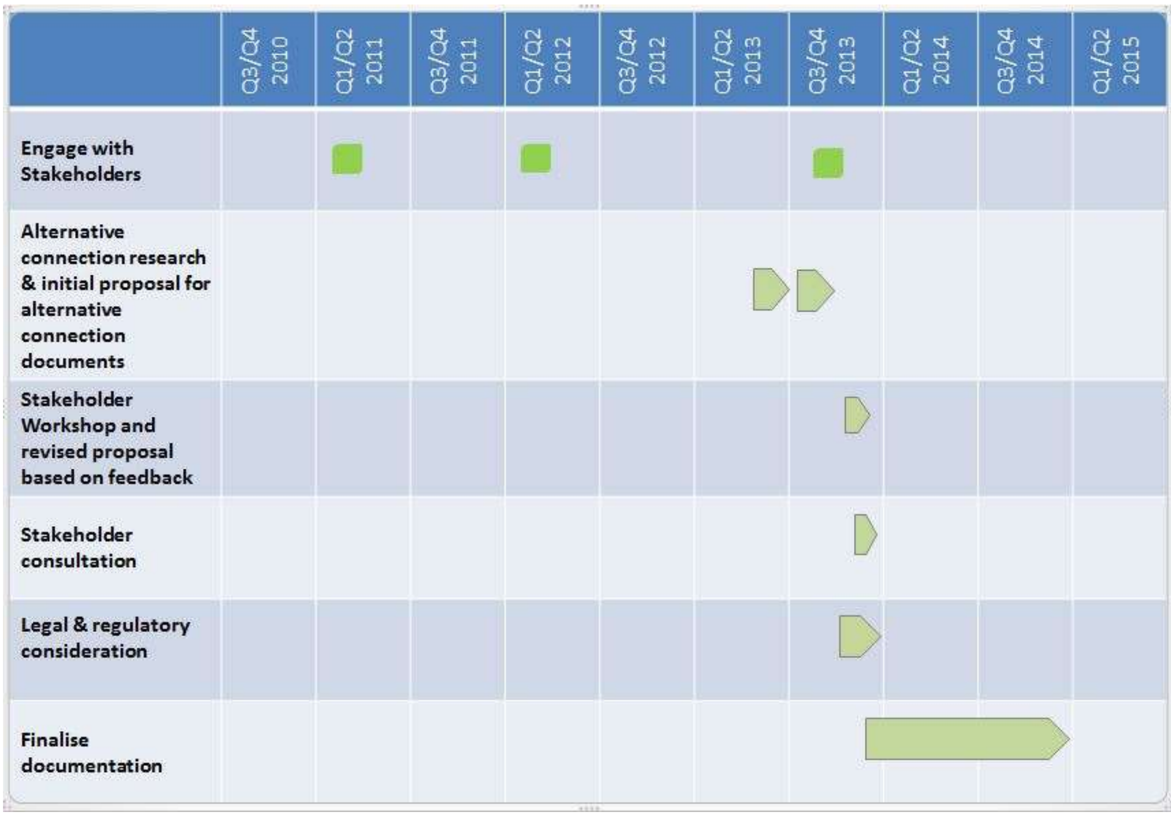

Figure 2 Commercial Arrangements project plan

1.8 Contract Documents

Having reached the decision to make alternative connection offers, as outlined in the section above, our attention turned to how our existing connection contract documents should be changed to accommodate this.

There are two key contract documents associated with generator connections – the offer letter and the connection agreement:

- The 'connection offer' letter is, in effect, a temporary contract designed to cover the period during which the connection works are being undertaken. The offer letter sets out details of the connection being offered (capacity, etc.), the connection works to be undertaken, and the payments to be made by the generator, and various terms and conditions around the works.

- Following completion of the connection works the offer letter falls away in favour of the 'connection agreement'. The connection agreement is an enduring contract which again sets out details of the connection (capacity, etc.) and various terms and conditions around the customer's use of the connection. The connection agreement refers to and builds on the industry standard National Terms of Connection[6].

Having reviewed both our standard connection offer letter and our standard connection agreements, it was clear that both documents would need to change to facilitate alternative connections. Where we issue two offers – one standard and one for active constrained connection – we have named the new connection offer letter the 'Alternative Connection Offer' to differentiate it from the standard offer.

WPD's legal advisors, Osborne Clarke, have reviewed our amendments to the standard connections documentation Osborne Clarke's advice was incorporated into both documents before the offer letter was sent out as part of the consultation and offered to DG developers for active constrained connections.

The methodology for offering constrained connections is published on our Low Carbon Hub website[7].

The alternative connection offer letter was disseminated in our mini consultation (see section 1.11), and is now being sent to DG developers requesting constrained connections to the Skegness Grid substation at all voltage levels, and to those requesting connection in other selected WPD areas.

[6] http://www.connectionterms.org.uk/assets/files/National%20Terms%20Of%20Connection_7%20November%202013.pdf
[7] http://www.westernpowerinnovation.co.uk/Lincolnshire-Low-Carbon-Hub.aspx

1.9 Planning Tools

To support the alternative connection agreements we will be offering DG customers in East Lincolnshire, we have developed two constrained connections tools in conjunction with TNEI and Smarter Grid Solutions to estimate the level of spare capacity in the network and the estimated number of constraints for different Generation developments in East Lincolnshire.

Customer Web Based Tool

This online software tool is hosted at www.lincolnshirelowcarbonhub.co.uk, it allows generation developers to create an account and assess the likely capacity across the Skegness Network area for different generation types, and size in different locations. The tool contains data for DG already connected to the network and accepted connection offers. The tool will not take into account connection offers that have been made but not yet accepted.

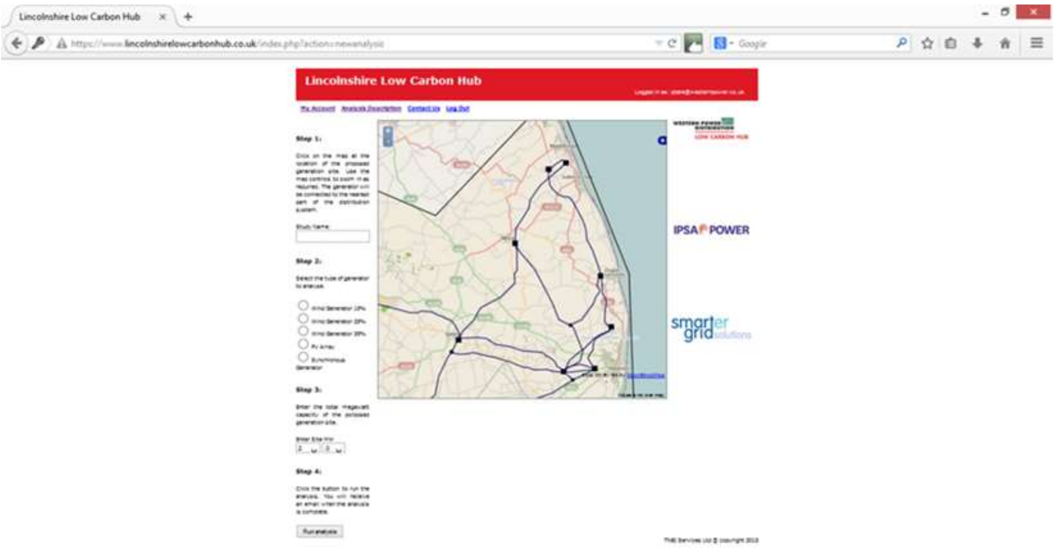

Figure 3 – Web based tool

The process is as follows;

1. The constraints analysis tool requested a developer to enter a generation location, size of development (1-30MW) and generation type (Solar, Wind or Synchronous generator).
2. The generation will connect the proposed site to the nearest geographical network asset and assume the cable connection will be the “as the crow flies” distance + 30%. The tool does not take into account roads, towns, rivers or any other geographical aspects.
3. Nodal analysis is performed with the additional generator for the half hour period 00:00 – 00:30 1st January 2012 to model the impact of the additional generator with the historic generation and demand.
4. The model will check all nodes for voltage limit or thermal limits; if no network violations are recorded the model will continue to the next half hour period 00:30 –

01:00 1st January 2012 checking for network violations with the generation and demand data from this period.

5. If a network violation is recorded, the output of the generator is reduced by 10% and the analysis is re run until the network operates within its design and statutory limits.
6. The analysis completes these steps to analyse 30 months of operational data.
7. The Generation Developer is presented with a rough outline of the expected number of constraints if that generation development was operating over the 30 month period.

The tool allows a generation developer to generate a high level estimated based on the number of connections and offers in the area. This information is intended to help developers to determine the impact of their development on the network and potential viability of a scheme before further time and cost is spent on a proposed development.

WPD planning tool

The WPD Planning tool provides enhanced features WPD primary planners can use to ensure connections comply with WPD's policies, whilst also provide a more detailed level of constraints based on the existing network operation, network operation with the LCH smart grid innovations, with today's demands and with a reduction in demand over a 25 year period.

The tool has additional functionality:

- The planner can select a Teed or looped in connection based on the existing network configuration, number off ends and protection scheme.
- The point of coupling to the network and the cable distance is selectable, allowing geographical features to be considered.
- The historical network demand can be scaled down to estimate the effect of a reduction in demand.
- Different Smart Grid options can be selected and modelled to determine their impact on the number of constraints.

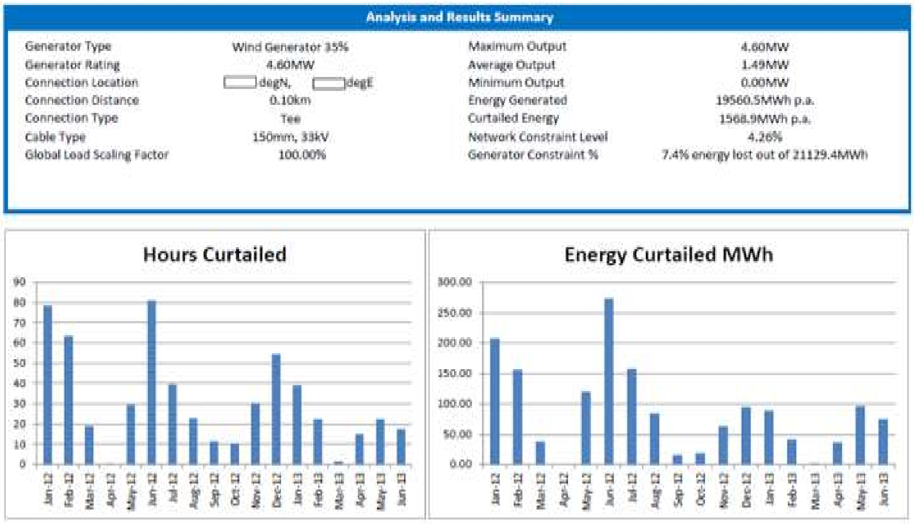

Figure 4 WPD Planning tool

The primary system planners can interrogate the IPSA nodal model to visualise the impact, ascertaining the constraint locations and if carrying out any network reinforcement would benefit the customer, economically reducing the level of constraints a site may experience.

1.10 Consultation

Following our Low Carbon Hub dissemination event held at the East Midlands Hilton on Thursday 3rd October 2013, we issued a mini-consultation document (see appendix 1). The document outlined our proposals and raised nine questions.
The number of responses to the consultation was relatively small, but the quality was high.

Question 1 - **Are constrained connections, as described in the consultation, likely to be an attractive alternative to standard connections?**

The Consensus amongst the DG Developers was supportive and suggest that constrained connections are and attractive alternative.

> "Alternative offers which aren't required to pay for extensive upgrades would be an attractive option as an alternative to conventional offers."

Based on our research and the responses received Western Power Distribution is making alternative connections available from autumn 2014.

Question 2 - **Is our proposal to provide a standard (non-constrained) offer alongside each alternative connection offer appropriate?**

Respondent's views were in favour of offering a standard offer alongside each alternative offer.

> *"When assessing a project's viability it is always beneficial to have every bit of the puzzle. It is therefore very useful to be provided with the cost for a non-constrained offer. We would wish for this process to be continued as for some projects it may transpire the project could support the cost of the upgrade if the constraint is deemed unacceptable/too great."*

Western Power Distribution will continue to provide both offers to DG Developers unless they specify they do not want to receive a standard offer.

Question 3 & Question 4 Is the proposed pro-forma 'Alternative Connection Offer' letter sufficiently clear and comprehensive?

Are the differences between the pro-forma 'Alternative Connection Offer' letter and the standard letter appropriate?

The responses fully supported the 'Alternative Connection Offer' letter.

"In our view, the format and content of the letter is fine"

"The differences are clear and appropriate."

Western Power Distribution has finalised and approved the document for use, when issuing alternative offers.

Question 5 - **Is LIFO an appropriate basis for allocating curtailment among alternative connections?**

The respondent's agreed that the increased certainty of current and future constraints meant that LIFO was the most appropriate curtailment methodology.

> *"Of the two proposals [Proportional and LIFO] LIFO does seem to have the edge but more importantly it is the degree of consistency of the predictability that is the key element."*

Question 6 - **Are our proposals for the LIFO 'queue' order appropriate?**

There was no general consensus from DG Developers in terms of the LIFO queue.
One respondent responded as below.

> *"Basing a LIFO queue on the date generators accept their connection offer seems appropriate but more information should be given to the developer when they receive their connection offer. For example, basing the LIFO queue on when the offer is accepted appears to mean that two Developers could apply for connection offers a month apart but if Developer 1 waits until the end of the acceptance period to accept it, and Developer 2 accepts theirs straight away, Developer 2 who applied second would be first in the LIFO queue. There may have been a good reason why Developer 1 waited to accept until late on and may have chosen to accept if it knew Developer 2 had an offer.*
> *Is there the potential to apply a moratorium period to Developers in the LIFO queue if it can be seen that multiple Developers have open offers that can be accepted across a similar time frame?*

Whilst another felt it would be more appropriate to take the following approach

> *How will the LIFO queue change if a project deemed no.2 in the LIFO queue connects before project no.1? If project 2 has been more pro-active in getting their project completed can they not benefit by being moved up the queue?"*

Western Power Distribution has considered the responses and made the decision to base the 'LIFO' queue on the date that all the relevant information is received to process the application. The position within the queue does not alter as long as the generator accepts within 90 days and complies with the terms set out in the offer letter.
However should any generator decide to withdraw from the 'LIFO' queue after acceptance then all those below that generator would keep the same LIFO number but have one less Generator ahead of them in the stack.

Question 7 – Are our proposals to avoid 'hoarding' of unused network capacity appropriate?

Opinions on 'hoarding' of unused network was divided with emphasis placed on concerns that strict programme of connection works may favour certain technology types.

> *"Your proposal to start work on construction within one year of accepting an offer is totally unrealistic. This would favour certain styles of development over others. The time period should be at least 2 years and up to 3 years to start construction and at least 3 years and up to four years to start operation. The fact that developers are committing resources to a project is a clear measure of their intent. There are other ways to prevent hoarding such as insisting on a set of milestones for other activities such as planning submission and pre planning studies. Developers should be able to assess projects and secure the necessary connection otherwise the risk is that a project could go all the way through planning and not be able to connect. This would detrimental to the whole process. Equally some measures do need to be in place to stop hoarding*

Western Power Distribution has taken these concerns into consideration and included reasonable default timescales for the programme of connection works that should be generally adhered to, however they may be extended where progress can be demonstrated and deemed appropriate to do so. A separate, consultation into demand and generation connection agreements was also recently conducted. This learning has been captured in both the conventional and alternative connection offers.

Question 8 - **Do you foresee any specific difficulties in relation to the funding of DG with alternative connections?**

Overall DG Developers do not see any specific problems with funding alternative connections but they do require as much information as possible to enable them to complete their own studies to estimate the level of curtailment they may experience.

> *"WPD needs to have an active involvement in providing the data for and encouraging the development of methods to allow the prediction of income and risks for curtailed connections. It is understood that WPD could not guarantee this data but it would be important that WPD has a stake in ensuring the methodologies for predicting downtime and risks to income streams were accepted by financing parties."*

Western Power Distribution has developed a customer web based planning tool to allow the developers to assess the likely capacity across the Skegness Network Area for different generation types and sizes in different locations. In addition we made available the single line diagram for the Skegness group, both 132kV and 33kV networks, ½ hourly network demands between January 2012 – June 2014 for all primary substations in the Skegness group, current circuit and transformer parameters (Resistance and Reactance).

Question 9 - **Do you agree that, where possible, WPD should mirror terms used by other DNOs until standardised terms can be agreed upon nationally?**

All respondents agreed that standardised terms across the industry would be the preferred option and until that could be agreed WPD should mirror terms used by other DNO's

> *"Two of the terms that are involved with connections such as these are constraint and curtailment. These terms are already in use in Ireland and have distinct definitions. It is important therefore to ensure that terms are standardised wherever possible to avoid confusion. It would also be important that where terms are being used which already have meaning that they are used in a way which mirrors their use by other DNO's.*
> *[We] would not have any reservations about contributing to the work needed to achieve this."*

Summary of new documents

The new pro-forma documents are the 'Alternative Connection Offer' and 'Connection Agreement'. Copies of these two documents are included in Appendix 2 and 3.

In preparing these documents we recognised the desirability of moving towards industry standardisation. We therefore gratefully accepted the support offered by UK Power Networks, and have adopted many of the features of their contract documentation, including a number of defined terms.

Many of the defined terms found in connection agreements are industry standard terms used in the National Terms of Connection. We have augmented these in our connection agreement with the following additional defined terms:

Adjusted Export Capacity	Has the meaning described to it in Clause 3.2 of this Agreement
Adjusted Import Capacity	Has the meaning described to it in Clause 3.2 of this Agreement
Active Network Management (ANM) Scheme	Means the overall active network management scheme including but without limitation the Company's Control Equipment.
Company's Control Equipment	Means the equipment and technical specification set out in Schedule 4

Curtail	Means: (a) to limit from time to time the maximum amount of electricity that may flow from the Distribution System through the Connection Point; or (b) to limit from time to time the maximum amount of electricity that may flow to the Distribution System through the Connection Point; or (c) in respect of the flow of electricity from the Company's Distribution System to the Customer's Installation to require this to be at a particular Power Factor or to be within a particular range of Power Factors; or (d) in respect of the flow of electricity from the Customer's Installation to the Company's Distribution System to require this to be at a particular Power Factor or to be within a particular range of Power Factors; For the purpose of active network management and 'Curtailed' and 'Curtailment' shall be construed accordingly.
Instruction	Means an instruction given by the Company to the Customer via the Company Control Equipment or verbally or in written form in accordance with the technical specifications set out in Schedule 5 in order to undertake curtailment.
Protected Export Capacity	Means in respect of a Connection Point (or Connection Points collectively) an amount of electricity (expressed in kVA) which shall not exceed the Maximum Export Capacity that the Customer is entitled to pass into the Distribution System through the Connection Point (or the Connection Points Collectively) subject to the National Terms of Connection, which the Company shall not intentionally interrupt for active network management purposes. The value of the Protected Export Capacity is described in Schedule 1. For the avoidance of doubt, the use of the term 'Protected' in this Agreement does not mean that provision of the capacity is resilient to a loss of one or more Connection Points.
Protected Import Capacity	Means in respect of a Connection Point (or Connection Points collectively) an amount of electricity (expressed in kVA) which shall not exceed the Maximum Import Capacity that the Customer is entitled to take from the Distribution System through the Connection Point (or the Connection Points Collectively) subject to the National Terms of Connection, which the Company shall not intentionally interrupt for active network management purposes. The value of the Protected Import Capacity is described in Schedule 1. For the avoidance of doubt, the use of the term 'Protected' in this Agreement does not mean that provision of the capacity is resilient to a loss of one or more Connection Points.

Alternative offers will provide terms for Active Constrained Connections, Will detail the type and method of curtailment, and set out the specific conditions of the active constraints and the responsibilities of both parties.

If accepted, the offer letter will form the contract between the Company (WPD) and the Customer, for the duration of the connection works. On completion of the connection works the Customer will be required to enter into a connection agreement with the Company. Once the connection agreement is signed by both parties, it will supersede the connection offer, which then falls away- .

The active constrained connection agreement will clearly set out terms of the connection and the ANM scheme which will control its operation. As set out above the active constrained connection agreement contains several new defined terms in addition to those in the standard document.

The key new terms **Adjusted Export Capacity** and **Adjusted Import Capacity**, which are not fully defined in the table above, mean that the Company shall be entitled to issue an Instruction to:

- specify a level of import and export capacity which shall not be less than the level of the Protected Import & Export Capacity and / or;
- Specify a particular Power Factor, or a particular range of Power Factors, for any flow of electricity to / from the Distribution System to the Customer's Installation.

The connection agreement is an important enduring contract, and WPD will need to ensure that it remains in place in the event that ownership of the generator changes hands. To facilitate this a new term 'Subsequent Owners' has been introduced, under which the Customer covenants that it shall not dispose of any interest in the Premises, the Customer's Installation or the Customer's Generating Equipment unless the Customer has obtained from the proposed transferee of such interest a deed of covenant in a form acceptable to the Company in its sole discretion binding the proposed transferee to this Connection Agreement and provided such deed to the Company.

Appendices

Appendix 1 Mini Consultation

WESTERN POWER DISTRIBUTION
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WPD - Low Carbon Hub – Draft Consultation

Date of publication

This consultation was published on31st October 2013

Target audience

This consultation will be of particular interest to those considering developing distributed generation (DG) connected at high voltage in the area of the Lincolnshire Low Carbon Hub trial.

The consultation may also be of interest to those involved in developing HV connected DG elsewhere, consumers and their representatives, transmission companies, distribution network companies, electricity suppliers, investors in DG, environmental organisations and others.

Deadline

The deadline for responses to this consultation is 14th November 2013. Responses should be sent to wpdinnovation@westernpower.co.uk

Overview

WPD was awarded £3m of funding in December 2010 from Ofgem's Low Carbon Network Fund to develop the Lincolnshire Low Carbon Hub (LCH) renewable energy connection project.

This funding will allow WPD to improve and increase the connection of a wide range of renewable energy projects to the electricity distribution network.

The LCH will enable us to increase the amount of renewable generation that can connect to the distribution network, by designing and operating the network more efficiently using new innovative techniques and offering alternative connections.

WPD held a workshop on 13 June 2013, which was well attended by interested parties, mainly DG developers and trade associations. The workshop was helpful in developing the proposals set out in this consultation document.

WPD also held a LCH dissemination event on 3 October 2013, which was very well attended. The proposals set out in this consultation were outlined and discussed as part of this event, which also covered the technical developments associated with the LCH project.

This consultation focuses on the commercial arrangements that WPD are developing for alternative connections.

The consultation is split into five sections:

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1. Alternative connections;
2. Offer letter;
3. Last in, first off (LIFO);
4. Financing; and
5. Standardisation of terms.

Each of the above sections includes its own specific consultation questions.

1. **Alternative connections**

In common with the other electricity distribution companies, WPD's traditional approach has been to provide robust DG connections that allow generators to feed electricity into the network under all reasonably foreseeable circumstances. This 'Standard' approach has provided reliable connections that do not require on-going active management by WPD. However, such connections can be very expensive, particularly where there is a requirement to reinforce the existing network, and this up-front cost sometimes deters generators from connecting.

WPD recognises that the standard approach has held back the connection of low carbon generation to some extent and that, for a large proportion of the time, there is a significant amount of unused network capacity. The aim of the LCH project is to unlock this unused capacity and use it to connect additional generators.

WPD plans to make two separate connection offers to generators that request connection in the LCH trial area - one based on the standard 'fit and forget' approach outlined above, and another based on 'Alternative Connection'.

Alternative connection will be associated with an agreement that WPD may, from time to time, curtail the generator's ability to export electricity. WPD's expectation is that alternative connection will provide significantly cheaper generator connections, in exchange for relatively insignificant periods of curtailment, in many cases.

Offers for active constrained connections will be supported by separate, non-binding, estimates of the likely levels of curtailment in each specific case. These estimates will be based on sets of assumptions about network demand, generator output, etc.

WPD will provide network information that generators can use to take independent specialist advices should they want to before accepting any alternative offer. Curtailment may take the form of reduced electrical output, or adjustment of generators' power factor. Instructions to curtail will be effected via communications with generators. In many cases communication will be via dedicated interface equipment, giving WPD the ability to curtail generators directly. In other cases it will be via media such as email or phone, as appropriate. In the event that a generator fails to respond to an instruction to curtail, WPD will have the right temporarily to disconnect the generator from the network.

Where a number of generators are subject to the same network constraint, any necessary curtailment will be undertaken on a 'last in, first off' (LIFO) basis, with reference to the date of

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their acceptance of the connection offer, and subject to connection works commencing within one year and generation commencing within two years.

WPD will give generators the reassurance that curtailment would only be instructed when necessary and would last only as long as necessary, in WPD's reasonable opinion. No compensation will be paid to generators that are curtailed in this way.

Question 1 - Are constrained connections, as described in the consultation, likely to be an attractive alternative to standard connections?

- If so, what would make them more attractive?
- If not, what makes them unattractive?

Question 2 - Is our proposal to provide a standard (non-constrained) offer alongside each alternative connection offer appropriate?

- If not, why not?

2. Offer letter

As mentioned above WPD plans to make two separate connection offers to generators that request connection in the LCH trial area - a standard offer based on the traditional 'fit and forget' approach outlined above, and an alternative offer based on active constrained connection. This will allow DG developers to compare the costs of the two types of connection.

We have prepared a pro-forma 'Alternative Connection Offer' letter, which will be used for all alternative connection offers. A copy of the main text of this pro-forma letter is provided as an addendum to this consultation, along with the standard pro forma letter for comparison.

In response to views expressed by stakeholders at our June workshop, we have tried to keep the alternative version of the letter as similar as possible to the standard one.

Question 3 - Is the proposed pro-forma 'Alternative Connection Offer' letter sufficiently clear and comprehensive?

- If not, in what ways could it be improved?

Question 4 - Are the differences between the pro-forma 'Alternative Connection Offer' letter and the standard letter appropriate?

- If not, which differences are not appropriate?

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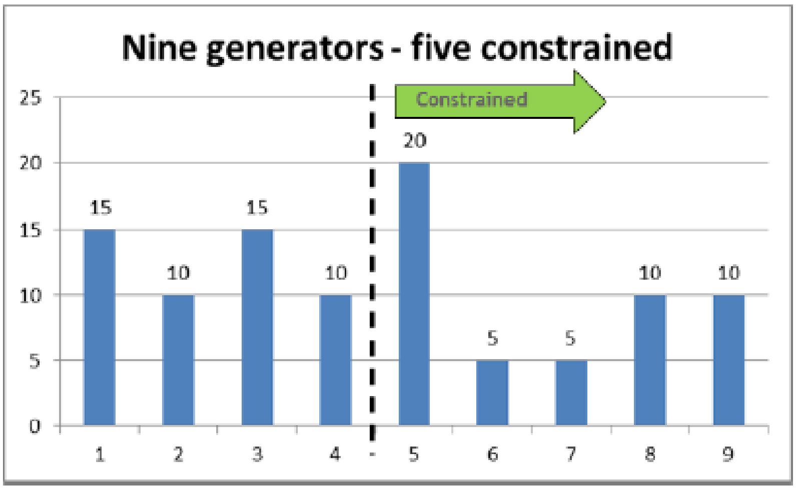
3. <u>Last in-first off (LIFO)</u>

Our review of the literature about different approaches to applying constraints has identified two basic methods – proportional and LIFO – as well as a number of hybrids.

Proportional constraint aims to curtail all constrained connections in equal proportion so as to achieve the desired outcome. In contrast to this LIFO applies maximum curtailment to the last connected generator, before curtailing the next to last connected, etc.

To illustrate the working of these two basic methods we present below a hypothetical scenario with nine generators totalling 100MW, all subject to the same network constraint. Generators number 1-4, totalling 50MW, are not subject to curtailment as they have elected to have standard connections. In the illustration below generators number 5-9 have opted for alternative connections and are shown in order of connection (generator 5 being the first and generator 9 the last):



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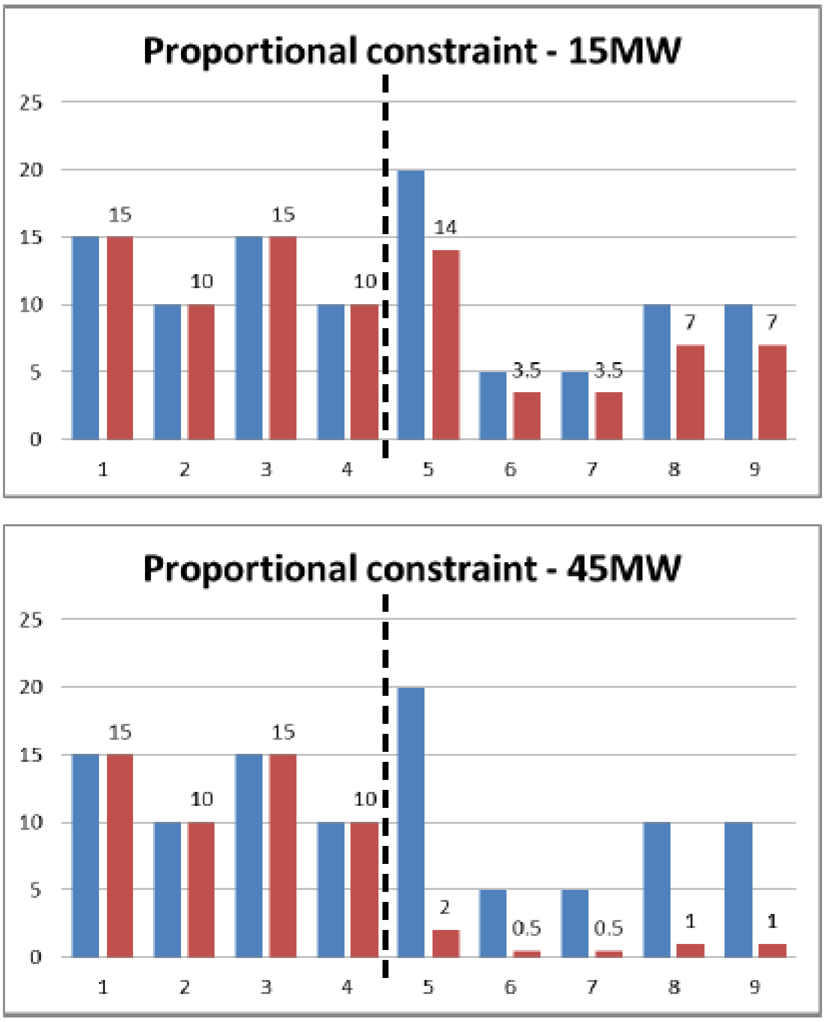
For each method, proportional and LIFO, the effects of two different levels of curtailment (15MW and 45MW) are illustrated in below:



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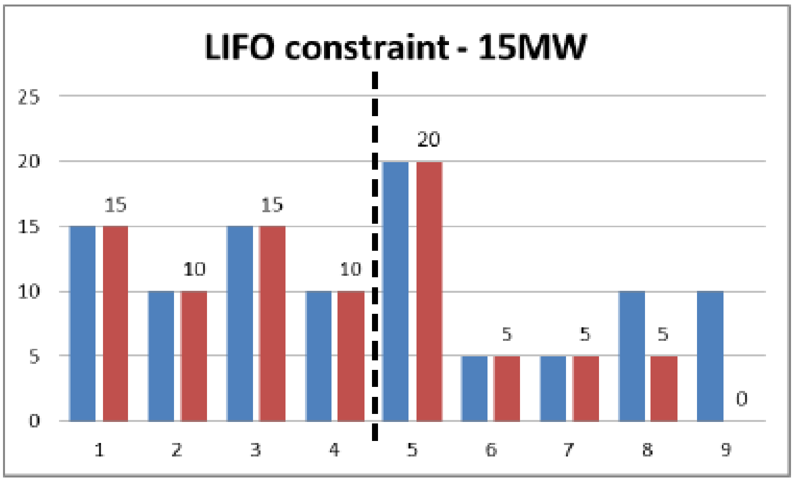

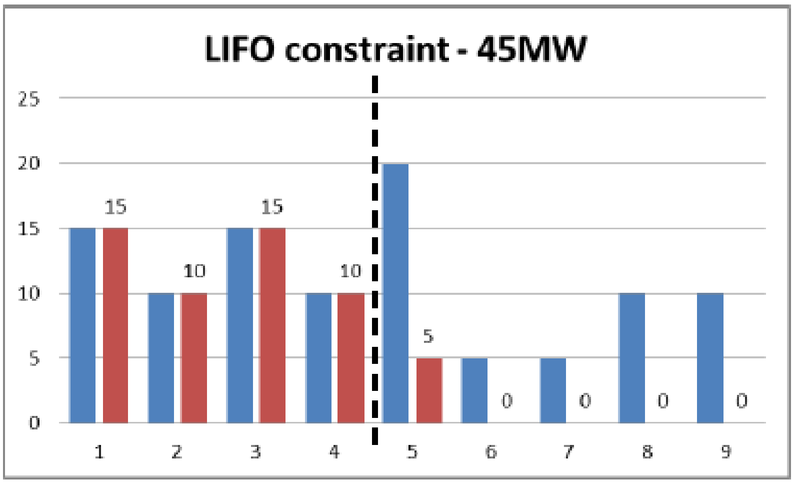

There are three important points to note about these hypothetical illustrations:

- With both proportional and LIFO constraint, generators 1-4 are not subject to curtailment under any scenario
- The unconstrained generators (1-4) are not necessarily connected prior to the constrained generators 5-9, as they may have opted to pay for standard connection, rather than alternative connection
- It is assumed that all generators' output can be constrained to any level between maximum output and nil - this may not always be possible for technical reasons

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Having considered the pros and cons of these two basic methods of allocating curtailment, and their various hybrids, we propose that curtailment will be applied on a LIFO basis.

Our main reasons for proposing LIFO are based on its simplicity, fairness, ability to protect early connecting generators from ones connecting later, and the robust economic signals that it sends.

The LIFO 'queue' order will be the date order in which generators accept their connection offer.

To avoid potential 'hoarding' of unused network capacity, we propose that places in the LIFO queue will be subject to the associated connection works commencing within one year of acceptance of our alternative connection offer, and generation commencing within two years.

Question 5 - Is LIFO an appropriate basis for allocating curtailment among alternative connections?

- If not, what basis would be more appropriate?

Question 6 – Are our proposals for the LIFO 'queue' order appropriate?

- If not, what would be more appropriate?

Question 7 – Are our proposals to avoid 'hoarding' of unused network capacity appropriate?

- If not, what would be more appropriate?
- Are the requirements to start connection works within one year and to commence generating within two years of acceptance reasonable?

4. Financing

In many cases DG is funded by commercial lenders or equity partners. In considering whether to lend against a particular DG project, financiers will need to be confident that the generator will be able to export its power via the network. In many cases lenders already understand and accept the risk associated with generators with non-firm, single feeder connections. Our hypothesis is that they will also come to understand and accept the risk associated with constrained connections, provided that appropriate data and analysis is made available.

Question 8 - Do you foresee any specific difficulties in relation to the funding of DG with alternative connections?

- If so, what could WPD do to ease these difficulties?

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Standardisation of terms

The advent of alternative connections gives rise to the need for new terms. In preparing the pro-forma offer letter referred to above we have been conscious of the need to avoid inventing new terms that may cause confusion. Most of the terms needed already exist, and many of these are defined in the National Terms of Connection and are in common use. Some other terms (such as 'Curtail', 'Protected Capacity', etc.) are new. Where new terms were required we have actively sought to mirror similar terms that have already been used by other DNOs. We believe that it would be helpful if the industry moved towards standardisation of the new terms needed to codify smart grids at an early stage in their development, rather than delaying this until differing terms have proliferated. We would support any national work towards achieving appropriate standardisation.

Question 9 - Do you agree that, where possible, WPD should mirror terms used by other DNOs until standardised terms can be agreed upon nationally?

- Do you support the need for standardisation of terms nationally?
- If so, would you be prepared to contribute to the work needed to achieve this?

Next steps

We will read and collate all responses to this consultation paper. Depending on the quantity of responses received, we will aim to publish a document outlining how we intend to proceed within two weeks of the consultation closing.

Appendix 2 Alternative Connection Offer

Primary System Design
Herald Way
Pegasus Business Park
East Midlands Airport
Castle Donington
DE74 2TU

Telephone: 01332 XXXXXX

Mr Smith
Building
Street
Town
Postcode

Our ref
00000000

Date
XX/XX/XXXX

Dear Mr Smith

Alternative Connection Offer for an active constrained electricity connection at Location by Western Power Distribution East Midlands plc ("WPD")

Thank you for your application requesting an Alternative Connection Offer to make a new electricity connection/augment the existing electricity connection to the Premises.

In addition to our standard Connection Offer 01/01/2015 made pursuant to and in accordance with the provisions of WPD's Distribution Licence (the " **Standard Connection Offer**"), I am pleased to provide this alternative connection offer to carry out the Connection Works for the Customer (the **"Alternative Connection Offer"**) on the basis of an active constrained electricity connection. This Alternative Connection Offer, which is based on WPD's understanding of the information provided by the Customer, comprises this letter (the **"Alternative Offer Letter"**) and the following documents:

a. Specific Conditions for Connection Works;
b. General Conditions for Connection Works;
c. Plan "Location Geographic Cable Route v1 and EHV POC 01_01_15 v1" dated 01/01/2015 showing WPD's existing Distribution System, Point of Connection location and Premises;
d. a single line diagram "Generator SLD and EHV POC 01_01_15" showing WPD's existing Distribution System and Point of Connection location;
e. a breakdown of the Connection Charge
f. the Letter of Acceptance (a form of which is attached), once signed by the Customer; and
g. a Health and Safety Questionnaire to be completed by the Customer; and
h. Three constraint analysis studies (Study 1, Study 2 and Study 3)

V0.1

This Alternative Connection Offer is made with the intention of providing a lower cost connection, in exchange for the facility for WPD to constrain the connection when required. Where more than one active constrained connection contributes to the same network constraint, when required WPD will constrain these on the basis of 'last in, first off' (LIFO).

The terms and conditions for WPD carrying out the Connection Works are more particularly described in both the attached Specific Conditions for Connection Works and General Conditions for Connection Works. Please ensure that you read the aforementioned documents carefully.

Provision of the Connection Works

This Connection Offer contains two options for Connection Works, Option 1 and Option 2. These options are mutually exclusive and you may only accept one of them.

Unless otherwise specified within the Connection Offer the terms and conditions specified shall apply equally to both options.

The Connection Charges stated within each option under this Connection Offer are broken down into contestable and non-contestable elements and are based on WPD undertaking the Non-contestable Connection Works and any Contestable Connection Works specified in clauses 3.2 and 3.3 of the Specific Conditions for Connection Works.

The Customer (or the Customer's appointed Connection Provider) will undertake the Contestable Connection Works specified in clause 3.3.5 of the Specific Conditions for Connection Works.

Acceptance of the Standard Connection Offer or the Alternative Connection Offer

The Standard Connection Offer and this Alternative Connection Offer are mutually exclusive and you may only accept one of them. On acceptance of the Standard Connection Offer this Alternative Connection Offer will automatically expire. On acceptance of this Alternative Connection Offer the Standard Connection Offer will automatically expire.

The Duration of the Alternative Connection Offer

This Alternative Connection Offer will (unless WPD agrees otherwise with you in writing) automatically expire on the earlier of:

(a) **ninety days** from the date of this Alternative Offer Letter; or
(b) the acceptance of the Standard Connection Offer.

Curtailment under normal running conditions

A study has been completed to assess the level of curtailment of this connection under normal running conditions. This study is based on recent historic trends and predicted generation output. Further details on the assumptions can be made available on request.

Estimated worst case with all generation at maximum output and a reduction in current demand by 25%	Estimated XX.X% Energy constrained from 219,150MWh output over 30 months (Jan 12-June 14)
Estimated current scenario with historical load and	Estimated XX.X% Energy constrained

V0.1

idealized generation profiles	from 76,702MWh output over 30 months (Jan 12-June 14)
Estimated current scenario with historical load and idealized generation profiles with the smart grid technologies working on Project XXXXXX.	Estimated XX.X% Energy constrained from 76,702MWh output over 30 months (Jan 12-June 14)

WPD has used historical load data, outage data, fault data and profiles for new and existing generators to provide an estimated level of constraints for this connection under two different scenarios. For the avoidance of doubt, WPD does not guarantee any level of duration or frequency of curtailment or constraints. The Customer is strongly encouraged to conduct their own assessment of the potential curtailments / constraints and risk associated with an alternative connection.

Last In, First Out Position (LIFO)

Where more than one connection within a given section of network needs to be curtailed then the connections shall be curtailed in order, with the last comer being curtailed first and the first comer being curtailed last. When the network limitation is lifted then the connections are restored to normal in the opposite order, i.e. the first comer is restored first and the last comer is restored last. This principle is known as Last In First Out (LIFO). Where a group of connections are handled in this way they are known as a LIFO stack.

The LIFO position number indicates the number of generators connected through alternative connections ahead of you in the LIFO queue.

Your generator will hold the following LIFO position: XX

The following generation is above you in the LIFO queue:

Generation Type	Generation Capacity (MW)	Number of Connections
Wind	X	X
Solar	X	X
Synchronous/Other	X	X

Acceptance

If you would like to accept this Alternative Connection Offer and confirm your acceptance to the terms therein please sign the enclosed Letter of Acceptance (confirming which option you wish to accept), the Letter of Indemnity and completed Health & Safety Questionnaire and return them to the above address. Once we receive the signed Letter of Acceptance the Alternative Connection Offer will be known as the "Agreement" and we will ask you to make an initial payment to cover our immediate costs. For the avoidance of doubt, you will be liable for the costs we have incurred even if you cancel the Connection Works and the Agreement is terminated. All provisions in the Specific Conditions which relate to the option that you have not accepted shall not form part of the Agreement.

As part of your planning process and before commencement of any site works you should contact WPD's Map Response Team to ascertain the location of any existing WPD apparatus on or in close proximity to the site and to take the necessary precautions to avoid possible danger from that apparatus. The WPD Map Response Team can be contacted on 0121 623 9780 or by email on WPDMapResponse@westernpower.co.uk

If you have any queries or are not satisfied with the terms of this Alternative Connection Offer and, after discussion, you and I are unable to reach agreement, I hope you will take the opportunity of talking to my manager: Tony Berndes, Primary System Design Manager (telephone number 0117 933 2101). If, following discussion with the Primary System Design Manager, we still cannot reach an agreement, please contact Alison Sleightholm on 0117 933 2175 or write to her at Avonbank, Feeder Road, Bristol BS2 0TB. She will investigate and try to resolve the matter with you. Our complaints procedure is available on our website www.westernpower.co.uk. If we are unable to resolve your complaint, you will have the right to refer the matter to the Energy Ombudsman for a decision. This is a free and independent dispute resolution service.

If you have any questions or wish to discuss any of the above, please do not hesitate to contact me.

Yours sincerely

Planner
Primary System Design

Western Power Distribution East Midlands plc

Important:

All rights in the design, specification, plans or drawings or any other document contained or accompanying this Alternative Connection Offer belong to and remain with WPD and shall not be used or disclosed by the Customer or any other person without WPD's written consent.

All data and information acquired or reviewed by the parties in connection with this Alternative Connection Offer is confidential and shall not be divulged to any third party without the prior written consent of the other party except insofar as may be required by law.

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Specific Conditions for Connection Works

1. **Definitions**

1.1 All words and expressions defined in the Offer Letter and the General Conditions for Connection Works shall, unless the context otherwise provides, have the same meanings in these Special Conditions for Connection Works.

1.2 Unless the context otherwise requires, the following words shall have the following meanings:

"Connection Provider" means a person with appropriate accreditation to undertake all or part of the Contestable Connection Works
"Customer" means Mr Smith (Company No.XXXXXX)
"Point of Connection" means the point on the Distribution System to which the new assets will be connected

2. Basis of the Alternative Connection Offer

2.1 Customer's Installation

2.1.1 WPD understands that the proposed Customer's Installation will comprise the following:-

- 5 x 2MVA (2MW), generation; and
- 5 x 2MVA, 33/0.650kV transformers

2.2 Connection and Supply Specification

2.2.1 The characteristics of the new connections will be:

Nominal Voltage at Connection Point: 33,000 V
No of Phases: 3
Nominal Frequency: 50 Hz
Maximum Export Capacity: 10,000 kVA @ 0.95 Power Factor
Maximum Import Capacity: 150 kVA @ 0.96 Power Factor
Please refer to paragraph 2.5.2. for full details of export.
Acceptable Power Factor Bandwidth for Export Capacity: Unity with transient excursions to 0.95 lagging and leading power factor being accepted (subject to agreement of National Grid Electricity Transmission plc (NGET)).
Acceptable Power Factor Bandwidth for Import Capacity: 0.95 lag to 0.95 lead

2.2.2 Maximum Import Capacity and Maximum Export Capacity means the maximum power in kilovolt amperes (kVA) which has been requested by the Customer and which WPD is prepared to make available. WPD accepts no obligation to provide capacity in excess of this. Further information is provided in WPD's Statement of

Methodology and Charges for Connection, which is available on WPD's website: www.westernpower.co.uk

2.3 Connection Point and Point of Connection

2.3.1 The Connection Point will be the 33,000V cable gland on the Customer's side of WPD's 33,000V metering unit. The section of the Customer's out-going cable within the 33,000V metering circuit breaker cable end box will need to be to WPD specification. It will be the Customer's responsibility to provide and maintain the Customer's Installation beyond the Connection Point in conformity with any regulations and orders for the use of electricity on the Premises.

2.3.2 The Point of Connection to WPD's existing Distribution System will be on the 33kV XXXXXXX circuit at pole XXXXXXXXX.

2.4 Security of Supply - Non-Firm Connection Scheme

2.4.1 WPD has based its design and costs on a single circuit connection. As a condition of the Alternative Connection Offer for a single circuit connection, the Customer acknowledges and accepts the increased risk of disconnection for fault or maintenance and that generation and/or demand may be constrained off for repair time or during certain stages of planned maintenance outages. WPD shall not be liable for any loss of output due to Distribution System unavailability, any DG network unavailability payments, or any related losses including but not limited to any financial loss.

2.4.2 At times of abnormal Distribution System configuration generation export will need to be constrained at the instruction of the WPD Control Centre. Where periods of constraint are identified for planned work WPD will so far as is reasonably practicable provide as much notice of the restrictions as we are able. For unplanned events WPD will use reasonable endeavours to request the generation be run down in a controlled manner, but reserve the right, depending upon system conditions prevailing on either WPD's or NGET's network at the time, to undertake the constraint of the generation, without notice. In such unplanned events it is in the Customer's own interest to ensure that WPD has 24 hour contact details and that the Customer is able to respond to requests from WPD to constrain without any delay.

2.5 Identified Generator Export Constraints

Note: This is not an exhaustive list

2.5.1 Generation may be constrained off under abnormal system running conditions. These constraints may include but are not limited to:

- A Substation A 400/132kV super grid transformer outage (planned or unplanned)

- Switchgear outages (planned or unplanned) at Substation A 132kV substation
- A 132kV circuit outage (planed or unplanned) on either the Substation A to Substation B No.1 or No.2 circuits
- Switchgear outages (planned or unplanned) at Substation A 132kV substation
- Switchgear outages (planned or unplanned) at Substation B 132kV substation
- A Substation B grid transformer outage (planned or unplanned)
- 33kV circuit or 33/11kV transformer outages (planned or unplanned) that cause demand transfers to be implemented from the Substation B 33kV group having the effect of reducing the minimum demand on the Substation B 33kV substation.
- 33kV circuit or 33/11kV transformer outages (planned or unplanned) that cause demand transfers to be implemented from 33kV feeders having the effect of reducing the minimum demand on 33kV circuits.
- An outage (planned or unplanned) of the ANM system or associated Customer owned communication systems or Company owned communication systems.

2.5.2 Generators may be constrained off under the active network management scheme when their output exceeds the ability of the Distribution System to absorb the generated energy. This will typically occur when a number of generators' output is high and, at the same time, distribution system demand is low – leading to either voltage, thermal or protection issues on the network.

2.6 Fault Level at the Connection Point

2.6.1 WPD's connection proposals are based on a maximum generator plant capacity of 9.9 MVA and our assumption that the total contribution from the Customer's Premises, as modelled at the 33,000V Connection Point, has been calculated to be:

- **L-L-L-G XX.XkA Make (Asymmetrical Peak @ 10ms - Make); and**
- **L-L-L-G X.XkA Break (RMS Symmetrical @ 100ms - Break);**

2.6.2 Final details of your proposals should include the total contribution to fault level from the Premises at the Connection Point. The proposed connection increases the sub-transient, transient and steady state fault level on the Distribution System. Under normal system configuration, this increased fault level is either within the rating of WPD switchgear or it can be managed within existing Distribution System constraints via network management. Your proposals impact on the fault rating of existing equipment. Our assessment, based on information provided to date, is that no remedial works will be necessary.

2.6.3 Please note that WPD will need to revisit fault level calculations for WPD's equipment and potentially other third party apparatus when full and final details of the Customer's proposals are available. The costs of any resultant remedial works that

3.3.9 The Connection Charge is broken into separate elements covering Contestable and Non-contestable Connection Works as follows:

Non-contestable Assessment & Design Fees :	**£XX,XXX.XX**
Non-contestable Connection Works:	**£XXX,XXX.XX**
Contestable Connection Works:	**£0.00**

Further detail concerning the Connection Charge is provided in the enclosed Customer Breakdown of Charges.

3.3.10 Payment

3.3.11 Payment of the Connection Charge shall be made in staged payments in line with WPD's incidence of expenditure. Details of payment stages are included in the following table.

Stage/Date	Amount due (Excluding VAT)
Initial payment on acceptance of the Connection Offer	£25,000
Prior to order of plant	£XX,XXX
Prior to WPD Connection Works commencing	£XX,XXX
Prior to Energisation	£XX,XXX

3.3.12 WPD may invoice the Customer when each payment is due. Payment must be made within 28 days of the date of the invoice. This Agreement will automatically terminate unless otherwise agreed in writing by WPD if the Customer fails to pay the initial payment within 28 days of the date such invoice is issued. WPD shall be under no obligation to start the Connection Works until the initial payment has been received.

3.3.13 Design Approval

3.3.14 The Customer (or their Connection Provider) is required to provide WPD with all information relating to their design in order to confirm suitability for adoption and connection to WPD's Distribution System. We require a (single) full and comprehensive design submission for all of the plant, equipment and cables/lines offered for adoption by WPD. Part or incomplete designs will not be accepted as the formal design submission. Where WPD does not consider the submission to be full and comprehensive, we will inform the Customer/Connection Provider that the submission has been rejected.

3.3.15 The Customer should refer to and comply with the requirements laid out under WPD'S appropriate design guide for switchgear and associated equipment. A copy of the appropriate guide and other design specification information is available on request or from WPD's website: www.westernpower.techinfo.co.uk

3.3.16 Where reasonably practicable the design submission shall be in electronic format. On receipt of a full design submission, WPD will either provide confirmation of approval or an explanation for rejection within 20 working days of receipt of the design. Where the design submission is rejected WPD may levy additional charges for considering subsequent design submissions.

3.3.17 Inspections

3.3.18 The charge for inspection of the Contestable Connection Works given in the enclosed break-down of Non-contestable costs is estimated according to the number of visits WPD anticipate it will normally make for this type and size of connection. Any additional visits subsequently required may be charged for.

3.3.19 Adoption Agreement

3.3.20 Where the Customer (or the Customer's appointed Connection Provider) wishes to provide some or all the Contestable Connection Work they must firstly satisfy WPD that they have the necessary competence and experience to carry out the work properly and safely by providing evidence of appropriate accreditation under the Lloyds Registration scheme. For further information reference should be made to www.lloydsregister.co.uk.

3.3.21 The Customer (or their appointed Connection Provider) must comply with all appropriate legislation, national standards, technical/engineering recommendations, WPD specifications for design, planning, materials, installation and recording of the Contestable Connection Works. Further information is available on request and via WPD's website: www.westernpower.co.uk.

3.3.22 If the Customer's appointed Connection Provider for the Contestable Connection Works is party to WPD's Network Access and Adoption Agreement, which sets out the terms and conditions upon which WPD shall adopt the assets installed by the Connection Provider, WPD will (upon approval by WPD of the Connection Provider's design) issue a site specific agreement to the Connection Provider for signature. If the Customer's appointed Connection Provider is not party to WPD's Network Access and Adoption Agreement the Customer and their appointed Connection Provider for the Contestable Connection Works must enter into an Adoption Agreement with WPD setting out the terms and conditions upon which WPD shall adopt the assets installed by the Connection Provider. This Connection Offer will form part of the Adoption Agreement.

The following terms and conditions apply to both Options 1 and Options 2

4. Other Works to be undertaken by the Customer

4.1 The Customer shall provide and install, at no cost to WPD, the following:-

- all the required civil works for establishment of the switchgear accommodation located at the Premises. Where required this may include a suitably fenced and level compound. A programme of on-site excavation must be agreed with WPD in advance of works commencing
- terminate the 33,000V outgoing (Customer side) cable onto the metering circuit breaker
- a suitable ducted cable entry, when required, for WPD's cables including any subsequent weatherproofing or other civil works after the cables have been installed
- a suitable weatherproof building to accommodate WPD's metering circuit breaker and auxiliary equipment, including protection and telecontrol equipment, d.c. batteries and charger. This building shall include provision of a separate metering room for WPD's metering equipment
- any works to the Customer's Installation required to establish inter-tripping and interlocking arrangements between the Customer's main circuit breaker and WPD's metered Connection Point circuit breaker
- a 230 volt supply and electrical installation within the substation building for lighting, battery charging, frost protection heating (including the heater) and twin switched socket outlets within the WPD section of the switchroom. The 230 volt supply must always be available whilst the Connection Point is energised. The Customer will bear the cost of the electricity consumed.
- where appropriate, a standard dedicated telephone line, with associated socket installed in the metering room, for use by the Customer's appointed meter operator for modem data collection from on-site metering. The Customer shall confirm the requirements for a standard telephone line with their appointed meter operator and install such a line, where required
- a suitable earthing system for the Customer's Premises
- outputs, to WPD's specification, for inclusion in WPD's telecontrol system by the date of Energisation of the Connection Point
- any necessary masts or supporting structures for communication equipment
- all on site cable excavation and reinstatement. The programme of on-site excavation must be agreed with WPD. Where required, the Customer shall be responsible for the provision of a stone dust bed around cables to WPD's specification.
- Any works at the Customer's installation required to accommodate the Company's ANM individual controller and associated small wiring exchange boxes.
- Small wiring connections between the Company's small wiring exchange box and the Customer's generator control system required for monitoring generator parameters, status indication and to deliver control instructions to the generator

4.2 In order to maintain essential electrical protection systems in the event of a prolonged mains supply interruption, the Customer is required to provide an auxiliary back up supply to the Premises, either via an additional connection at LV or HV to

WPD's Distribution System, or via a standby generator arrangement. No provision has been allowed in the Connection Offer for providing an auxiliary supply and the cost of installing any such back up supply is the Customer's responsibility. Any back up arrangement must have an appropriate interlock arrangement to avoid the back up and normal LV supply operating in parallel. Where a standby generator arrangement is installed, an appropriate interlock arrangement must be provided by the Customer to prevent the generator running in parallel with any back up supply. We will be pleased to discuss with you the viability of any permanent auxiliary connection made from our Distribution System and can provide a quotation upon request.

4.3 The Customer shall be responsible for all on-going repairs and maintenance of all accommodation and facilities it has provided.

3.4 The Customer shall also work with WPD and their Active Network Management supplier, at no cost to WPD, to incorporate their generator plant into the Active Network Management Scheme, responding to instructions to curtail within the specified timescales

5. Conditions of the Connection Charge

5.1 The Connection Charge is based upon current market rates and design assumptions. It is subject to the following variables:

5.1.1 Final competitive tenders and increases in labour, contract, or material costs. For schemes with long lead in times this may be some time after acceptance of the Connection Offer.

5.1.2 A full design review of the protection regime following acceptance of the Connection Offer. Allowance has been made for a basic scheme. No allowance has been allowed beyond the WPD's metering circuit breakers into the Customer's Premises.

5.1.3 A full site survey, layout and design at the Customer's Premises substation for the required civil works.

5.1.4 Any works, which are identified as being required following a future Steady State, Transient or Voltage Stability Study.

5.1.5 Any works which are identified as being required following a future power quality study

5.1.6 Any potential adverse effect to WPD's switchgear and Distribution System assets due to an increase in fault level identified when full and final details of the Customer's generators and their contribution to fault level are known.

5.1.7 Proposed cable/overhead line routes indicated being achievable.

5.1.8 Subsequent information provided relating to health, safety and the environment that influence the design of the scheme.

5.1.9 Any change to the characteristics of the connection design and/or data for the proposed connection.

5.1.10 A full ANM study, telecoms design and incorporation to the ANM core systems.

5.2 WPD reserves the right to amend its proposals and Connection Charge to account for any of the variables identified under paragraph 5.1. WPD will notify the Customer in writing as soon as is reasonably practicable informing the Customer of any changes to the proposals and/or Connection Charge.

6. Matters outside the scope of the Connection Charge

6.1 The following matters have not been included in the estimated Connection Charge:

6.1.1 The diversion of any third party apparatus (including without limitation any gas pipes and telephone lines).

6.1.2 Unless otherwise stated, the diversion of WPD's existing assets (if any) undertaken as a consequence of the Connection Works that are required to provide the connection to the Premises;

6.1.3 Specialist disposal of soil (in accordance with The Landfill (England and Wales) Regulations 2007) and import of suitable backfill;

6.1.4 Excavation and cable laying at abnormal depth, or through rock or other hard substances or in contaminated soil;

6.1.5 Foundations for buildings, towers etc. to be established in ground which is not normal ground bearing type;

6.1.6 Construction of access roads to the substation site;

6.1.7 Costs associated with the extension of existing system inter-tripping;

6.1.8 Unforeseen costs incurred in complying with the Traffic Management Act including permits, alterations to the route, or restrictions on working hours;

6.1.9 Permanent reinstatement of any excavation on the Premises; and

6.1.10 Testing and commissioning that is undertaken in accordance with Engineering Recommendation G59/2 that must be witnessed by WPD. WPD's charges for witnessing are available on request.

6.2 WPD may increase the Connection Charge to incorporate any costs it has incurred in relation to such matters set out at 6.1.1 to 6.1.10. WPD shall not be liable for any delay in commencement or performance of the Connection Works resulting from such matters and all costs resulting from such delay shall be borne by the Customer.

7. Customer Installation

7.1 The Customer shall be required to confirm the electrical layout, provisions for protection and electrical parameters of the Customer's Installation prior to commencement of the Connection Works by WPD.

7.2 WPD has the right to amend the Agreement in the event that the Customer makes changes to the proposed apparatus at the Customer's Installation that, in the opinion of WPD, cause the Connection Works to be unsuitable.

7.3 The Customer shall also ensure that

any voltage fluctuation or unbalance and harmonics caused by any of its electrical equipment or apparatus on the Development site does not exceed the levels laid down in National Engineering Recommendations P28, P29 and G5/4, as amended, and if appropriate, as modified by us.

- P28 covers 'Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom'
- P29 covers 'Planning limits for voltage unbalance in the United Kingdom'
- G5/4 sets down the 'Limits for harmonics in the United Kingdom supply system'

7.4 Please note that where appropriate, we may define harmonic limitations that take account of the multiple connection applications to the same part of the Distribution System to give equitable treatment for all. This means that the Customer may be allocated a portion of the margin between background level and planning level as set out in G5/4, rather than allowing one connection to take the whole margin.

7.5 Assessment reports in line with and in relation to the above documents will be required. Energisation will not be possible until the reports are reviewed and any required mitigation put in place. In view of this the Customer is advised to commence preparation of the reports early in the design process. The Customer's choice of equipment may influence the need for mitigation significantly (e.g. harmonic emissions produced by equipment with a similar function can vary substantially with some makes/models being cleaner than others).

8. Programme of Connection Works

8.1 A detailed programme of Connection Works has not yet been finalised. The program will be discussed and agreed following acceptance of the Alternative Connection Offer and depending on the level of Contestable Connection Works undertaken by the Customer. By way of non-binding indication, a scheme of this nature typically has a timescale of approximately 12-18 months from acceptance of the Alternative

Connection Offer to energisation. This Alternative Connection Offer is however, made on the understanding that the following milestones are met:

i) Planning consent shall have been granted within 12 months of the date of acceptance of this Alternative Connection Offer;

ii) the Connection Works are commenced within 18 months of the date of acceptance of this Alternative Connection Offer (save for in the event that this milestone is missed as a direct result of an act or omission by WPD); and

iii) the Connection Works are completed within 24 months of the date of acceptance of this Alternative Connection Offer (save for in the event that this milestone is missed as a direct result of an act or omission by WPD).

8.2 Upon request the Customer shall provide evidence to WPD's reasonable satisfaction confirming the progress on each of the above milestones and that it has, or reasonably believes it will meet each one by the dates specified. In the event that the Customer is unable to meet the above milestones WPD shall be entitled, at its sole option, to terminate the Agreement or to propose an amendment to the Alternative Connection Offer and/or Connection Charge under the Agreement. Where the Customer becomes aware that it will fail to meet any of the milestones but can demonstrate to WPD that it is still making progress toward the relevant milestone, WPD may take due account of this fact before considering whether to terminate the Agreement. Should the Customer's programme of works fall outside the above timescale, WPD reserve the right to vary or terminate the Agreement as WPD deem appropriate.

8.3 The date of connection is dependent on Distribution System access, operational constraints, manpower availability and delivery times for cables, switchgear, transformers and other equipment. WPD accept no liability should any of the above mentioned delay the date of connection. It is also conditional upon the Customer fulfilling the Agreement terms and conditions and any additional requirement reasonably required by WPD. However, WPD will use commercially reasonable endeavours to meet the Customer's requested connection date.

8.4 If WPD is unable to complete the Connection Works by the end of the 24 month period due to any reasons beyond WPD's reasonable control, WPD reserves the right, at its sole option, to amend or terminate the Agreement, including amending the Connection Charge.

9. Additional Conditions Precedent to commencement of Connection Works

9.1 In addition to the Conditions set out in this Alternative Connection Offer, the Connection Works are also subject to the following conditions:

9.1.1 WPD obtaining any necessary wayleaves and consents for the Connection Works;

9.1.2 WPD/the Customer obtaining any necessary planning consents from the local authority;

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9.1.3 that no action is identified by NGET as a result of any request made by WPD for a Statement of Works;

9.1.4 the Customer, where required, confirming it has fulfilled its obligations in accordance with the Connection and Use of System Code, Grid Code and Distribution Code;

9.1.5 the Customer shall have signed and returned the Letter of Indemnity, printed on its official headed paper together with the Letter of Acceptance;

9.1.6 the Customer shall not make or request any modification or deviation to the physical or electrical characteristics documented within the Specific Conditions for Connection Works.

9.1.7 the Customer having completed the enclosed Health and Safety Questionnaire identifying any hazards specific to this site together with the risks that they may pose to people working on the site with the control measures that you may be planning.

9.2 Should any of the above conditions not be met at any time, WPD reserves the right, at its sole option, to terminate the Agreement and issue a new Alternative Connection Offer or to revise the Connection Charge in this Alternative Connection Offer. For the avoidance of doubt this may be after acceptance by you.

10. Statement of Works

10.1 WPD may be required to request a Statement of Works from NGET in order to ascertain the effects of the generator proposals on the transmission system. On receipt of this request, NGET will consider whether or not a modification application is required. NGET fees for a Statement of Works and a modification application are payable in advance.

10.2 The Customer shall be responsible for the initial advance payments and any further additional fees as required. These fees are not included in this Alternative Connection Offer and will be notified to the Customer upon confirmation from NGET at the time of application.

10.3 The Customer shall be responsible for the costs of any works required on the transmission system as a result of the modification application.

11. Notice of Completion

11.1 WPD will, where agreed between WPD and the Customer, allow the connection to be/remain Energised subject to the terms and conditions as set out below and any other conditions set out under this Alternative Connection Offer.

11.1.1 The Customer shall ensure that the Customer's Installation is installed in such a manner that it will comply with Regulations 8(4) and 25 of The Electricity

Safety, Quality and Continuity Regulations 2002, as amended immediately prior to Energisation.

11.1.2 The Customer must provide WPD with a completed Notice of Completion of Installation (Notice).

11.1.3 The Customer must allow WPD access to any property covered by the Alternative Connection Offer to ensure that the Customer's Installation complies with Regs 8(4) and 25.

12. Safety

12.1 Any work in the vicinity of WPD equipment must be carried out in a safe manner, including, as a minimum, compliance with the relevant Health and Safety Executive Guidance Notes available from HMSO.

12.2 In particular:

- GS6 - Avoidance of danger from overhead electric lines.
- HS(G)47 - Avoiding danger from underground cables.

13. Construction of substation enclosures

13.1 WPD cannot warrant the suitability of the substation enclosure design for a particular site and whilst the superstructure arrangement is fixed, the suitability of the proposed substructure detail needs to be ascertained through investigation by the Customer, who will be required to propose modifications/ alternative proposals to WPD as necessary. The Customer, in evaluating the suitability of the WPD proposal, should take into account engineering considerations including:

- Bearing capacity at proposed founding depth;
- Risk of differential settlement;
- Potential passage of radon, explosive gases, contaminants and the like
- Effect of groundwater; and
- Other site-specific geotechnical considerations outside the above.

13.2 Where the substation includes a shared building (to be built to WPD specification) for both the Customer's Installation and WPD's protection, telecontrol and battery equipment then the Customer shall either:-

- establish separate sections of the building for WPD and the Customer's equipment, with separate access and locking arrangements for WPD personnel and the Customer's personnel, such that access to any of the WPD equipment is limited to WPD personnel only and access is not possible from any section of the switchroom to which the Customer has access; or
- ensure that where access is required by the Customer, or a representative thereof, to any part of the building that contains any of the WPD equipment, then the Customer, or Customer's representative, shall be appropriately authorised by WPD for such access.

13.3 For safety & operational reasons, the Customer shall be required to provide 24 hour unhindered vehicular access to the substation for WPD personnel, or authorised agents thereof.

13.4 The Customer shall produce detailed civil drawings & specifications in line with WPD's performance specification for the construction of the substation. Detailed proposals shall be submitted to WPD for approval, at least one calendar month in advance of commencement of construction works on site.

13.5 WPD reserves the right to make site inspections by prior arrangement with the Customer to ensure construction meets the required specification and quality. This does not remove the Customer's obligation to provide a structurally stable, secure, weather-tight and non-hazardous environment to accommodate WPD plant.

13.6 The construction of substations is not usually classed as permitted development and consequently the Customer may need to obtain planning permission for the construction beforehand.

13.7 All work shall be carried out to WPD specification. This specification is prepared on the presumption of a level site and that competent, non-variable bearing strata can be achieved at normal founding depth.

13.8 WPD will provide applicable specification documents upon acceptance of this Alternative Connection Offer.

14. System Protection

14.1 It is a precondition for Energisation, and the Customer's responsibility, to ensure that

14.1.1 the operation of any generators in parallel with WPD's Distribution System conforms to National Engineering Recommendations G59: 'Recommendations for the Connection of Generating Plant to the Distribution Systems of Licensed Distribution Network Operators' (ERG59) as amended from time to time. This will include a requirement for interface protection, including loss of mains protection. The detail of this protection is to be agreed with WPD.

14.1.2 the proposed generation runs in parallel with WPD's Distribution System through the agreed Connection Point. Any alternative or back-up supplies must be subject to WPD's agreement and suitably interlocked.

14.1.3 the multiple generating units start sequentially in order to minimise the rate of voltage rise on the surrounding Distribution System.

14.1.4 that there shall be no electrical interconnection between the proposed new electricity connection and any existing connection at the Premises.

14.2 Prior to any parallel operation of the Customer's proposed new generation with the Distribution System WPD must witness commissioning tests carried out on the

Customer's Installation with regard to compliance with ERG59 (as amended). WPD will make an additional charge for providing this service. Parallel operation with the Distribution System can only be permitted following written confirmation that the commissioning has been successfully completed by the Customer and witnessed by WPD. A minimum of two weeks' notice will be required for the witnessing to be arranged.

14.3 The proposed WPD-owned 33,000V metered circuit breaker at the Connection Point substation shall have installed as standard overcurrent and earth fault protection. In addition, depending on Distribution System configuration and operational conditions there may be a requirement for NVD, overvoltage and inter-tripping schemes. WPD shall provide the Customer with details of the protection settings employed at the metering circuit breakers. It is the Customer's responsibility to ensure that these settings provide adequate protection of the Customer's Installation.

14.4 It is the Customer's responsibility to ensure their equipment and installation is adequately protected. The Customer shall provide IDMT overcurrent, IDMT earth fault and instantaneous overcurrent protection on the Customer's 33,000V circuit breaker. The Customer shall be responsible for the provision of suitable protection to ensure tripping of the proposed generation under 'loss of mains conditions'.

14.5 As the Distribution System is predominantly overhead, under fault conditions auto-reclosers will operate. A detailed protection analysis of the effect of the Customer's connection on the Distribution System will need to be performed following acceptance of the Alternative Connection Offer. The cost of any additional works will be borne by the Customer.

14.6 WPD may consider accepting tripping signals from the Customer. Each request will be considered on its merits. WPD will not accept any responsibility or liability for the inclusion of its own equipment and protection into the Customer's protection scheme and this facility is offered on the basis that it is entirely at the Customer's risk. These arrangements will need to be agreed prior to completion. Where WPD agrees to accept tripping signals from the Customer, normally open volt free contacts for this purpose shall be provided by the Customer.

14.7 The Customer shall make provision for the establishment of inter-tripping and interlocking arrangements as follows:-

- a trip operation of WPD's metering circuit breaker(s), shall cause the Customer's generator circuit breaker to be tripped. A single set of normally open 'remote trip' volt free contacts, for incorporation, by the Customer, into the tripping circuit of the Customer's generator circuit breaker, shall be provided from WPD's metering circuit breaker(s).

- operation of the Customer's emergency trip button at the Customer's Connection Point substation shall trip WPD's metering circuit breaker(s). The Customer shall provide a single set of normally open volt free contacts from the emergency trip button, for this purpose.

- closure of WPD's metering circuit breaker(s), shall be inhibited unless the Customer's generator circuit breaker(s) is open. The Customer shall provide a set of normally closed volt free contacts from the Customer's generator circuit breaker(s) for this purpose.

14.8 Where interlocking/inter-tripping arrangements are to be established by wiring between the Customer's generator circuit breaker panel and WPD's metering circuit breaker(s), the Customer shall make arrangements for such wiring to utilise links mounted on the panels to enable the wiring to be segregated, where required for testing.

14.9 The Customer shall provide an emergency trip button, of a break glass type, within the metering room, for the Customer's purposes. WPD will make provision to enable the Customer to trip WPD's metering circuit breaker(s), using the emergency trip button should an emergency arise.

14.10 Inter-tripping will be required between WPD's Distribution System and the Customer's Installation (inter-trip received from both WPD's and the Customer's Installation). Allowance has been made for a basic scheme. No allowance has been allowed beyond the metering circuit breaker(s) into the Premises. The responsibility and costs of this part of the inter-tripping scheme is to be borne by the Customer. Details of the final inter-trip scheme will need to be agreed with WPD. WPD reserve the right to amend proposals and costs to accommodate the Customer's protection proposal.

14.11 Costs will be subject to review following the design of a full operational inter-trip scheme following acceptance of this Alternative Connection Offer.

14.12 The Customer shall be responsible for the costs of any communication channels required for telecontrol, protection and operational inter-tripping.

14.13 Any requirements to accelerate existing protection (and associated cost) will be highlighted as part of the steady state and transient stability analysis. A detailed design of protection requirements will be carried out following completion of the necessary stability studies. In order to carry out these stability studies details of the generator control system and the Customer's proposed protection arrangements will be required.

14.14 Please note, all protection requirements shall be agreed with WPD prior to installation.

15. Earthing

15.1 This Alternative Connection Offer is conditional on an earthing study being carried out for the Premises to assess the earthing requirements for the connection. The costs of such a study are not included in the Connection Charge and shall be borne by the Customer. It is the Customer's responsibility to arrange this study and provide a copy of the results to WPD free of charge. On request, WPD will provide the necessary fault level and circuit information in order that these studies can be completed.

15.2 Upon completion of the Customer's earthing system installation, the Customer shall provide WPD with detailed 'as constructed' drawings for the Customer's earthing system, including details of electrode size and installed depth.

15.3 It is the Customer's responsibility to ensure that the Customer's Installation has adequate earth fault protection, and no liability will be accepted by WPD if its earth terminal is used. The Customer shall allow WPD to connect to the Customer's earthing system at no cost.

15.4 Special precautions must be taken with telecommunications plant and strict working procedures adopted in the immediate vicinity of substations where the rise of local earth potential could under severe fault conditions exceed 430V. Where this limit is exceeded the site will be classified as 'hot'.

15.5 ENA Engineering Recommendation S36, as amended, defines the criteria for classification of substations and power stations as 'Hot Sites'. For safety reasons it may be necessary for mitigation to be applied at and in the vicinity of Hot Sites. If the WPD substation/customer installation is assessed to be a Hot Site then the Customer shall consult with Openreach to establish if any mitigation is required. WPD require written confirmation that Openreach agree to Energisation of the Hot Site before WPD will Energise a Hot Site. This confirmation must be relevant to the actual installed substation/customer installation. Note that sometimes sites that are predicted to be 'cold' do become Hot Sites if the earth impedance actually achieved is higher than predicted. As this can be identified late in the connection process it is recommended that assessments at the design phase are conservative and that consultation with Openreach occurs at an early stage to avoid prolonged delays to the Premises being Energised, in the case of Openreach mitigation measures.

15.6 Before Energisation WPD will examine the Customer's earthing design to ensure that it complies with WPD's specification. The earthing system must be designed so that, if reasonably practicable, the substation does not become 'hot'. The costs of any works associated with making the Customer's Installation or WPD's substation 'cold', or for any remedial works by third parties due to either installation being 'hot', shall be borne by the Customer.

15.7 The earthing system must meet the requirements of Engineering Recommendation ENA TS 41-24 (available from the Electricity Networks Association) and any WPD specification as notified.

16. Appointing a Supplier / Meter Operator

16.1 Before a supply of electricity can be imported or exported through the new connection the Customer must ensure an electricity supplier is appointed and has registered in accordance with electricity trading arrangements. For a list of licensed suppliers please call WPD on (01208) 892288. Alternatively, you can visit the Ofgem website, www.ofgem.gov.uk/Licensing.

16.2 Prior to connection WPD will provide the Customer with an import and export Supply Number for the new electricity connection. The Customer will need to quote the Supply Number(s) to the electricity Supplier of their choice in order to arrange an electricity supply. If the Supplier fails to register the Supply Number WPD will be unable to Energise the connection.

16.3 For connections with a maximum demand above 100kW and a generation capability above 30kW, half hourly metering is mandatory. The Customer's appointed Supplier may arrange for a Meter Operator to install half hourly metering but it is usual for the Customer to appoint their Meter Operator directly.

16.4 A list of Meter Operators can be obtained from the Association of Meter Operators, www.meteroperators.org.uk. It will be necessary for the Customer to ensure in conjunction with the meter operator, that suitable metering exists/is installed for the required level of import/export capacity.

16.5 WPD provides metering services to customers in the UK and can provide half hourly metering. Please inform us if you would like WPD to be your Meter Operator.

17. Connection Agreement

17.1 Prior to Energisation of the Customer's Installation the Customer must enter into a formal Connection Agreement with WPD.

17.2 The Connection Agreement will govern the terms and conditions under which the Customer's Installation may be connected (and remain connected) to WPD's Distribution System. The Connection Agreement is based on an industry standard and terms and conditions contained therein are largely non-negotiable. Any request by the Customer to amend the Connection Agreement will require referral for legal advice and the Customer shall be responsible for costs incurred by WPD regardless of whether or not these changes or amendments are agreed and incorporated in the Connection Agreement.

WPD
General Conditions For Connection Works ("The Conditions")

1. Definitions and Interpretation

1.1 All words and expressions defined in the Offer Letter and the Specific Conditions (if any) shall, unless the context otherwise requires, have the same meanings in these General Conditions.

1.2 Unless the context otherwise requires, the following words have the following meanings:

"Act" means the Electricity Act 1989 as amended from time to time.

"Agreement" means these General Conditions, the Offer Letter, the Specific Conditions, the Characteristics and Charge Statement or Letter of Acceptance each signed by the Customer and any schedule or annexure to the Offer Letter, and any other document in agreed form.

"Characteristics and Charge Statement" means the electrical characteristics of the proposed connection at the Connection Point and details of the Connection Charge to be completed and signed by the Customer confirming the Customer's acceptance to the terms of the Alternative Connection Offer and concluding the contract between the parties in respect of the subject matter of this Agreement.

"Conditions Precedent" means the conditions which must be fulfilled prior to the commencement of the Connection Works and continue to be fulfilled for the duration of the Agreement, as detailed in clause 2 and the Specific Conditions, if applicable.

"Connection Equipment" means all electric lines, materials, structures, equipment, plant, cables and apparatus necessary for the supply of electricity to or from the Connection Point, which forms part of the Distribution System.

"Connection Point" means the point of connection at which a supply of electricity may flow between the Distribution System and the Customer's Installation upon Energisation.

"Connection Works" means the works carried out by WPD under this Agreement as more particularly set out in the Specific Conditions.

"Contestable Connection Works" means the works that the Customer has an option to carry out itself or by appointing a contractor as more particularly described in the Specific Conditions.

"Customer's Installation" means any electric lines, materials, structures, equipment, plant, cables and apparatus (not being Connection Equipment) installed or to be installed by the Customer, owned or operated, used or to be used by the Customer and connected or to be connected to the Distribution System pursuant to this Agreement (including, without limitation the Customer's distribution network or generating plant).

"Customer Works" means any works to be carried out by the Customer or the Customer's contractor including, without limitation Contestable Connection Works as set out in the Specific Conditions.

"Distribution System" means WPD's electricity distribution system.

"Energisation" means the movement of any switch or the insertion of any fuse or the taking of any other step so as to enable an electrical current to flow to or from the Distribution System through WPD's Connection Equipment to and, where applicable, from the Customer's Installation at the Connection Point and **"Energise"** shall be construed accordingly.

"Event of Force Majeure" means an event beyond the reasonable control of a party including but not limited to acts, defaults or omissions of sub-contractors, strike, lock out or other form of industrial action, other than by a party's own employees or agents, act of God, fire, explosion or flood, any third party obstruction preventing access to the Premises, theft and malicious damage or an electrical system emergency, provided that no event shall be treated as an Event of Force Majeure if it is attributable in whole or part to any wilful act or omission or any failure to take reasonable precautions by the affected party.

"Letter of Acceptance" means the letter in the form attached to the Offer Letter to be completed and signed by the Customer confirming the Customer's acceptance to the terms of the Alternative Connection Offer and concluding the contract between the parties in respect of the subject matter of this Agreement.

"Non-contestable Connection Works" means that part of the Connection Works which will always be carried out by WPD and which the Customer is not entitled to carry out itself or through an appointed contractor as more particularly set out in the Specific Conditions.

"Premises" the premises or development (including, without limitation, any land, building or structure, owned or occupied by the Customer) where or in relation to which the Connection Works are to be carried out.

1.3 In this Agreement, unless the context otherwise requires:

(a) words in the singular include the plural and vice versa and words in one gender include any other gender;

(b) a reference to a statute or other statutory provision includes:

(i) any subordinate legislation (as defined in Section 21(1) Interpretation Act 1978) made under it;

(ii) any repealed statute or statutory provision which it re-enacts (with or without modification); and

(iii) any statute or statutory provision which modifies, consolidates, re-enacts or supersedes it;

(c) references to:

(i) any party include its permitted successors in title and permitted assigns;

(ii) clauses and schedules are to clauses and schedules of this Agreement and references to sub-clauses and paragraphs are references to sub-clauses and paragraphs of the clause or schedule in which they appear;

(d) the headings are for convenience only and shall not affect the interpretation of this Agreement.

2. Commencement of Connection Works and Conditions Precedent

2.1 As soon as reasonably practicable after WPD has received the Customer's acceptance of the Alternative Connection Offer , the parties shall agree in writing a date for commencement of the Connection Works.

2.2 WPD shall be under no obligation to commence the Connection Works until the following Conditions Precedent have been met:

(a) the Customer has:

(i) entered into the Agreement, pursuant to the Alternative Connection Offer, by WPD by completing, signing and returning the Letter of Acceptance or Characteristics and Charge Statement, as appropriate;

(ii) completed any necessary civil works, civil engineering or building works that are necessary to enable the Connection Works to commence;

(iii) complied with its obligations under clauses 3 and 4.1; and

(iv) made any initial payments required under the Offer Letter or Specific Conditions; and

(b) WPD has, at its normal rates, obtained all necessary easements, leases and transfers as well as any off site third party wayleaves and consents to lay its cables or construct an overhead line connection. Should any of these not be granted, or granted on terms in excess of WPD's normal rates, the Connection Charge may be revised to take account of any additional cost to WPD.

2.3 If any of the Conditions Precedent have not been met by either party or waived by WPD within (6) months of the date of the Offer Letter, the Agreement shall automatically expire without prejudice to any accrued rights or obligations to either party under it.

2.4 The Customer shall not in any way obstruct or impede Connection Works or the delivery of any Connection Equipment to the Premises, and shall use its reasonable endeavours to procure that its sub-contractors or agents shall not in any way obstruct or impede the Connection Works or the delivery of any Connection Equipment to the Premises so as to prevent WPD from, or hinder or delay WPD in performing its obligations under this Agreement.

2.5 WPD shall use its reasonable endeavours to complete the Connection Works within the timescales laid out under the Offer Letter or Specific Conditions. This period for completion shall be extended to the extent that progress of the Connection Works is delayed as a consequence of any act or omission on the part of the Customer, its agents or sub-contractors or a Distribution System emergency.

3. Property Matters

3.1 Where the Customer is the owner of the Premises or any adjacent land on which the Connection Works are to be carried out it shall, where reasonably required, and at the request of WPD, for the sum of £1:

(a) grant an easement in perpetuity to WPD to carry out the Connection Works and install, lay, repair, replace, renew, alter and maintain the Connection Equipment; and

(b) enter into a lease for a term of 99 years for the benefit of WPD of any part or parts of the Premises for the siting, repairing, maintenance and access to the accommodation and the Connection Equipment, or

(c) transfer the Customer's ownership in an acceptable form to WPD of any part or parts of the Premises for the siting, repairing, maintenance and access to the accommodation and/or Connection Equipment.

3.2 Where the Customer owns a leasehold interest in the Premises or any adjacent land the Customer shall, where reasonably required, and at the request of WPD, for the sum of £1:

(a) grant an easement to WPD for a term of years expiring one day before the end of Customer's interest in the Premises for the benefit of WPD to carry out the Connection Works and install, lay, repair, replace, renew, alter and maintain the Connection Equipment and;

(b) enter into a lease with WPD for a term of years expiring one day before the end of Customer's leasehold interest in the Premises for the benefit of WPD of any part or parts of the Premises for the installation, laying, siting, repairing, replacement, renewing, altering, maintenance and access to the accommodation and the Connection Equipment;

provided that WPD shall not be required to enter into the documents set out in 3.2(a) or 3.2(b) until the Customer has obtained the consent of the freehold owner to such documents.

3.3 Where the Customer owns neither the freehold nor the leasehold interest in the Premises or the adjacent land the Customer shall use reasonable endeavours to procure that the owner of the freehold interest of the Premises and the adjacent land enters into documents set out in clause 3.1 for the benefit of WPD.

3.4 Where the Customer is the owner or occupier of the Premises or the adjacent land, the Customer shall indemnify WPD from and keep WPD fully indemnified against any proceedings, claims, demand, costs, charges and expenses WPD incurs as a result of the Customer's failure to grant or obtain for WPD the appropriate easement or property rights to carry out the Connection Works and to install and maintain the Connection Equipment.

3.5 WPD may, in its discretion, carry out the Connection Works if it has obtained a wayleave to do so in lieu of any easements. The acquiring of any wayleaves shall not diminish the duties and obligations on the Customer pursuant to this clause 3.

3.6 If the Customer or a third party prevents WPD from entering the Premises, adjacent land or other land with the result that WPD is unable to carry out the Connection Works, or the Connection Works are suspended on the Customer's instruction for which WPD is not responsible or due to alterations to the layout of the Premises, WPD shall not be deemed to be in breach of this Agreement and any additional costs reasonably incurred by WPD in consequence thereof shall be added to the Connection Charge.

3.7 The Customer shall except and reserve out from the conveyance/lease to the purchaser/lessee of the Premises, full right and liberty for WPD to place/install electric lines through the property conveyed or leased and thereafter to use, inspect, repair, replace, alter, maintain and renew the same provided that WPD shall make good any damage caused as soon as practicable and shall not break open the surface of any land covered by a building.

3.8 Any legal costs incurred in conveying any part of the Premises to WPD shall be apportioned between the parties in accordance with the Specific Conditions.

4. Compliance, consents, safety and access

4.1 The Customer shall:

(a) before the time specified for delivery of any of WPD's Connection Equipment to the Premises, obtain all consents and approvals in connection with the regulations and by-laws of any local or other authority which shall be applicable to the Connection Works on the Premises;

(b) provide all accommodation, equipment, buildings, structures, foundations, approaches or work equipment of the quality specified in the Specific Conditions, if any;

(c) ensure that the 'Co-ordinator' and the 'Principal Contractor' as defined by the Construction (Design & Management) Regulations 2007 ("**CDM Regulations**") carry out all their duties and obligations as set out in the CDM Regulations;

(d) at all times provide and maintain suitable access to the Premises for the purposes of carrying out the Connection Works or delivering, installing, laying, repairing, replacing, renewing, altering, or maintaining the Connection Equipment and on production of written identity the Customer shall allow any WPD representative to enter the Premises provided that such visits are made during normal working hours (being between 07:00-19:00 hrs., Monday to Friday except for bank holidays); and at other times with the Customer's consent.

4.2 Each party shall take all reasonable steps to ensure the safety of the other party's employees, sub-contractors and agents while the Connection Works are in progress or while WPD is maintaining or repairing the Connection Equipment.

4.3 WPD shall not be under any obligation to commence or continue to provide the Connection Works unless it is reasonably satisfied that each part of the Customer's Installation is so constructed, installed, protected and used so far as is reasonably practicable to prevent danger, and not to cause interference with the Distribution System.

4.4 The inspection, non-inspection or non-rejection of the Customer's Installation by WPD shall not constitute any warranty or representation express or implied as to the adequacy, safety or other characteristics of the Customer's Installation.

5. Performance of Connection Works

5.1 WPD shall:

(a) perform the Connection Works with reasonable skill and care and in accordance with the terms of this Agreement; and

(b) provide such information as is reasonably required by the Customer from time to time to keep the Customer informed of the progress of the Connection Works.

5.2 WPD specifically excludes all warranties, express or implied, including but not limited to any implied term, condition, representation or warranty of satisfactory quality or fitness for a particular purpose, that the Connection Works or Connection Equipment will meet the Customer's requirements except those that cannot be excluded at law.

6. Connection Charges and payment

6.1 The Customer will pay to WPD the Connection Charge. The Connection Charge has been determined on the basis that WPD will provide the Non-contestable Connection Works and those Contestable Connection Works, if any, as identified in the Specific Conditions. If the Customer wishes to provide some or all the Contestable Connection Works it shall first satisfy WPD that it (or its appointed contractor) has the necessary competence and experience to carry out such Contestable Connection Works properly and safely.

6.2 If WPD is unable to complete the Connection Works within the estimated timescales set out in the Offer Letter or Specific Conditions due to any act, default or omission by the Customer, its employees, agents or sub-contractors or the Customer's breach of the Agreement or breach of statutory duty, WPD reserves the right to increase the Connection Charge to recover any costs incurred by it as a result of such delay.

6.3 Payment of the Connection Charge shall be made in accordance with the Offer Letter or Specific Conditions. WPD shall invoice the Customer the amount stated. The Customer shall pay WPD within 28 days of receipt by the Customer of such invoice.

6.4 If the Customer makes any late payment of the Connection Charge or any part of it WPD may, at its discretion, suspend the Connection Works or postpone their commencement.

6.5 Without prejudice to any other rights and remedies which WPD may have, if the Customer fails to pay WPD by date an invoice is due, WPD may charge interest at a rate of 5% over the base rate of the Lloyds TSB, until it receives full payment of such invoice in cleared funds from the Customer.

6.6 WPD shall be under no obligation to Energise the Connection Point prior to receiving full and final payment of the Connection Charge in cleared funds from the Customer. Full payment of the Connection Charge shall be due in accordance with the payment terms set out under the Offer Letter or Specific Conditions and in any event at least 7 days prior to the Energisation date.

6.7 Where under this Agreement any party agrees to pay to any other party any sum or to furnish to any other party consideration which (in either case) is consideration for a taxable supply that sum or consideration shall be exclusive of Value Added Tax payable on it and the recipient of the supply shall pay an amount equal to such Value Added Tax in addition to any sum or consideration on receipt of a valid Value Added Tax invoice from the relevant party.

6.8 WPD shall be entitled to require security from the Customer before the commencement of the Connection Works.

7. Ownership, use and removal of Connection Equipment

7.1 The Connection Equipment shall be installed in a position agreed by WPD.

7.2 The property in the Connection Equipment shall remain with WPD who may use it to connect its other customers.

7.3 If prior to the Connection Works being completed, WPD or the Customer cancels the Connection Works or part of them WPD may require the Customer, (at no cost to WPD), to assist WPD in removing the Connection Equipment and to pay within 7 days to WPD the amount of any expenditure reasonably incurred by WPD in the expectation of the performance of such Connection Works or part of them, or otherwise arising in consequence of such cancellation to the extent not yet invoiced.

8 Customer Works and Customer Installation

8.1 The Customer shall carry out all Customer Works with reasonable skill and care and in accordance with all applicable laws, rules and regulations.

8.2 WPD shall be under no obligation to permit the Customer's Installation to be connected directly or indirectly to the Distribution System unless it is satisfied that:

(a) it will not cause danger or damage to, or undue interference with the Distribution System or the electricity supply to any third party; and

(b) if applicable, the Customer has done everything necessary to lawfully operate and use the Customer's Installation for export of electricity to the Distribution System.

8.3 The Customer shall produce such evidence as may be reasonably required by WPD to show that the Customer has complied with its obligations under clause 8.2 above.

8.4 Save where express written representations are made by WPD or where the relevant works are carried out by WPD, neither by inspection, Energisation, connection nor in any other way does WPD give any guarantee or warranty, expressed or implied, as to the adequacy, safety or any other characteristic of the Customer's Installation or anything connected to it directly or indirectly (save for any Connection Equipment). WPD shall be under no obligation to carry out any repair or maintenance to the Customer's Installation.

9. EU Procurement Regulations

Where the EC Procurement Regulations apply to the procurement by WPD of works, goods or services which are necessary to carry out the Connection Works, WPD shall comply with such Regulations and provide any details reasonably required by the Customer to prove such compliance.

10. Liability

10.1 Each party accepts unlimited liability for death or personal injury caused by its negligence.

10.2 WPD's aggregate liability for physical damage to the Customer's tangible property (save where provided in clause 10.3) resulting from any act, default or omission (whether negligent or otherwise) of WPD, its employees, agents or sub-contractors, or from WPD's breach of the Agreement or breach of statutory duty, shall be limited to £5,000,000 per event or series of connected events.

10.3 WPD shall have no liability whatsoever, arising in contract, tort (including negligence) or breach of statutory duty, for any:

(a) defect, malfunction or otherwise in the Customer's electrical equipment or the Customer's Installation, if applicable;

(b) defects in the Connection Equipment and the Distribution System which are a result of any Customer Works;

(c) loss of profit, business, contract, revenue, opportunity, goodwill, use of software or data, anticipated savings or for any administrative and overhead costs;

(d) indirect or consequential loss; and

(e) loss arising from any claim made against the Customer by any other person, unless such loss results directly from WPD's negligence or breach of contract in which event WPD's liability shall be limited to £5,000,000 per event or series of connected events.

10.4 Nothing in this clause 10 shall exclude or restrict or otherwise prejudice or affect the rights, powers, duties and obligations of either party which are conferred or created by the Act, WPD's distribution licence or the Electricity Safety, Quality and Continuity Regulations 2002, as amended.

11. Force Majeure

11.1 Neither party shall be deemed to be in breach of this Agreement, or otherwise be liable to the other, by reason of any delay or non-performance of any of its obligations (other than any payment obligations) under this Agreement to the extent that such delay or non-performance is due to an Event of Force Majeure. Such obligations shall be suspended while the Event of Force Majeure continues.

11.2 The party affected by an Event of Force Majeure shall immediately notify the other party in writing of the nature and extent of the Event of Force Majeure and the affected party shall use all reasonable endeavours to mitigate its effects.

11.3 If the Event of Force Majeure continues for more than 2 calendar months, the unaffected party shall be at liberty to terminate this Agreement with immediate effect by giving written notice on the other. The service of such notice shall be without prejudice to any rights or obligations that have accrued prior to termination.

12. Termination

12.1 The Customer may by 30 days' prior notice in writing terminate the Agreement at any time without cause.

12.2 Either party may by notice in writing terminate the Agreement with immediate effect at any time if the other party commits a material breach of the Agreement provided that where such breach is capable of remedy the party in breach has been advised in writing of the breach and has not rectified it within thirty (30) days of receipt of such advice/notice. For the purposes of this sub-clause a breach shall be considered capable of remedy if time is not of the essence in performance of the obligation and if that party can comply with the obligation within the 30 day period.

12.3 WPD may by notice in writing terminate the Agreement with immediate effect on or at any time on the happening of any of the following events:

(a) the passing of a resolution for the Customer's winding-up or the making by a court of competent jurisdiction of an order for the winding-up or the dissolution of the Customer;

(b) the making of an administration order or the appointment of an administrator under the out-of-court procedure under the Enterprise Act 2002 or the appointment of a receiver or an administrative receiver over, or the taking possession or sale by an encumbrance of, any of the Customer's assets;

(c) the Customer making an arrangement or composition with its creditors generally or making an application to a court of competent jurisdiction for protection from its creditors generally;

(d) the Customer ceasing to do business at any time for 30 consecutive days; or

(e) WPD being unable to commence the Connection Works within two (2) months from the date agreed between the parties due to any act, default or omission (whether negligent or otherwise) by the Customer, provided that such date shall not be earlier than 6 months from the date of this Agreement.

12.4 On Energisation this Agreement shall automatically expire save as set out in clause 13.

12.5 The provisions of this clause 12 are without prejudice to any other right or remedy either party may have against the other for breach or non-performance of this Agreement.

13. Consequences of Termination

13.1 All rights and obligations of the parties shall cease to have effect immediately upon expiry or termination of this Agreement except that termination shall not affect:

(a) the accrued rights and obligations of the parties at the date of termination or expiry; and

(b) the provisions contained in clauses 7, 8, 13, 15, 17, 18, and 19 which shall survive the expiry or termination of this Agreement howsoever caused and shall continue in full force and effect.

13.2 If on termination of the Agreement any staged payments made by the Customer exceed the actual costs incurred by WPD in carrying out the Connection Works up to and including the date of termination, WPD shall issue a credit note in respect of such excess amount and reimburse the Customer accordingly, provided that WPD shall have the right to set off from such amount any sums due to WPD by the Customer under this Agreement.

14. Variation

14.1 Each party shall be entitled to propose variations to the terms of this Agreement provided no purported variation to the Agreement shall be effective unless it is in writing and signed on behalf of both parties.

14.2 The Connection Charge shall be adjusted by such an amount as is reasonable to reflect the increased or, as the case may be, decreased cost to WPD of meeting its obligations under this Agreement as a result of the variation.

14.3 If the parties are unable to agree a proposed variation, the parties shall attempt to resolve the matter in accordance with the internal dispute resolution procedure set out in clauses 15.1 and 15.2. If the senior representatives of the parties fail to resolve the matter, neither party shall have any obligation to implement the variation.

15. Dispute Resolution

15.1 Subject to clause 15.4 if a dispute arises out of or in connection with this Agreement, the parties shall:

(a) within 7 days of written notice of the dispute being received by the receiving party in good faith seek to resolve the dispute through negotiations between the parties' senior representatives who have the authority to settle it;

(b) not pursue any other remedies available to them until at least 28 days after the first written notification of the dispute.

15.2 The appointed representatives shall use all reasonable endeavours to resolve the dispute.

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15.3 Nothing in this clause 15 shall prevent any party from having recourse to a court of competent jurisdiction for the sole purpose of seeking a preliminary injunction or such other provisional judicial relief as it considers necessary to avoid irreparable damage.

16. Assignment

16.1 This Agreement shall be binding on and enure for the benefit of the successors in title of the parties but, except as set out in sub-clause 16.2, shall not be assignable by either party without the prior written consent of the other. In addition, a party to this Agreement may not hold the benefit of the Agreement or any rights under it on trust for any third party or parties.

16.2 WPD may assign the benefit of this Agreement to any company within its Group. For the purposes of this Agreement, "Group" means a company's subsidiaries, its holding companies and any subsidiaries of such holding companies, "subsidiary" and "holding company" having the meanings ascribed to those terms in Section 1159 of the Companies Act 2006.

17. General

17.1 This Agreement and any documents referred to in this Agreement set out the entire agreement and understanding between the parties in respect of the subject matter of this Agreement.

17.2 To the extent that any of the provisions in these General Conditions conflict with the provisions in the other documents which constitute this Agreement, the order of precedence shall be as follows:

(a) the Specific Conditions;

(b) the Characteristics and Charge Statement, or Letter of Acceptance (as appropriate) as signed by the Customer;

(c) the Offer Letter; and

(d) these General Conditions.

17.3 To the extent that any provision of this Agreement is found by any court or competent jurisdiction to be invalid, unlawful or unenforceable it shall not affect the enforceability of the remainder of the Agreement.

17.4 No single or partial exercise or failure or delay in exercising any right, power or remedy by either party shall constitute a waiver by that party of, impair or preclude any further exercise of, that or any right, power or remedy arising under this Agreement or otherwise.

17.5 No express term of this Agreement or any term implied under it is enforceable pursuant to the Contracts (Rights of Third parties) Act 1999 by any person who is not a party to it.

17.6 Joint and several liability

(a) where any liability or obligation is undertaken by two or more persons, the liability or obligation of each of them shall be joint and several;

(b) the release or compromise in whole or in part of the liability of or grant of any time or indulgence to any one or more of joint and several obligors shall not affect the liability of the other or others.

18. IP rights and confidentiality

18.1 All rights in the design, specification, plans or drawings contained or accompanying this Alternative Connection Offer belong to and remain with WPD and shall not be used by the Customer or any other person without WPD's written consent.

18.2 All data and information acquired or reviewed by the parties in connection with this Alternative Connection Offer is confidential and shall not be divulged to any third party without the prior written consent of the other party except insofar as may be required by law.

19. Notices

19.1 Any notice to a party under this Agreement shall be in writing signed by or on behalf of the party giving it and shall, unless delivered to a party personally, be left at, or sent by prepaid first class post, prepaid recorded delivery or facsimile to the address of the party as set out in this Agreement or as otherwise notified in writing from time to time.

A notice shall be deemed to have been served:

(a) at the time of delivery if delivered personally;

(b) 48 hours after posting; or

(c) 2 hours after transmission if served by facsimile on a Business Day prior to 3 pm or in any other case at 10 am on the Business Day after the date of despatch.

19.2 A party shall not attempt to prevent or delay the service on it of a notice connected with this Agreement.

20. Governing law and jurisdiction

The Agreement shall be governed by and construed in accordance with the laws of England and Wales and subject to clause 15 the parties irrevocably submit for all purposes to the exclusive jurisdiction of the courts of England and Wales.

Letter of Acceptance

To:

Western Power Distribution (East) plc
Primary System Design
Herald Way
Pegasus Business Park
East Midlands Airport
Castle Donington
DE74 2TU

FAO Planner

From:

Mr Smith
Building
Street
Town
Postcode

Tel. No. 01332 XXXXXX

Our Ref: XXXXXXX & XXXXXXX Your Ref:

Alternative Connection Offer for an electricity connection at Location.

We accept the terms of your Connection Offer dated 01/01/2015 for:

Option 1 – WPD to undertake both Non-contestable and Contestable works ☐

Option 2 – WPD to undertake the Non-contestable work only ☐

[Please tick as appropriate]

We confirm that we do require you to provide a Maximum Import Capacity of 150kVA and a Maximum Export Capacity of 10,000kVA.

We accept responsibility for all reasonable costs that WPD may incur as a result of our termination of this Agreement or any variation, cancellation of the Connection Works and agree that outstanding costs will then be invoiced by WPD for immediate payment.

Signed:

…………………………………………… for and on behalf of the Customer

Full Name……………………………………………………………………………………

Designation…………………………………………………………………………………

Dated ……………………………………….
(THIS MUST BE SIGNED BY AN AUTHORISED PERSON)

March 2014

Indemnity

Mr Smith, Company No, XXXXXX (the "**Customer**") has requested **Western Power Distribution East Midlands plc** Company No. 02366923 whose registered office is at Avonbank, Feeder Road, Bristol BS2 0TB ("**WPD**") to carry out the following works on its behalf:

Provide an electricity connection at the premises known as Location in accordance with WPD's Alternative Connection Offer dated 01/01/2015, Reference: XXXXXXX & XXXXXXX (the "**Connection Works**").

Indemnity

In consideration of WPD carrying out any action in preparation for its anticipated performance of the Connection Works, such action to include without limitation, placing an order with a manufacturer or supplier for the manufacture, supply, delivery and if appropriate installation of any plant, electrical equipment or other equipment of whatever nature which is not held in stock by WPD and which is required by WPD for the purpose of performing the Connection Works, the Customer HEREBY AGREES TO INDEMNIFY WPD and keep WPD fully indemnified from and against all expenses, losses, costs, claims and damages incurred or suffered by WPD as a result of WPD taking any such action as aforesaid to the extent not covered by a Connection Charge paid by the Customer and received by WPD, notwithstanding a decision by the Customer not to instruct WPD to carry out the Connection Works. The payment of any sum of money due under this indemnity shall be made within 14 days of issue of a written demand by WPD.

Signed:

……………………………………………
for and on behalf of the Customer

Full Name …………………………………………………………………………………………

Designation ………………………………………………………………………………..

Dated ………………………………………

March 2014

Project Definition Phase Construction (Design and Management) Regulations 2007 Health, Safety and Environment Information		
Site Address		
Potential Hazard/Risk	What action is being taken to address this potential risk? By whom and when?	Are further details attached *Please delete as appropriate
Asbestos		yes/no*
Air Pollution		yes/no*
PCBs		yes/no*
Oil Spillage		yes/no*
Noise		yes/no*
Working at Height		yes/no*
Confined Spaces		yes/no*
Demolition		yes/no*
Hot Work		yes/no*
Uneven Ground		yes/no*
Deep Excavation		yes/no*
Limited Access/Egress		yes/no*
Street Works		yes/no*
Heavy Plant		yes/no*
Vehicle Access		yes/no*
Parking/Traffic		yes/no*
Site Security		yes/no*
Earthing System		yes/no*
Other Utilities		yes/no*

March 2014

Overhead Lines		yes/no*
U/G Cables		yes/no*
Rail Track		yes/no*
Space Restrictions		yes/no*
From Adjacent Sites		yes/no*
To Adjacent Site		yes/no*
Environment: Flammable/Explosive Corrosive/Dusty/Wet* Invasive Plants Protected Species e.g. Bats		yes/no*
Radon		yes/no*
Mining		yes/no*
Mine Workings		yes/no*
Ground Contamination		yes/no*
Other hazard(s)		yes/no*
		yes/no*
		yes/no*

Is the development subject to notification under the CDM Regulations 2007? **If yes, please provide a copy of the F10 and where available the Pre-Construction Health and Safety Information.** **N.B. WPD will take on duties of the "Client", and where applicable the "CDM Coordinator" and "Principal Contractor" for the installation of our equipment**	yes/no*

Signature: .... Print Name:... Date: ....

Designation: (if signing for a Company):...Company: ....

March 2014

Appendix 3 Alternative Connection Agreement

ALTERNATIVE CONNECTION AGREEMENT

THIS AGREEMENT is made the	123	day of	Month 2014
Between:	**Western Power Distribution (East Midlands) plc** Registered in England and Wales No. 2366923 Whose **REGISTERED OFFICE** is at Avonbank Feeder Road Bristol BS2 0TB (The "Company")		
And	Any Company Ltd Registered in England & Wales No 123456 Any Street Any Town Any County Any Postcode (The "Customer")		
Concerning the Customer's Premises known as	Any Company Ltd Registered in England & Wales No 123456 Any Street Any Town Any County Any Postcode		

Address for Notices	Any Company Ltd Registered in England & Wales No 123456 Any Street Any Town Any County Any Postcode	**Western Power Distribution (East Midlands) plc** Avonbank Feeder Road Bristol BS2 0TB

The Company and the Customer shall together be referred to as the "Parties" and each a "Party".

This agreement (excluding the schedules to this agreement) shall be referred to as the "Agreement", the schedules to the Agreement shall be referred to as the "Schedules", and Schedule 3 of the national terms of connection shall be referred to as the "National Terms of Connection". The Agreement, the Schedules, and the National Terms of Connection shall together be referred to as the "Connection Agreement".

The National Terms of Connection are available to view on the website: www.connectionterms.co.uk. Alternatively the Customer may request a copy of the National Terms of Connection from the Company by written request to the address for notices given above. The Customer confirms that they have read, fully understand and accept the terms of the National Terms of Connection.

Subject to the express provisions of this Agreement:

(a) the National Terms of Connection will apply as if set out in this Agreement;

(b) references in the National Terms of Connection to "this agreement" or to "this Agreement" shall be interpreted as if references to this Connection Agreement; and

(c) expressions used in this Agreement and the Schedules shall have the same meanings as if given to them in the National Terms of Connection.

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Details of the Premises, the Connection Points, the technical characteristics of the Connection Points and other matters are set out in the Schedules.

The Company agrees to Connect the Customer's Installation to the Company's Distribution System on the terms and conditions of this Connection Agreement and in consideration of the Company's agreement to do so the Customer agrees to be bound contractually by the terms and conditions of this Connection Agreement.

NOW IT IS HERBY AGREED as follows:

1. DEFINITION, INTERPRETATION AND CONSTRUCTION

1.1. In the event of any conflict between the terms of this Agreement, the Schedules or the National Terms of Connection, the documents shall have the following order of priority (in descending order):
(a) the terms of this Agreement;
(b) the Schedules; and
(c) the National Terms of Connection.

1.2. This Connection Agreement constitutes the entire agreement between the Parties in relation to the Premises. Each Party acknowledges that it has not entered into this Connection Agreement on the basis of, and has not relied on, any statement, representation, warranty, promise or term made or agreed to by any Party, (whether a Party to this agreement or not) except those expressly written out in full in this Connection Agreement. Neither Party shall have any liability in respect of any other representation, warranty or promise made prior to the date of this Connection Agreement unless it was made fraudulently.

1.3. This Agreement may be executed in any number of counterparts and by the Parties on separate counterparts, but shall not be effective until each Party has executed at least one counterpart. Each counterpart, when executed, shall be an original of this Agreement and all counterparts shall together constitute one instrument.

1.4. Subject to clause 1.5, any variation to this Agreement shall be in writing and signed by authorised signatories for the Parties.

1.5. Each Party shall effect any amendments required as a result of a change in the Electricity Distribution Licence or any Applicable Legislation and the Customer hereby authorises and instructs the Company to make any such amendment on its behalf and undertakes not to withdraw, qualify or revoke such authority or instruction at any time.

1.6. The following terms and expressions shall have the meaning set out below:

Adjusted Export Capacity	Has the meaning ascribed to it in Clause 3.2 of this Agreement
Adjusted Import Capacity	Has the meaning ascribed to it in Clause 3.2 of this Agreement
ANM Scheme	Means the overall active network management scheme including but without limitation the Company's Control Equipment.
Annual Alternative Connection Charge	Means the charge payable annually by the Customer (in accordance with clause 6.4) for the amount specified in clause 3.8(c).

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Applicable Legislation	Means all laws, statutes, statutory instruments, acts, regulations, codes, judgements, orders, directives or determinations which affect the Electricity Distribution Licence or the performance of any of the Company's obligations under the Agreement.
Company's Control Equipment	Means the equipment and technical specification set out in Schedule 5
Curtail	Means: (a) to limit from time to time the maximum amount of electricity that may flow from the Distribution System through the Connection Point; or (b) to limit from time to time the maximum amount of electricity that may flow to the Distribution System through the Connection Point; or (c) in respect of the flow of electricity from the Company's Distribution System to the Customer's Installation to require this to be at a particular Power Factor or to be within a particular range of Power Factors; or (d) in respect of the flow of electricity from the Customer's Installation to the Company's Distribution System to require this to be at a particular Power Factor or to be within a particular range of Power Factors; for the purpose of active network management, 'Curtailed' and 'Curtailment' shall be construed accordingly.
Instruction	Means an instruction given by the Company to the Customer via the Company Control Equipment or verbally or in written form in accordance with the technical specifications set out in Schedule 5 in order to undertake curtailment.
Protected Export Capacity	Means in respect of a Connection Point (or Connection Points collectively) an amount of electricity (expressed in kVA) which shall not exceed the Maximum Export Capacity that the Customer is entitled to pass into the Distribution System through the Connection Point (or the Connection Points Collectively) subject to the National Terms of Connection, which the Company shall not intentionally interrupt for active network management purposes. The value of the Protected Export Capacity is described in Schedule 1. For the avoidance of doubt, the use of the term 'Protected' in this Agreement does not mean that provision of the capacity is resilient to a loss of one or more Connection Points.
Protected Import Capacity	Means in respect of a Connection Point (or Connection Points collectively) an amount of electricity (expressed in kVA) which shall not exceed the Maximum Import Capacity that the Customer is entitled to take from the Distribution System through the Connection Point (or the Connection Points Collectively) subject to the National Terms of Connection, which the Company shall not intentionally interrupt for active network management purposes. The value of the Protected Import Capacity is described in Schedule 1. For the avoidance of doubt, the use of the term 'Protected' in this Agreement does not mean that provision of the capacity is resilient to a loss of one or more Connection Points.

2. COMPLIANCE WITH SITE SPECIFIC CONDITIONS AND OPERATIONAL ARRANGEMENTS

2.1. The site specific conditions and operational arrangements applicable to the Connection Points, the Customer's Installation and the details of Curtailment are specified in Schedule 5.

3. MAXIMUM CAPACITY, POWER FACTOR AND DEFINED INTERUPTIBILITY

3.1. In addition to the Company's rights of curtailment under the National Terms of Connection, set out above, and notwithstanding clause 12 of the National Terms of Connection – 'Limitation of Capacity', the Company shall be entitled (at no cost to the Company) to instruct the Curtailment of the flow of electricity through the Connection Point in accordance with clause 3.2 in the event that:

(a) the Protected Import Capacity is less than the Maximum Import Capacity; and/or

(b) the Protected Export Capacity is less than the Maximum Export Capacity.

3.2. Subject to clause 3.1, the Company shall be entitled to issue an Instruction to:

(a) specify a level of import capacity expressed in kVA ('Adjusted Import Capacity') may not be greater than the Maximum Import Capacity provided that the Adjusted Import Capacity shall not be less than the level of the Protected Import Capacity;

(b) specify a level of export capacity expressed in kVA ('Adjusted Export Capacity') may not be greater than the Maximum Export Capacity provided that the Adjusted Export Capacity shall not be less than the level of the Protected Export Capacity;

(c) specify a particular Power Factor, or a particular range of Power Factors, for any flow of electricity from the Company's Distribution System to the Customer's Installation; and

(d) specify a particular Power Factor, or a particular range of Power Factors, for any flow of electricity from the Customer's Installation to the Company's Distribution System.

3.3. Upon receipt from the Company of an Instruction in accordance with clause 3.2 above and for so long as this Instruction remains in force, the Customer shall not whether by act or omission:

(a) cause or permit the flow of electricity from the Company's Distribution System to the Customer's Installation to exceed the Adjusted Import Capacity;

(b) cause or permit the flow of electricity from the Customer's Installation to the Company's Distribution System to exceed the Adjusted Export Capacity;

(c) cause or permit the flow of electricity from the Company's Distribution System to the Customer's Installation at a Power Factor other than that instructed; or

(d) cause or permit the flow of electricity from the Customer's Installation to the Company's Distribution System at a Power Factor other than that instructed.

3.4. Upon receipt from the Company's Control Equipment of an Instruction to limit the maximum amount of electricity that may flow from or to the Distribution System through the Connection Point in accordance with clauses 3.2 and 3.3 above, the Customer shall respond to the Instruction within x Seconds unless otherwise agreed with the Company in writing.

3.5. If the Customer fails to comply with clause 3.3 and 3.4 above, the Company shall be entitled to De-energise the Connection Point and the Customer's Installation as is appropriate.

3.6. Without prejudice to the Company's rights under the National Terms of Connection to De-energise the Connection Point, the magnitude and/or duration of Curtailment in accordance with Clauses 3.2 and 3.3 of this Agreement shall be no longer than, in the reasonable opinion of the Company, is

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appropriate in the circumstances and the Company shall cease Curtailment as soon as reasonably practicable after the circumstances leading to the Curtailment have ceased to exist.

3.7. Subject to the terms of this Connection Agreement the Company shall use reasonable endeavours to ensure that the Maximum Import Capacity and the Maximum Export Capacity is available at the Connection Point during the period of this Connection Agreement subject to the Curtailment in accordance with Clauses 3.2 and 3.3.

3.8. The Customer's entitlement to a Maximum Import Capacity or Maximum Export Capacity is conditional upon:

(a) the installation by the Company (at the Customer's sole cost) of the Company's Control Equipment and the connection of the Customer's equipment to the Company's Control Equipment;

(b) the Customer maintaining the Customer's Installation and its equipment in accordance with Clause 6 of this Agreement at the Customer's sole cost; and

(c) paying the Annual Alternative Connection Charge of £xx,xxx (excluding value added tax) in accordance with clause 6.4,

to enable monitoring and carrying out of Curtailment as set out in Schedule 5.

3.9 Curtailment of the connection will occur at a varying level based on a real-time assessment on the Distribution System, with the Adjusted Import/Export Capacity being maintained between the Maximum Import/Export Capacity and the Protected Import/Export Capacity. The level of curtailment will depend on a number of factors including, but not limited to:

- NGET limitations or outages (planned or unplanned)
- Any outages (planned or unplanned) of the circuits, transformers or switchgear utilised in the normal feeding arrangement, from the point of connection, through the different voltage levels of the Distribution System, up to the grid supply point
- A reduction in the normal ability for the Distribution System to absorb generation export
- A reduction in the normal ability for the Distribution System to supply load import
- An outage (planned or unplanned) of the Active Network Management system or associated communication systems.

The Company has used historical load data, outage data, fault data and profiles for new and existing generators to provide an estimated level of constraints for this connection under three different scenarios. For the avoidance of doubt, the Company does not guarantee any availability or any level of duration or frequency of curtailment or constraints. The Company expects the Customer to have carried out their own analysis prior to acceptance.

Estimated worst case with all generation at maximum output and a reduction in current demand by 25%	Estimated [ ]% Energy constrained from [ ] MWh output over 18 months (Jan 12-June 13)
Estimated current scenario with no smart grid technology	Estimated [ ]% Energy constrained from [ ] MWh output over 18 months (Jan 12-June 13)
Estimated current scenario with smart grid technology	Estimated [ ]% Energy constrained from [ ] MWh output over 18 months (Jan 12-June 13)

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4. LIABILITY FOR CURTAILMENT

4.1. Subject to Clause 15.3 of the National Terms of Connection the Company shall under no circumstances be liable to the Customer or any person for any physical damage, costs, losses, expenses, claims or compensation arising from or in connection with any Curtailment of the Generating Equipment by the Company.

5. ADDITIONAL TERMINATION RIGHTS

5.1. In addition to the termination rights set out in Clause 19.3 of the National Terms of Connection, the Parties agree that the Company may terminate the Connection Agreement by giving notice of such termination to the Customer in the event that the Customer commits a material breach of any of its obligations contained in Clause 3 of this Agreement.

6. CUSTOMER'S OBLIGATIONS

6.1. The Customer shall maintain the connection of the Customer's Installation to the Company's Control Equipment and such parts of the ANM Scheme that the Customer is responsible for, as identified in Schedule 4 so that it is fit for the purpose for which it is used, and so that neither it nor its operation or use shall be liable to cause damage to, or interference with, the Distribution System or the National Electricity Transmission System (or their operation or use or the flow of electricity through them) nor affect the sustained operation of the ANM Scheme.

6.2. The Customer shall not change any parts of the ANM Scheme that are the Customer's responsibility without obtaining the prior written consent of the Company.

6.3. The Customer shall notify the Company in writing at least 28 days prior to undertaking any maintenance of those parts of the ANM Scheme that the Customer is responsible for maintaining.

6.4 The Customer shall pay to the Company the Annual Alternative Connection Charge on Energisation and on each subsequent anniversary thereafter in advance in respect of each year of this Agreement. The Company shall issue an invoice for the Annual Alternative Connection Charge each year when the payment is due. Payment must be made within 28 days of the date of the invoice.

6.5 The Annual Alternative Connection is non-refundable in all circumstances including, but not limited to, termination of this Agreement by either Party for any reason.

7. SUBSEQUENT OWNERS

7.1. The Customer covenants that it shall not dispose of any interest in the Premises, the Customer's Installation or the Customer's Generating Equipment unless the Customer has obtained from the proposed transferee of such interest a deed of covenant in a form acceptable to the Company in its sole discretion binding the proposed transferee to this Connection Agreement and provided such deed to the Company. This clause shall not apply to the extent that the proposed transferee does not require the Connection Point to remain Energised.

Signed for : Any Customer LTD	Signed for Western Power Distribution (East Midlands) Plc
Signature	Signature..
Print Name..	Print Name...
Designation..	Designation Contracts and Agreement Manager

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SCHEDULE 1 - SPECIFIC TERMS FOR CONNECTION

Characteristics of the supply of electricity: [example data]

Maximum Import Capacity:	XXXX kVA
Maximum Export Capacity:	XXXX kVA
Protected Import Capacity:	XXXX kVA
Protected Export Capacity:	XXXX kVA
Import Power Factor (normal operation):	XX
Export Power Factor (normal operation):	XX
Voltage:	XXXX Volts
Phase:	Three phase
Frequency:	50 Hertz
Current:	Alternating
Last In First Off (LIFO) Queue Number:	x
Last In First Off (LIFO) Generation Breakdown:	

Generation Type	Generation Capacity (MW)	Number of Connections
Wind	[ ]	[ ]
Solar	[ ]	[ ]
Synchronous/Other	[ ]	[ ]

General

The Customer will pay to the Company the Annual Alternative Connection Charge in accordance with Clauses 3.8 and 6.4 of this Agreement.

The Maximum Import Capacity stated in this Schedule 1 has been requested by the Customer and agreed by the Company.

The Maximum Import Capacity will be fixed from the date that this Connection Agreement takes effect unless increased by agreement between the Customer and the Company.

The Maximum Export Capacity stated in this Schedule 1 has been requested by the Customer and agreed by the Company.

The Maximum Export Capacity will be fixed from the date that this Connection Agreement takes effect unless increased by agreement between the Customer and the Company.

The Maximum Import Capacity, Maximum Export Capacity, Import Power Factor and Export Power Factor may be subject to Curtailment by the Company, as set out in Clause 3 of this Agreement.

Where more than one connection within a given section of the Distribution System needs to be curtailed then the connections shall be curtailed in order, with the last comer being curtailed first and the first comer being curtailed last. When the Distribution System limitation is lifted then the connections are restored to normal in the opposite order, i.e. the first comer is restored first and the last comer is restored last. This principle is known as 'Last In, First Off' (**"LIFO"**). Where a group of connections are handled in this way they deemed to be in the same **"LIFO Queue"**.

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The LIFO Queue Number corresponds to the position of the Customer's Installation with respect to other alternative connections in the same LIFO Queue. Alternative connections are constrained off in the reverse order of the LIFO Queue so that connections with a higher LIFO Queue Number will not influence the constraints of the Customer's Installation.

SCHEDULE 2 - CONNECTION POINTS & ASSET USE

Connection Point:

[For example:]

The outgoing terminals of the Company's 33kV metering circuit breaker.

Connection Extension Assets – Relevant Connection Equipment:

[For example:]
33kV switchgear
1 x 33kV cable
Control, protection and metering equipment at Customer's substation
Sole use ANM Assets

Shared Use Reinforcement Assets – Relevant Connection Equipment:

[For example:]
33kV overhead line (3km reinforced)
Shared ANM Assets

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SCHEDULE 3 - GENERATING EQUIPMENT

1. DEFINITIONS

In this Schedule 3, except where the context requires otherwise, the following terms shall have the meanings set opposite them. Other terms which relate to both this Schedule and the National Terms for Connection are defined in the National Terms for Connection.

"**Authorised Person**" a person who has received an Authorisation.

"**Earthing System**" the arrangement of Earthing Electrodes and conductors connecting an electrical network to Earth.

"**Generating Plant**" an installation comprising of one or more Generating Units.

"**Generating Unit**" any apparatus which produces electricity.

"**Interface Protection**" Protection equipment installed to meet the requirements of National Engineering Recommendation G59/1 as may be updated or superseded from time to time.

"**High Voltage**" any alternating voltage exceeding 1000 volts.

"**Island Mode**" an operating mode of a Generating Plant, where the connection between the Company's Distribution System and the Generating Plant is disconnected while the Generator operates.

"**NGC**" National Grid Electricity Transmission plc.

"**On-Site Generator**" a third party, who owns and/or operates a Generating Plant on the Customer's premises.

"**Operation**" a scheduled or planned action carried out on an electrical network.

"**Parallel Mode**" an operating mode of a Generating Plant where the connection is maintained between the Company's Distribution System and the Generating Plant while the Generator operates.

"**Protection**" The provisions for detecting abnormal conditions in an electrical network and initiating fault clearance or actuating signals and indications.

2. The Company consents to the following generators being directly connected to the Company's Distribution System:

Type of Generation	Generation Unit Identification Name and/or Nonmenclature	Generation Unit Manufacturer, Make & Type	Installed Size of Generation (kW/per Unit)	No. of Units	No. of Phases	Commissioning Date	Long / Short Term Parallel or Stand-by Generation
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

3. General Conditions for Generation

3.1 Where the Company gives its written consent for a third party (the "On-Site Generator") to connect a Generating Plant to the Customer's Premises the Customer shall:

(a) procure that the On-Site Generator is subject to and complies in all respects with the obligations set out in this Connection Agreement as though it were party to it;

(b) procure that the Company shall have such rights and powers over the On-Site Generator's Plant, Apparatus and Premises as it would have if the On-Site Generator was a party to this Connection Agreement;

(c) ensure that the On-Site Generator does not amend, alter, renew or replace the Generating Plant, Apparatus or associated Protection without the Company's prior written consent; and

(d) Notwithstanding clause 15.4 of the National Terms of Connection, indemnify and keep indemnified the Company against all costs, losses, claims, expenses and/or liabilities that the Company may suffer or incur arising out of or in relation to the On-Site Generator provided that the Customer's liability under this indemnity shall be limited to £1,000,000 per incident or series of related incidents.

3.2 The appointment of the On-Generator shall not relieve the Customer of any obligations under this Connection Agreement, and the acts of omissions of the On-Site Generator appointed in accordance with clause 3.1 shall, for the purposes of this Connection Agreement, be deemed to be acts or omissions of the Customer.

3.3 In addition to the termination rights set out in Clause 19.3 of the National Terms of Connection, the Parties agree that the Company may terminate the Connection Agreement by giving notice of such termination to the Customer in the event that:

(a) the Customer breaches its obligations in clause 3.1 (a) to (c) (inclusive) above; or

(b) any of the events set out in Clause 19.3.3 of the National Terms of Connection occurs in respect of the On-Site Generator.

4. Site Specific Generation Conditions

4.1 The specification of the Customer's Generating Plant is in accordance with Table 1.

4.2 Under the terms of this Connection Agreement the Customer's Generating Plant may operate in Parallel Mode.

4.3 The means of connecting and disconnecting the Customer's Generating Plant is shown on drawing [XXXX].

4.4 The design and installation of the Earthing System for the Customer's Premises is the Customer's responsibility. The Customer may connect the Customer's High Voltage Apparatus to the Company's High Voltage Earthing System. It is the Customer's responsibility to ensure the earthing arrangements are adequate for the Customer's premises and no liability will be accepted by the Company if the Company's Earthing System is used.

4.5 The design and installation of the Protection for the Customer's Generating Plant is the Customer's responsibility.

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- The Customer warrants to the Company that the Customer has taken all reasonable measures and in any event acted in accordance with Good Industry Practice to design and install Protection systems which adequately protect the Customer's Plant and Apparatus and the Company's Distribution System.
- The Customer's Protection and control systems shall be designed, operated and maintained so as to safely connect, operate and disconnect the Customer's Generating Plant in accordance with National Engineering Recommendation G59/2 (as may be updated or superseded from time to time).
- Protection settings on the Customer's Plant and Apparatus at the Ownership Boundary and on the Interface Protection shall be agreed with the Company. The agreed Protection and settings are specified in Table 2.
- The Customer shall allow the Company all reasonable access to witness the commissioning of the Customer's Interface Protection equipment when it is initially installed and following any future modifications to the arrangement and Operation of the Generating Plant, or Protection equipment.
- The Customer shall re-test the Interface Protection at intervals not exceeding 3 years. The Customer shall, on request by the Company, provide the Company, within ten (10) working days of the request, with records of the Customer's Protection settings, test results, and any other applicable records, accounts, or documentation.

4.6 In the event that an abnormal operating condition arises on the Distribution System or NGC's transmission system that in the Company's reasonable opinion requires the Customer's generation to be constrained off or export capacity to be reduced the Company shall instruct the Customer to immediately De-energise or implement an immediate reduction to the Maximum Export Capacity ("the Revised Maximum Export Capacity") as appropriate.

- The Company shall use reasonable endeavours to give notice of such an instruction in accordance with the provisions for De-energisation set out under the National Terms of Connection.

4.7 In the event of instruction being given to the Customer in accordance with clause 4.6 above, such instruction may be given verbally or in writing but if given verbally the Company shall confirm this instruction in writing within 2 Working Days of the verbal instruction being made. The Customer shall at the Customer's own expense immediately comply with an instruction howsoever received from the Company, to reduce the Maximum Export Capacity ("the Revised Maximum Export Capacity") at the Connection Point.

- The Customer shall not increase the Revised Maximum Export Capacity until normal operating conditions have been resumed and the Company has given notice to the Customer confirming that the reduction to the Maximum Export Capacity ceases to apply.
- Subject to Clause 15.3 of the National Terms of Connection, the Company shall under no circumstances be liable to the Customer for any costs, damages, expenses, losses (including, without limitation, third party losses, loss of profit or economic loss) incurred for the duration that the Connection Point remains De-energised or the Revised Export Capacity remains in place. The Customer shall indemnify and keep indemnified the Company against all actions, claims, costs, charges and expenses that the Company may suffer or incur arising out of or in relation to the Customer's failure to comply with the provisions of clauses 4.6 and 4.7.

4.8 For the avoidance of doubt, in the event of an Instruction being given to the Customer from the Company's Control Equipment (under normal or abnormal operating conditions on the Distribution System or NGC's transmission system) the provisions of sections 4.6 and 4.7 above will not apply.

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TABLE 1: GENERATOR DETAILS

Maximum Fault Contribution From All Generating Units (kA):

Peak asymmetrical short circuit current at 10ms (ip) for a 3phase short circuit fault at the Connection Point	RMS value of the initial symmetrical short circuit current (Ik) for a 3phase short circuit fault at the Connection Point	RMS value of the symmetrical short circuit current at 100ms (Ik(100)) for a 3phase short circuit fault at the Connection Point
xxx	xxx	xxx

TABLE 2 : INTERFACE PROTECTION

Generator connected at HV [Example data]

Protection Function	CT VT Ratio	Protection Setting	Circuit Breaker Tripped
Over Current Protection	N/A	Ph Flt IDMT OC 0.5A TM=0.16 Std Inv Ph Flt HSOC 1.125A Time=0.05s Def Time Ph Flt DOC 0.275A TSM=0.1 Std Inv Ang=+30deg	Company's 33kV Incoming CB
Earth Fault Protection	N/A	Earth Fault IDMT OC I=0.1A Time multiplier=0.16 Standard Inverse Characteristic	Company's 33kV Incoming CB
Under Voltage Stage 1	N/A	Vn - 13% 2.5s Customer's	Customer's 33kV CB
Under Voltage Stage 2	N/A		Customer's 33kV CB
Over Voltage Stage 1	N/A		Customer's 33kV CB
Over Voltage Stage 2	N/A		Customer's 33kV CB
Under Frequency Stage 1	N/A		Customer's 33kV CB
Under Frequency Stage 2	N/A		Customer's 33kV CB
Over Frequency Stage 1	N/A		Customer's 33kV CB
Over Frequency Stage 2	N/A		Customer's 33kV CB
<Neutral Voltage Displacement>			Company's 33kV Incoming CB
<Rate of Change of Frequency>	N/A		Customer's 33kV CB
<Vector Shift>	N/A		Customer's 33kV CB

Vn = nominal voltage

SCHEDULE 4 – SITE RESPONSIBILITY SCHEDULES

1. DEFINITIONS

In this Schedule 4, except where the context requires otherwise, the following terms shall have the meanings set opposite them. Other terms which relate to both this Schedule and the National Terms of Connection are defined in the National Terms of Connection.
"Authorisation" the formal sanction given in writing to undertake specified tasks that has a specific meaning in Safety Management Systems.
"Authorised Person" a person who has received an Authorisation.
"Control Person" a person who is responsible for controlling and coordinating Operations on an electrical network.
"Equipment" Plant and/or Apparatus.
"Operations" a scheduled or planned action carried out on an electrical network.
"Protection" the provisions for detecting abnormal conditions in an electrical network and initiating fault clearance or actuating signals and indications.
"Safety Management System" the procedure adopted by the owner of an electrical network to ensure safe Operation of their electrical network and the safety of personnel required to work on that electrical network.
"Switching Schedule" a schedule which defines the agreed sequence of Operations. Provision is made on the Switching Schedule to allow the name of the operator and the time of Operation to be filled in as they are completed.
"System Control" the administrative and other arrangements established to maintain as far as possible the proper safety and security of the electrical network.
"Company's Distribution Safety Rules" the Company's rules and procedures that ensure the safe Operation of the Company's Distribution System.

2. SYSTEM RESPONSIBILITIES

2.1 The person responsible for coordination of operational safety on the Company's behalf is either:-
(a) a central Control Person, or

(b) a field Control Person who has been delegated control of part of the Company's Distribution System by the Company's central Control Person.

The name of the Company's Control Person at any particular time can be obtained from the Operations Support Engineer (South West or South Wales call 02920 332887, or for the Midlands area please call 01332 827093) or other revised telephone number advised by the Company in writing.
Alternatively the Customer can write to:

South West / South Wales	Midlands
The Operations Support Engineer	The Operations Support Engineer
Western Power Distribution	Western Power Distribution
Control Centre	Control Centre
Mardy Industrial Estate	Pegasus Business Park
Lamby Way	Herald Way
Rumney	Castle Donnington
Cardiff	DE74 2TU
CF3 2EQ	

2.2 The Customer shall at all times have nominated a person or persons to be responsible for the co-ordination of safety.

2.3 The person responsible for the coordination of safety on the Customer's behalf ("the Customer's Safety Coordinator") is:-

[insert details]

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2.4 Operational liaison shall be between the Company's Control Person and the Customer's Safety Coordinator.

3. OWNERSHIP BOUNDARY

3.1 The Company's responsibility for the Connection ends at the Connection Point. The Customer is responsible for providing the installation beyond this point in conformity with the appropriate Regulations and the terms of this Connection Agreement.

3.2 Where the Company agree to provide Protection for the Customer's Installation it shall remain the Customer's responsibility to ensure that the Protection the Company provide is adequate. The Company will provide details of the Protection utilised upon written request.

3.3 Ownership responsibilities are in accordance with Table A.

3.4 Each Party shall allow the other Party's representatives reasonable access to its Equipment for testing of Protection, Metering and Metering Equipment.

4. SAFETY MANAGEMENT SYSTEM

4.1 The Company's Control Person and the Customer's Authorised Person shall agree who is to carry out the Operations and the Safety Management System to be used, which shall as a minimum default to the Company's Distribution Safety Rules and to the Company's standard technique, ST:OS6E/2 (as updated or superseded from time to time) relating to "Safety Co-ordination at the Interface between the Company and Customer's Networks".
4.2 The Company's Control Person and the Customer's Authorised Person shall agree the switching Operations to be undertaken in accordance with the Switching Schedule.
4.3 All Operations shall be carried out under the respective System Control.

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TABLE A - RESPONSIBILITY SCHEDULE

Substation Name XXX

Substation Number XXXX

Equipment Number and/or nonmenclature	Responsible Company			
	Ownership	Control	Operation	Maintenance
Metering Circuit Breaker	COMPANY	COMPANY	COMPANY	COMPANY
Metering Unit	COMPANY	COMPANY	COMPANY	COMPANY
Outgoing Switch	CUSTOMER	CUSTOMER	CUSTOMER	CUSTOMER
Telecontrol Unit	COMPANY	COMPANY	COMPANY	COMPANY
110V Batteries/ Charger	COMPANY	COMPANY	COMPANY	COMPANY
48V Batteries/ Charger	COMPANY	COMPANY	COMPANY	COMPANY
Protection Panel	COMPANY	COMPANY	COMPANY	COMPANY
Signal Exchange Box	COMPANY	COMPANY	COMPANY	COMPANY
Voltage Transformer Cubicle	COMPANY	COMPANY	COMPANY	COMPANY
Security and Fire Alarm	COMPANY	COMPANY	COMPANY	COMPANY
Heating and Lighting	COMPANY	COMPANY	COMPANY	COMPANY
Low Voltage AC Supply	COMPANY	COMPANY	COMPANY	COMPANY
33kV Interconnecting Cable	CUSTOMER	CUSTOMER	CUSTOMER	CUSTOMER
Company Control Equipment	COMPANY	COMPANY	COMPANY	COMPANY

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SCHEDULE 5 - SITE SPECIFIC OPERATING ARRANGEMENTS

The voltage flicker caused by the operation of the Customer's Installation shall be limited to the stage 2 limits of Engineering Recommendation P28 at the point of common coupling.

The generators shall be controlled such that it is possible, if so required, to introduce a minimum period of one minute between the start or restart of each generator.

The Company has consented that the Generator Unit(s) listed under Schedule 3 be directly connected to the Company's Distribution System. It is a requirement that the Maximum Export Capacity given under Schedule 1 shall under no circumstances be exceeded and the Customer agrees to constrain any export energy below this limit by means of an automatic management system.

The Customer's Installation should comply with the requirements of:

> Energy Networks Association Engineering Recommendation G5/4 - "Planning Levels for Harmonic Voltage Distortion and the Connection of Non-linear Equipment to the Transmission Systems and Distribution Networks in the United Kingdom" (as may be updated or superseded from time to time);
>
> Energy Networks Association Engineering Recommendation P28 - "Planning Limits for Voltage Fluctuations caused by Industrial, Commercial and Domestic Equipment in the United Kingdom" (as may be updated or superseded from time to time); and
>
> Energy Networks Association Engineering Recommendation P29 - "Planning Limits for Voltage Unbalance in the United Kingdom" (as may be updated or superseded from time to time).

The Company shall give notice to the Customer whenever it considers it appropriate to do so, requesting the Customer to restrict the generator export or disconnect the generator from the Distribution System when abnormal running arrangements are in force. The Customer shall at its own expense comply with any notice given by the Company.

When exporting energy onto the Company's Distribution System the Customer shall, at all times and at its own expense, take all reasonable precautions to ensure that the Customer's site export operates as near as practicable to unity power factor (unless instructed to the contrary under Clause 3.2). Notwithstanding this requirement the export or import of reactive power to the Distribution System shall be permitted under transient conditions provided that the power factor of the exported is no less than 0.95 leading and unity. Generator plant and equipment must comply with the requirements of the Electricity Supply Industry's Engineering Recommendation G59/2 'Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators' (as may be updated or superseded from time to time).

The 33kV connection is made as a single connection between the Company's 33kV network and the Customer's Installation through one Connection Point. For the avoidance of doubt, no alternative connection at 33kV will be provided and the Company does not guarantee that the customer will be able to export electricity through the Connection Point at all times. The ability to export, is conditional upon the Connection Point being Energised - in accordance with the terms of this Agreement

The Connection Site is to be operated strictly in accordance with the provisions and requirements of the Electricity Supply Industry's Engineering Recommendation G59/2 entitled ""Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators' operators' (as may be updated or superseded from time to time) or other reasonable provisions as may, from time to time, be required by the Company.

The Company accepts the inclusion of its connection point circuit breaker and its associated protection in the Customer's protection scheme for the site. The inclusion of the Company's own equipment and protection into the Customer's protection scheme is the responsibility of the Customer and this facility is provided entirely at the Customer's risk. The Company shall provide the customer with details of the protection settings employed at the connection point circuit breaker. It is the Customer's responsibility to ensure that these settings provide adequate protection of the Customer's plant and apparatus.

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SCHEDULE 6 - ACCOMMODATION

The Customer will provide accommodation to the Company's specification as referred to below, such accommodation to be located on the land shown coloured pink on the attached Drawing Number XXXXXX

As the Customer's Connection is or will be at High Voltage (i.e. exceeding 1,000 volts AC), the Customer shall provide, without cost to the Company:

(a) Accommodation on the Premises (where appropriate, as specified in this Schedule) in accordance with the Company's requirements for the Company's Equipment, and (where appropriate) with separately located accommodation for the Company's Control Equipment, Metering Equipment, cable termination and ancillary equipment; and

(b) where required, a 30mA RCD protected dual switch socket outlet, a luminaire and space heating to a minimum standard so as to give frost protection together with a 230 volt electricity supply; and the Customer will keep in good order repair and condition all parts of the accommodation including the interior surfaces and any boundary fences and/or cladding which enclose the accommodation.

Appendix C – Sample Alternative Connection offer letter

Primary System Design
Herald Way
Pegasus Business Park
East Midlands Airport
Castle Donington
DE74 2TU

Telephone: 01332 XXXXXX

Mr Smith
Building
Street
Town
Postcode

Our ref
00000000

Date
XX/XX/XXXX

Dear Mr Smith

Alternative Connection Offer for an active constrained electricity connection at Location by Western Power Distribution East Midlands plc ("WPD")

Thank you for your application requesting an Alternative Connection Offer to make a new electricity connection/augment the existing electricity connection to the Premises.

In addition to our standard Connection Offer 01/01/2015 made pursuant to and in accordance with the provisions of WPD's Distribution Licence (the " **Standard Connection Offer**"), I am pleased to provide this alternative connection offer to carry out the Connection Works for the Customer (the **"Alternative Connection Offer"**) on the basis of an active constrained electricity connection. This Alternative Connection Offer, which is based on WPD's understanding of the information provided by the Customer, comprises this letter (the **"Alternative Offer Letter"**) and the following documents:

a. Specific Conditions for Connection Works;
b. General Conditions for Connection Works;
c. Plan "Location Geographic Cable Route v1 and EHV POC 01_01_15 v1" dated 01/01/2015 showing WPD's existing Distribution System, Point of Connection location and Premises;
d. a single line diagram "Generator SLD and EHV POC 01_01_15" showing WPD's existing Distribution System and Point of Connection location;
e. a breakdown of the Connection Charge
f. the Letter of Acceptance (a form of which is attached), once signed by the Customer; and
g. a Health and Safety Questionnaire to be completed by the Customer; and
h. Three constraint analysis studies (Study 1, Study 2 and Study 3)

This Alternative Connection Offer is made with the intention of providing a lower cost connection, in exchange for the facility for WPD to constrain the connection when required. Where more than one active constrained connection contributes to the same network constraint, when required WPD will constrain these on the basis of 'last in, first off' (LIFO).

The terms and conditions for WPD carrying out the Connection Works are more particularly described in both the attached Specific Conditions for Connection Works and General Conditions for Connection Works. Please ensure that you read the aforementioned documents carefully.

Provision of the Connection Works

This Connection Offer contains two options for Connection Works, Option 1 and Option 2. These options are mutually exclusive and you may only accept one of them.

Unless otherwise specified within the Connection Offer the terms and conditions specified shall apply equally to both options.

The Connection Charges stated within each option under this Connection Offer are broken down into contestable and non-contestable elements and are based on WPD undertaking the Non-contestable Connection Works and any Contestable Connection Works specified in clauses 3.2 and 3.3 of the Specific Conditions for Connection Works.

The Customer (or the Customer's appointed Connection Provider) will undertake the Contestable Connection Works specified in clause 3.3.5 of the Specific Conditions for Connection Works.

Acceptance of the Standard Connection Offer or the Alternative Connection Offer

The Standard Connection Offer and this Alternative Connection Offer are mutually exclusive and you may only accept one of them. On acceptance of the Standard Connection Offer this Alternative Connection Offer will automatically expire. On acceptance of this Alternative Connection Offer the Standard Connection Offer will automatically expire.

The Duration of the Alternative Connection Offer

This Alternative Connection Offer will (unless WPD agrees otherwise with you in writing) automatically expire on the earlier of:

(a) **ninety days** from the date of this Alternative Offer Letter; or
(b) the acceptance of the Standard Connection Offer.

Curtailment under normal running conditions

A study has been completed to assess the level of curtailment of this connection under normal running conditions. This study is based on recent historic trends and predicted generation output. Further details on the assumptions can be made available on request.

Estimated worst case with all generation at maximum output and a reduction in current demand by 25%	Estimated XX.X% Energy constrained from 219,150MWh output over 30 months (Jan 12-June 14)
Estimated current scenario with historical load and	Estimated XX.X% Energy constrained

idealized generation profiles	from 76,702MWh output over 30 months (Jan 12-June 14)
Estimated current scenario with historical load and idealized generation profiles with the smart grid technologies working on Project XXXXXX.	Estimated XX.X% Energy constrained from 76,702MWh output over 30 months (Jan 12-June 14)

WPD has used historical load data, outage data, fault data and profiles for new and existing generators to provide an estimated level of constraints for this connection under two different scenarios. For the avoidance of doubt, WPD does not guarantee any level of duration or frequency of curtailment or constraints. The Customer is strongly encouraged to conduct their own assessment of the potential curtailments / constraints and risk associated with an alternative connection.

Last In, First Out Position (LIFO)

Where more than one connection within a given section of network needs to be curtailed then the connections shall be curtailed in order, with the last comer being curtailed first and the first comer being curtailed last. When the network limitation is lifted then the connections are restored to normal in the opposite order, i.e. the first comer is restored first and the last comer is restored last. This principle is known as Last In First Out (LIFO). Where a group of connections are handled in this way they are known as a LIFO stack.

The LIFO position number indicates the number of generators connected through alternative connections ahead of you in the LIFO queue.

Your generator will hold the following LIFO position: XX

The following generation is above you in the LIFO queue:

Generation Type	Generation Capacity (MW)	Number of Connections
Wind	X	X
Solar	X	X
Synchronous/Other	X	X

Acceptance

If you would like to accept this Alternative Connection Offer and confirm your acceptance to the terms therein please sign the enclosed Letter of Acceptance (confirming which option you wish to accept), the Letter of Indemnity and completed Health & Safety Questionnaire and return them to the above address. Once we receive the signed Letter of Acceptance the Alternative Connection Offer will be known as the "Agreement" and we will ask you to make an initial payment to cover our immediate costs. For the avoidance of doubt, you will be liable for the costs we have incurred even if you cancel the Connection Works and the Agreement is terminated. All provisions in the Specific Conditions which relate to the option that you have not accepted shall not form part of the Agreement.

As part of your planning process and before commencement of any site works you should contact WPD's Map Response Team to ascertain the location of any existing WPD apparatus on or in close proximity to the site and to take the necessary precautions to avoid possible danger from that apparatus. The WPD Map Response Team can be contacted on 0121 623 9780 or by email on WPDMapResponse@westernpower.co.uk

If you have any queries or are not satisfied with the terms of this Alternative Connection Offer and, after discussion, you and I are unable to reach agreement, I hope you will take the opportunity of talking to my manager: Tony Berndes, Primary System Design Manager (telephone number 0117 933 2101). If, following discussion with the Primary System Design Manager, we still cannot reach an agreement, please contact Alison Sleightholm on 0117 933 2175 or write to her at Avonbank, Feeder Road, Bristol BS2 0TB. She will investigate and try to resolve the matter with you. Our complaints procedure is available on our website www.westernpower.co.uk. If we are unable to resolve your complaint, you will have the right to refer the matter to the Energy Ombudsman for a decision. This is a free and independent dispute resolution service.

If you have any questions or wish to discuss any of the above, please do not hesitate to contact me.

Yours sincerely

Planner
Primary System Design

Western Power Distribution East Midlands plc

Important:

All rights in the design, specification, plans or drawings or any other document contained or accompanying this Alternative Connection Offer belong to and remain with WPD and shall not be used or disclosed by the Customer or any other person without WPD's written consent.

All data and information acquired or reviewed by the parties in connection with this Alternative Connection Offer is confidential and shall not be divulged to any third party without the prior written consent of the other party except insofar as may be required by law.

Specific Conditions for Connection Works

1. **Definitions**

1.1 All words and expressions defined in the Offer Letter and the General Conditions for Connection Works shall, unless the context otherwise provides, have the same meanings in these Special Conditions for Connection Works.

1.2 Unless the context otherwise requires, the following words shall have the following meanings:

"Connection Provider" means a person with appropriate accreditation to undertake all or part of the Contestable Connection Works
"Customer" means Mr Smith (Company No.XXXXXX)
"Point of Connection" means the point on the Distribution System to which the new assets will be connected

2. Basis of the Alternative Connection Offer

2.1 Customer's Installation

2.1.1 WPD understands that the proposed Customer's Installation will comprise the following:-

- 5 x 2MVA (2MW), generation; and
- 5 x 2MVA, 33/0.650kV transformers

2.2 Connection and Supply Specification

2.2.1 The characteristics of the new connections will be:

Nominal Voltage at Connection Point: 33,000 V
No of Phases: 3
Nominal Frequency: 50 Hz
Maximum Export Capacity: 10,000 kVA @ 0.95 Power Factor
Maximum Import Capacity: 150 kVA @ 0.96 Power Factor
Please refer to paragraph 2.5.2. for full details of export.
Acceptable Power Factor Bandwidth for Export Capacity: Unity with transient excursions to 0.95 lagging and leading power factor being accepted (subject to agreement of National Grid Electricity Transmission plc (NGET)).
Acceptable Power Factor Bandwidth for Import Capacity: 0.95 lag to 0.95 lead

2.2.2 Maximum Import Capacity and Maximum Export Capacity means the maximum power in kilovolt amperes (kVA) which has been requested by the Customer and which WPD is prepared to make available. WPD accepts no obligation to provide capacity in excess of this. Further information is provided in WPD's Statement of Methodology and Charges for Connection, which is available on WPD's website: www.westernpower.co.uk

2.3 Connection Point and Point of Connection

2.3.1 The Connection Point will be the 33,000V cable gland on the Customer's side of WPD's 33,000V metering unit. The section of the Customer's out-going cable within the 33,000V metering circuit breaker cable end box will need to be to WPD specification. It will be the Customer's responsibility to provide and maintain the Customer's Installation beyond the Connection Point in conformity with any regulations and orders for the use of electricity on the Premises.

2.3.2 The Point of Connection to WPD's existing Distribution System will be on the 33kV XXXXXXX circuit at pole XXXXXXXXX.

2.4 Security of Supply - Non-Firm Connection Scheme

2.4.1 WPD has based its design and costs on a single circuit connection. As a condition of the Alternative Connection Offer for a single circuit connection, the Customer acknowledges and accepts the increased risk of disconnection for fault or maintenance and that generation and/or demand may be constrained off for repair time or during certain stages of planned maintenance outages. WPD shall not be liable for any loss of output due to Distribution System unavailability, any DG network unavailability payments, or any related losses including but not limited to any financial loss.

2.4.2 At times of abnormal Distribution System configuration generation export will need to be constrained at the instruction of the WPD Control Centre. Where periods of constraint are identified for planned work WPD will so far as is reasonably practicable provide as much notice of the restrictions as we are able. For unplanned events WPD will use reasonable endeavours to request the generation be run down in a controlled manner, but reserve the right, depending upon system conditions prevailing on either WPD's or NGET's network at the time, to undertake the constraint of the generation, without notice. In such unplanned events it is in the Customer's own interest to ensure that WPD has 24 hour contact details and that the Customer is able to respond to requests from WPD to constrain without any delay.

2.5 Identified Generator Export Constraints

Note: This is not an exhaustive list

2.5.1 Generation may be constrained off under abnormal system running conditions. These constraints may include but are not limited to:

- A Substation A 400/132kV super grid transformer outage (planned or unplanned)
- Switchgear outages (planned or unplanned) at Substation A 132kV substation
- A 132kV circuit outage (planed or unplanned) on either the Substation A to Substation B No.1 or No.2 circuits
- Switchgear outages (planned or unplanned) at Substation A 132kV substation
- Switchgear outages (planned or unplanned) at Substation B 132kV substation
- A Substation B grid transformer outage (planned or unplanned)
- 33kV circuit or 33/11kV transformer outages (planned or unplanned) that cause demand transfers to be implemented from the Substation B 33kV group having the effect of reducing the minimum demand on the Substation B 33kV substation.
- 33kV circuit or 33/11kV transformer outages (planned or unplanned) that cause demand transfers to be implemented from 33kV feeders having the effect of reducing the minimum demand on 33kV circuits.
- An outage (planned or unplanned) of the ANM system or associated Customer owned communication systems or Company owned communication systems.

2.5.2 Generators may be constrained off under the active network management scheme when their output exceeds the ability of the Distribution System to absorb the generated energy. This will typically occur when a number of generators' output is high and, at the same time, distribution system demand is low – leading to either voltage, thermal or protection issues on the network.

2.6 Fault Level at the Connection Point

2.6.1 WPD's connection proposals are based on a maximum generator plant capacity of 9.9 MVA and our assumption that the total contribution from the Customer's Premises, as modelled at the 33,000V Connection Point, has been calculated to be:

- **L-L-L-G XX.XkA Make (Asymmetrical Peak @ 10ms - Make); and**
- **L-L-L-G X.XkA Break (RMS Symmetrical @ 100ms - Break);**

2.6.2 Final details of your proposals should include the total contribution to fault level from the Premises at the Connection Point. The proposed connection increases the sub-transient, transient and steady state fault level on the Distribution System. Under normal system configuration, this increased fault level is either within the rating of WPD switchgear or it can be managed within existing Distribution System constraints via network management. Your proposals impact on the fault rating of existing equipment. Our assessment, based on information provided to date, is that no remedial works will be necessary.

2.6.3 Please note that WPD will need to revisit fault level calculations for WPD's equipment and potentially other third party apparatus when full and final details of the Customer's proposals are available. The costs of any resultant remedial works that may come to light as a result of these investigations are to be borne by the Customer.

2.6.4 Transient and steady state stability studies are required to be carried out prior to any construction works or orders being placed. This Alternative Connection Offer is made subject to the results of these studies. The costs of these studies are not included in our Connection Charge and shall be borne by the Customer. Should the results of these stability studies indicate any modification required to our proposals, WPD reserves the right, at its sole option, to terminate the Agreement or modify the Alternative Connection Offer as appropriate. Should the results of the stability studies indicate a requirement for specific protection to be installed as part of the generator/site protection, these modifications and the associated costs shall be borne by the Customer.

2.6.5 The Alternative Connection Offer is subject to final Distribution System studies when full generator plant information is known.

2.7 Cost apportionment for reinforcement works

2.8 The Non-contestable Connections Works charge identified under each option in section 3 below includes an amount for reinforcement of WPD's shared use Distribution System. The cost of these works is apportioned between the Customer and WPD in accordance with our charging methodology contained in our Statement of Methodology and Charges for Connection to our Distribution System which may be found on our website: www.westernpower.co.uk. The Customer's contribution toward the cost is calculated using the following formula to determine the Cost Apportionment Factor (CAF):

$$\text{Security CAF} = \frac{\text{Required Capacity}}{\text{New Network Capacity}} \times 100$$

$$\frac{10}{42} \times 100 = 23.8\%$$

2.9 The above calculated CAF only applies to those reinforcement costs up to the high-cost project threshold of £200/kW, i.e. 200 x 10,000 = £2,000,000. All reinforcement costs in excess of this value are charged to the Customer in full.

3. Outline of the Connection Works

3.1 The Alternative Connection Offer provides the Customer with two mutually exclusive options for Connection Works.

3.2 OPTION 1

The first option is for WPD to undertake both the Non-Contestable and the

Contestable Connection Works.

3.2.1 Non-contestable Connection Works undertaken by WPD

3.2.2 WPD will provide the connection by performing the following Non-contestable Connection Works:

- undertake an overhead line survey to design the tee-off configuration
- impose a new stout pole with pin insulators into the existing 33,000V overhead line complete with a cross-arm and two backstays in tandem
- erect 30m of 33,000V overhead line from the tee-off pole to the section pole
- erect a stout section pole with a lightweight 33,000V ABI
- install telecontrol equipment within the Connection Point substation, for supervisory control and data acquisition for WPD's apparatus at the substation
- install a metering panel in the metering room at the Connection Point substation and make the final connection, onto the metering panel, of the multicore wiring between the proposed 33,000V metered indoor circuit breaker at the Connection Point substation and the metering panel. WPD shall provide the multicore cable required for the wiring between the circuit breaker and the metering panel
- witnessing of commissioning of protection, including (G59) protection
- at Substation B 132kV substation, the installation of the ANM overarching controller and associated small wiring exchange box.
- within the Customer's premises (exact location to be agreed), the installation of an ANM individual controller and associated small wiring exchange boxes.
- installation of ANM.
- install Telecontrol and ANM DC batteries and charger,

3.2.3 Contestable Connection Works undertaken by WPD

3.2.4 WPD will provide the connection by performing the following Contestable Connection Works:

- lay approximately XXXm of 185mm^2 EPR 33,000V underground cable to the Connection Point substation. All excavation, cable installation, backfill and reinstatement of the cable route shall be undertaken by WPD. The proposed cable route is as per Plan "Location Geographic Cable Route v1" and "EHV POC 01_01_15 v1"Dated 01/01/2015.
- install a new 33,000V metering circuit breaker at the Customer's site, in a building provided by the Customer to WPD's specification
- terminate the 33,000V incoming (WPD side) cable onto the metering circuit breaker
- install d.c. batteries and charger for use with WPD's apparatus at the Connection Point substation
- install the multicore wiring between the 33,000V metering circuit breaker at the Connection Point substation and WPD's metering panel (the final connection onto the metering panel shall be performed by WPD), using multicore cable provided by WPD

3.2.5 Connection Charge

3.2.6 The contribution required for providing an electricity connection to the Customer's Premises is:

£XXX,XXX.XX excluding VAT which shall be payable at the appropriate rate (the **"Connection Charge"**).

3.2.7 The Connection Charge is broken into separate elements covering Contestable and Non-contestable Connection Works as follows:

Non-contestable Assessment & Design Fees : **£XX, XXX.XX**

Non-contestable Connection Works: **£XXX, XXX.XX**

Contestable Connection Works: **£XXX,XXX.XX**

Further detail concerning the Connection Charge is provided in the enclosed Customer Breakdown of Charges.

3.2.8 Payment

3.2.9 Payment of the Connection Charge shall be made in staged payments in line with WPD's incidence of expenditure. Details of payment stages are included in the following table.

Stage/Date	Amount due (Excluding VAT)
Initial payment on acceptance of the Connection Offer	£25,000
Prior to order of plant	£XXX,XXX
Prior to WPD Connection Works commencing	£ XXX,XXX
Prior to Energisation	£ XXX,XXX

3.2.10 WPD may invoice the Customer when each payment is due. Payment must be made within 28 days of the date of the invoice. This Agreement Offer will automatically terminate unless otherwise agreed in writing by WPD if the Customer fails to pay the initial payment within 28 days of the date such invoice is issued. WPD shall be under no obligation to start the Connection Works until the initial payment has been received.

3.3 OPTION 2

The second option is for WPD to undertake only the Non-Contestable Connection Works.

3.3.1 Non-contestable Connection Works performed by WPD

3.3.2 WPD will provide the connection by performing the following Non-contestable Connection Works:

- undertake an overhead line survey to design the tee-off configuration
- impose a new stout pole with pin insulators into the existing 33,000V overhead line complete with a cross-arm and two backstays in tandem
- erect 30m of 33,000V overhead line from the tee-off pole to the section pole
- erect a stout section pole with a lightweight 33,000V ABI
- install telecontrol equipment within the Connection Point substation, for supervisory control and data acquisition for WPD's apparatus at the substation
- install a metering panel in the metering room at the Connection Point substation and make the final connection, onto the metering panel, of the multicore wiring between the proposed 33,000V metered indoor circuit breaker at the Connection Point substation and the metering panel. WPD shall provide the multicore cable required for the wiring between the circuit breaker and the metering panel
- witnessing of commissioning of protection, including (G59) protection
- at Substation B 132kV substation, the installation of the ANM overarching controller and associated small wiring exchange box.
- within the Customer's premises (exact location to be agreed), the installation of an ANM individual controller and associated small wiring exchange boxes.
- installation of ANM.
- install Telecontrol and ANM DC batteries and charger,

3.3.3 Contestable Connection Works undertaken by WPD

3.3.4 WPD will provide the connection by performing the following Contestable Connection Works:

None

3.3.5 Contestable Connection Works undertaken by the Customer

3.3.6 The Customer shall, at no cost to WPD, undertake the following:

- design and construct the Contestable Connection Works from the Point of Connection to the Connection Point
- arrange legal documentation (wayleave, easement, lease or transfer as applicable to the site and WPD policy) to be completed in WPD's name prior to adoption of the equipment by WPD.

3.3.7 Connection Charge

3.3.8 The contribution required for providing an electricity connection to the Customer's Premises is:

£XXX,XXX excluding VAT which shall be payable at the appropriate rate (the **"Connection Charge"**).

3.3.9 The Connection Charge is broken into separate elements covering Contestable and Non-contestable Connection Works as follows:

Non-contestable Assessment & Design Fees : **£XX,XXX.XX**

Non-contestable Connection Works: **£XXX,XXX.XX**

Contestable Connection Works: **£0.00**

Further detail concerning the Connection Charge is provided in the enclosed Customer Breakdown of Charges.

3.3.10 Payment

3.3.11 Payment of the Connection Charge shall be made in staged payments in line with WPD's incidence of expenditure. Details of payment stages are included in the following table.

Stage/Date	Amount due (Excluding VAT)
Initial payment on acceptance of the Connection Offer	£25,000
Prior to order of plant	£XX,XXX
Prior to WPD Connection Works commencing	£XX,XXX
Prior to Energisation	£XX,XXX

3.3.12 WPD may invoice the Customer when each payment is due. Payment must be made within 28 days of the date of the invoice. This Agreement will automatically terminate unless otherwise agreed in writing by WPD if the Customer fails to pay the initial payment within 28 days of the date such invoice is issued. WPD shall be under no obligation to start the Connection Works until the initial payment has been received.

3.3.13 Design Approval

3.3.14 The Customer (or their Connection Provider) is required to provide WPD with all information relating to their design in order to confirm suitability for adoption and connection to WPD’s Distribution System. We require a (single) full and comprehensive design submission for all of the plant, equipment and cables/lines offered for adoption by WPD. Part or incomplete designs will not be accepted as the formal design submission. Where WPD does not consider the submission to be full and comprehensive, we will inform the Customer/Connection Provider that the submission has been rejected.

3.3.15 The Customer should refer to and comply with the requirements laid out under WPD'S appropriate design guide for switchgear and associated equipment. A copy of the appropriate guide and other design specification information is available on request or from WPD's website: www.westernpower.techinfo.co.uk

3.3.16 Where reasonably practicable the design submission shall be in electronic format. On receipt of a full design submission, WPD will either provide confirmation of approval or an explanation for rejection within 20 working days of receipt of the design. Where the design submission is rejected WPD may levy additional charges for considering subsequent design submissions.

3.3.17 Inspections

3.3.18 The charge for inspection of the Contestable Connection Works given in the enclosed break-down of Non-contestable costs is estimated according to the number of visits WPD anticipate it will normally make for this type and size of connection. Any additional visits subsequently required may be charged for.

3.3.19 Adoption Agreement

3.3.20 Where the Customer (or the Customer's appointed Connection Provider) wishes to provide some or all the Contestable Connection Work they must firstly satisfy WPD that they have the necessary competence and experience to carry out the work properly and safely by providing evidence of appropriate accreditation under the Lloyds Registration scheme. For further information reference should be made to www.lloydsregister.co.uk.

3.3.21 The Customer (or their appointed Connection Provider) must comply with all appropriate legislation, national standards, technical/engineering recommendations, WPD specifications for design, planning, materials, installation and recording of the Contestable Connection Works. Further information is available on request and via WPD's website: www.westernpower.co.uk.

3.3.22 If the Customer's appointed Connection Provider for the Contestable Connection Works is party to WPD's Network Access and Adoption Agreement, which sets out the terms and conditions upon which WPD shall adopt the assets installed by the Connection Provider, WPD will (upon approval by WPD of the Connection Provider's design) issue a site specific agreement to the Connection Provider for signature. If the Customer's appointed Connection Provider is not party to WPD's Network Access and Adoption Agreement the Customer and their appointed Connection Provider for the Contestable Connection Works must enter into an Adoption Agreement with WPD setting out the terms and conditions upon which WPD shall adopt the assets installed by the Connection Provider. This Connection Offer will form part of the Adoption Agreement.

The following terms and conditions apply to both Options 1 and Options 2

4. Other Works to be undertaken by the Customer

4.1 The Customer shall provide and install, at no cost to WPD, the following:-

- all the required civil works for establishment of the switchgear accommodation located at the Premises. Where required this may include a suitably fenced and level compound. A programme of on-site excavation must be agreed with WPD in advance of works commencing
- terminate the 33,000V outgoing (Customer side) cable onto the metering circuit breaker
- a suitable ducted cable entry, when required, for WPD's cables including any subsequent weatherproofing or other civil works after the cables have been installed
- a suitable weatherproof building to accommodate WPD's metering circuit breaker and auxiliary equipment, including protection and telecontrol equipment, d.c. batteries and charger. This building shall include provision of a separate metering room for WPD's metering equipment
- any works to the Customer's Installation required to establish inter-tripping and interlocking arrangements between the Customer's main circuit breaker and WPD's metered Connection Point circuit breaker
- a 230 volt supply and electrical installation within the substation building for lighting, battery charging, frost protection heating (including the heater) and twin switched socket outlets within the WPD section of the switchroom. The 230 volt supply must always be available whilst the Connection Point is energised. The Customer will bear the cost of the electricity consumed.
- where appropriate, a standard dedicated telephone line, with associated socket installed in the metering room, for use by the Customer's appointed meter operator for modem data collection from on-site metering. The Customer shall confirm the requirements for a standard telephone line with their appointed meter operator and install such a line, where required
- a suitable earthing system for the Customer's Premises
- outputs, to WPD's specification, for inclusion in WPD's telecontrol system by the date of Energisation of the Connection Point
- any necessary masts or supporting structures for communication equipment
- all on site cable excavation and reinstatement. The programme of on-site excavation must be agreed with WPD. Where required, the Customer shall be responsible for the provision of a stone dust bed around cables to WPD's specification.
- Any works at the Customer's installation required to accommodate the Company's ANM individual controller and associated small wiring exchange boxes.
- Small wiring connections between the Company's small wiring exchange box and the Customer's generator control system required for monitoring generator parameters, status indication and to deliver control instructions to the generator

4.2 In order to maintain essential electrical protection systems in the event of a prolonged mains supply interruption, the Customer is required to provide an auxiliary back up supply to the Premises, either via an additional connection at LV or HV to WPD's Distribution System, or via a standby generator arrangement. No provision has been allowed in the Connection Offer for providing an auxiliary supply and the cost of installing any such back up supply is the Customer's responsibility. Any back up arrangement must have an appropriate interlock arrangement to avoid the back up and normal LV supply operating in parallel. Where a standby generator arrangement is installed, an appropriate interlock arrangement must be provided by the Customer to prevent the generator running in parallel with any back up supply. We will be pleased to discuss with you the viability of any permanent auxiliary connection made from our Distribution System and can provide a quotation upon request.

4.3 The Customer shall be responsible for all on-going repairs and maintenance of all accommodation and facilities it has provided.

3.4 The Customer shall also work with WPD and their Active Network Management supplier, at no cost to WPD, to incorporate their generator plant into the Active Network Management Scheme, responding to instructions to curtail within the specified timescales

5. Conditions of the Connection Charge

5.1 The Connection Charge is based upon current market rates and design assumptions. It is subject to the following variables:

5.1.1 Final competitive tenders and increases in labour, contract, or material costs. For schemes with long lead in times this may be some time after acceptance of the Connection Offer.

5.1.2 A full design review of the protection regime following acceptance of the Connection Offer. Allowance has been made for a basic scheme. No allowance has been allowed beyond the WPD's metering circuit breakers into the Customer's Premises.

5.1.3 A full site survey, layout and design at the Customer's Premises substation for the required civil works.

5.1.4 Any works, which are identified as being required following a future Steady State, Transient or Voltage Stability Study.

5.1.5 Any works which are identified as being required following a future power quality study

5.1.6 Any potential adverse effect to WPD's switchgear and Distribution System assets due to an increase in fault level identified when full and final details of the Customer's generators and their contribution to fault level are known.

5.1.7 Proposed cable/overhead line routes indicated being achievable.

5.1.8 Subsequent information provided relating to health, safety and the environment that influence the design of the scheme.

5.1.9 Any change to the characteristics of the connection design and/or data for the proposed connection.

5.1.10 A full ANM study, telecoms design and incorporation to the ANM core systems.

5.2 WPD reserves the right to amend its proposals and Connection Charge to account for any of the variables identified under paragraph 5.1. WPD will notify the Customer in writing as soon as is reasonably practicable informing the Customer of any changes to the proposals and/or Connection Charge.

6. Matters outside the scope of the Connection Charge

6.1 The following matters have not been included in the estimated Connection Charge:

6.1.1 The diversion of any third party apparatus (including without limitation any gas pipes and telephone lines).

6.1.2 Unless otherwise stated, the diversion of WPD’s existing assets (if any) undertaken as a consequence of the Connection Works that are required to provide the connection to the Premises;

6.1.3 Specialist disposal of soil (in accordance with The Landfill (England and Wales) Regulations 2007) and import of suitable backfill;

6.1.4 Excavation and cable laying at abnormal depth, or through rock or other hard substances or in contaminated soil;

6.1.5 Foundations for buildings, towers etc. to be established in ground which is not normal ground bearing type;

6.1.6 Construction of access roads to the substation site;

6.1.7 Costs associated with the extension of existing system inter-tripping;

6.1.8 Unforeseen costs incurred in complying with the Traffic Management Act including permits, alterations to the route, or restrictions on working hours;

6.1.9 Permanent reinstatement of any excavation on the Premises; and

6.1.10 Testing and commissioning that is undertaken in accordance with Engineering Recommendation G59/2 that must be witnessed by WPD. WPD’s charges for witnessing are available on request.

6.2 WPD may increase the Connection Charge to incorporate any costs it has incurred in relation to such matters set out at 6.1.1 to 6.1.10. WPD shall not be liable for any delay in commencement or performance of the Connection Works resulting from such matters and all costs resulting from such delay shall be borne by the Customer.

7. Customer Installation

7.1 The Customer shall be required to confirm the electrical layout, provisions for protection and electrical parameters of the Customer's Installation prior to commencement of the Connection Works by WPD.

7.2 WPD has the right to amend the Agreement in the event that the Customer makes changes to the proposed apparatus at the Customer's Installation that, in the opinion of WPD, cause the Connection Works to be unsuitable.

7.3 The Customer shall also ensure that

any voltage fluctuation or unbalance and harmonics caused by any of its electrical equipment or apparatus on the Development site does not exceed the levels laid down in National Engineering Recommendations P28, P29 and G5/4, as amended, and if appropriate, as modified by us.

- P28 covers ‘Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom’
- P29 covers ‘Planning limits for voltage unbalance in the United Kingdom’
- G5/4 sets down the ‘Limits for harmonics in the United Kingdom supply system’

7.4 Please note that where appropriate, we may define harmonic limitations that take account of the multiple connection applications to the same part of the Distribution System to give equitable treatment for all. This means that the Customer may be allocated a portion of the margin between background level and planning level as set out in G5/4, rather than allowing one connection to take the whole margin.

7.5 Assessment reports in line with and in relation to the above documents will be required. Energisation will not be possible until the reports are reviewed and any required mitigation put in place. In view of this the Customer is advised to commence preparation of the reports early in the design process. The Customer’s choice of equipment may influence the need for mitigation significantly (e.g. harmonic emissions produced by equipment with a similar function can vary substantially with some makes/models being cleaner than others).

8. Programme of Connection Works

8.1 A detailed programme of Connection Works has not yet been finalised. The program will be discussed and agreed following acceptance of the Alternative Connection Offer and depending on the level of Contestable Connection Works undertaken by the Customer. By way of non-binding indication, a scheme of this nature typically has a timescale of approximately 12-18 months from acceptance of the Alternative Connection Offer to energisation. This Alternative Connection Offer is however, made on the understanding that the following milestones are met:

i) Planning consent shall have been granted within 12 months of the date of acceptance of this Alternative Connection Offer;

ii) the Connection Works are commenced within 18 months of the date of acceptance of this Alternative Connection Offer (save for in the event that this milestone is missed as a direct result of an act or omission by WPD); and

iii) the Connection Works are completed within 24 months of the date of acceptance of this Alternative Connection Offer (save for in the event that this milestone is missed as a direct result of an act or omission by WPD).

8.2 Upon request the Customer shall provide evidence to WPD's reasonable satisfaction confirming the progress on each of the above milestones and that it has, or reasonably believes it will meet each one by the dates specified. In the event that the Customer is unable to meet the above milestones WPD shall be entitled, at its sole option, to terminate the Agreement or to propose an amendment to the Alternative Connection Offer and/or Connection Charge under the Agreement. Where the Customer becomes aware that it will fail to meet any of the milestones but can demonstrate to WPD that it is still making progress toward the relevant milestone, WPD may take due account of this fact before considering whether to terminate the Agreement. Should the Customer's programme of works fall outside the above timescale, WPD reserve the right to vary or terminate the Agreement as WPD deem appropriate.

8.3 The date of connection is dependent on Distribution System access, operational constraints, manpower availability and delivery times for cables, switchgear, transformers and other equipment. WPD accept no liability should any of the above mentioned delay the date of connection. It is also conditional upon the Customer fulfilling the Agreement terms and conditions and any additional requirement reasonably required by WPD. However, WPD will use commercially reasonable endeavours to meet the Customer's requested connection date.

8.4 If WPD is unable to complete the Connection Works by the end of the 24 month period due to any reasons beyond WPD's reasonable control, WPD reserves the right, at its sole option, to amend or terminate the Agreement, including amending the Connection Charge.

9. Additional Conditions Precedent to commencement of Connection Works

9.1 In addition to the Conditions set out in this Alternative Connection Offer, the Connection Works are also subject to the following conditions:

9.1.1 WPD obtaining any necessary wayleaves and consents for the Connection Works;

9.1.2 WPD/the Customer obtaining any necessary planning consents from the local authority;

9.1.3 that no action is identified by NGET as a result of any request made by WPD for a Statement of Works;

9.1.4 the Customer, where required, confirming it has fulfilled its obligations in accordance with the Connection and Use of System Code, Grid Code and Distribution Code;

9.1.5 the Customer shall have signed and returned the Letter of Indemnity, printed on its official headed paper together with the Letter of Acceptance*;*

9.1.6 the Customer shall not make or request any modification or deviation to the physical or electrical characteristics documented within the Specific Conditions for Connection Works.

9.1.7 the Customer having completed the enclosed Health and Safety Questionnaire identifying any hazards specific to this site together with the risks that they may pose to people working on the site with the control measures that you may be planning.

9.2 Should any of the above conditions not be met at any time, WPD reserves the right, at its sole option, to terminate the Agreement and issue a new Alternative Connection Offer or to revise the Connection Charge in this Alternative Connection Offer. For the avoidance of doubt this may be after acceptance by you.

10. Statement of Works

10.1 WPD may be required to request a Statement of Works from NGET in order to ascertain the effects of the generator proposals on the transmission system. On receipt of this request, NGET will consider whether or not a modification application is required. NGET fees for a Statement of Works and a modification application are payable in advance.

10.2 The Customer shall be responsible for the initial advance payments and any further additional fees as required. These fees are not included in this Alternative Connection Offer and will be notified to the Customer upon confirmation from NGET at the time of application.

10.3 The Customer shall be responsible for the costs of any works required on the transmission system as a result of the modification application.

11. Notice of Completion

11.1 WPD will, where agreed between WPD and the Customer, allow the connection to be/remain Energised subject to the terms and conditions as set out below and any other conditions set out under this Alternative Connection Offer.

11.1.1 The Customer shall ensure that the Customer's Installation is installed in such a manner that it will comply with Regulations 8(4) and 25 of The Electricity Safety, Quality and Continuity Regulations 2002, as amended immediately prior to Energisation.

11.1.2 The Customer must provide WPD with a completed Notice of Completion of Installation (Notice).

11.1.3 The Customer must allow WPD access to any property covered by the Alternative Connection Offer to ensure that the Customer's Installation complies with Regs 8(4) and 25.

12. Safety

12.1 Any work in the vicinity of WPD equipment must be carried out in a safe manner, including, as a minimum, compliance with the relevant Health and Safety Executive Guidance Notes available from HMSO.

12.2 In particular:

- GS6 - Avoidance of danger from overhead electric lines.
- HS(G)47 - Avoiding danger from underground cables.

13. Construction of substation enclosures

13.1 WPD cannot warrant the suitability of the substation enclosure design for a particular site and whilst the superstructure arrangement is fixed, the suitability of the proposed substructure detail needs to be ascertained through investigation by the Customer, who will be required to propose modifications/ alternative proposals to WPD as necessary. The Customer, in evaluating the suitability of the WPD proposal, should take into account engineering considerations including:

- Bearing capacity at proposed founding depth;
- Risk of differential settlement;
- Potential passage of radon, explosive gases, contaminants and the like
- Effect of groundwater; and
- Other site-specific geotechnical considerations outside the above.

13.2 Where the substation includes a shared building (to be built to WPD specification) for both the Customer's Installation and WPD's protection, telecontrol and battery equipment then the Customer shall either:-

- establish separate sections of the building for WPD and the Customer's equipment, with separate access and locking arrangements for WPD personnel and the Customer's personnel, such that access to any of the WPD equipment is limited to WPD personnel only and access is not possible from any section of the switchroom to which the Customer has access; or
- ensure that where access is required by the Customer, or a representative thereof, to any part of the building that contains any of the WPD equipment,

then the Customer, or Customer's representative, shall be appropriately authorised by WPD for such access.

13.3 For safety & operational reasons, the Customer shall be required to provide 24 hour unhindered vehicular access to the substation for WPD personnel, or authorised agents thereof.

13.4 The Customer shall produce detailed civil drawings & specifications in line with WPD's performance specification for the construction of the substation. Detailed proposals shall be submitted to WPD for approval, at least one calendar month in advance of commencement of construction works on site.

13.5 WPD reserves the right to make site inspections by prior arrangement with the Customer to ensure construction meets the required specification and quality. This does not remove the Customer's obligation to provide a structurally stable, secure, weather-tight and non-hazardous environment to accommodate WPD plant.

13.6 The construction of substations is not usually classed as permitted development and consequently the Customer may need to obtain planning permission for the construction beforehand.

13.7 All work shall be carried out to WPD specification. This specification is prepared on the presumption of a level site and that competent, non-variable bearing strata can be achieved at normal founding depth.

13.8 WPD will provide applicable specification documents upon acceptance of this Alternative Connection Offer.

14. System Protection

14.1 It is a precondition for Energisation, and the Customer's responsibility, to ensure that

14.1.1 the operation of any generators in parallel with WPD's Distribution System conforms to National Engineering Recommendations G59: 'Recommendations for the Connection of Generating Plant to the Distribution Systems of Licensed Distribution Network Operators' (ERG59) as amended from time to time. This will include a requirement for interface protection, including loss of mains protection. The detail of this protection is to be agreed with WPD.

14.1.2 the proposed generation runs in parallel with WPD's Distribution System through the agreed Connection Point. Any alternative or back-up supplies must be subject to WPD's agreement and suitably interlocked.

14.1.3 the multiple generating units start sequentially in order to minimise the rate of voltage rise on the surrounding Distribution System.

14.1.4 that there shall be no electrical interconnection between the proposed new electricity connection and any existing connection at the Premises.

14.2 Prior to any parallel operation of the Customer's proposed new generation with the Distribution System WPD must witness commissioning tests carried out on the Customer's Installation with regard to compliance with ERG59 (as amended). WPD will make an additional charge for providing this service. Parallel operation with the Distribution System can only be permitted following written confirmation that the commissioning has been successfully completed by the Customer and witnessed by WPD. A minimum of two weeks' notice will be required for the witnessing to be arranged.

14.3 The proposed WPD-owned 33,000V metered circuit breaker at the Connection Point substation shall have installed as standard overcurrent and earth fault protection. In addition, depending on Distribution System configuration and operational conditions there may be a requirement for NVD, overvoltage and inter-tripping schemes. WPD shall provide the Customer with details of the protection settings employed at the metering circuit breakers. It is the Customer's responsibility to ensure that these settings provide adequate protection of the Customer's Installation.

14.4 It is the Customer's responsibility to ensure their equipment and installation is adequately protected. The Customer shall provide IDMT overcurrent, IDMT earth fault and instantaneous overcurrent protection on the Customer's 33,000V circuit breaker. The Customer shall be responsible for the provision of suitable protection to ensure tripping of the proposed generation under 'loss of mains conditions'.

14.5 As the Distribution System is predominantly overhead, under fault conditions auto-reclosers will operate. A detailed protection analysis of the effect of the Customer's connection on the Distribution System will need to be performed following acceptance of the Alternative Connection Offer. The cost of any additional works will be borne by the Customer.

14.6 WPD may consider accepting tripping signals from the Customer. Each request will be considered on its merits. WPD will not accept any responsibility or liability for the inclusion of its own equipment and protection into the Customer's protection scheme and this facility is offered on the basis that it is entirely at the Customer's risk. These arrangements will need to be agreed prior to completion. Where WPD agrees to accept tripping signals from the Customer, normally open volt free contacts for this purpose shall be provided by the Customer.

14.7 The Customer shall make provision for the establishment of inter-tripping and interlocking arrangements as follows:-

- a trip operation of WPD's metering circuit breaker(s), shall cause the Customer's generator circuit breaker to be tripped. A single set of normally open 'remote trip' volt free contacts, for incorporation, by the Customer, into the tripping circuit of the Customer's generator circuit breaker, shall be provided from WPD's metering circuit breaker(s).

- operation of the Customer's emergency trip button at the Customer's Connection Point substation shall trip WPD's metering circuit breaker(s). The

Customer shall provide a single set of normally open volt free contacts from the emergency trip button, for this purpose.

- closure of WPD's metering circuit breaker(s), shall be inhibited unless the Customer's generator circuit breaker(s) is open. The Customer shall provide a set of normally closed volt free contacts from the Customer's generator circuit breaker(s) for this purpose.

14.8 Where interlocking/inter-tripping arrangements are to be established by wiring between the Customer's generator circuit breaker panel and WPD's metering circuit breaker(s), the Customer shall make arrangements for such wiring to utilise links mounted on the panels to enable the wiring to be segregated, where required for testing.

14.9 The Customer shall provide an emergency trip button, of a break glass type, within the metering room, for the Customer's purposes. WPD will make provision to enable the Customer to trip WPD's metering circuit breaker(s), using the emergency trip button should an emergency arise.

14.10 Inter-tripping will be required between WPD's Distribution System and the Customer's Installation (inter-trip received from both WPD's and the Customer's Installation). Allowance has been made for a basic scheme. No allowance has been allowed beyond the metering circuit breaker(s) into the Premises. The responsibility and costs of this part of the inter-tripping scheme is to be borne by the Customer. Details of the final inter-trip scheme will need to be agreed with WPD. WPD reserve the right to amend proposals and costs to accommodate the Customer's protection proposal.

14.11 Costs will be subject to review following the design of a full operational inter-trip scheme following acceptance of this Alternative Connection Offer.

14.12 The Customer shall be responsible for the costs of any communication channels required for telecontrol, protection and operational inter-tripping.

14.13 Any requirements to accelerate existing protection (and associated cost) will be highlighted as part of the steady state and transient stability analysis. A detailed design of protection requirements will be carried out following completion of the necessary stability studies. In order to carry out these stability studies details of the generator control system and the Customer's proposed protection arrangements will be required.

14.14 Please note, all protection requirements shall be agreed with WPD prior to installation.

15. Earthing

15.1 This Alternative Connection Offer is conditional on an earthing study being carried out for the Premises to assess the earthing requirements for the connection. The costs of such a study are not included in the Connection Charge and shall be borne by the Customer. It is the Customer's responsibility to arrange this study and provide a copy of the results to WPD free of charge. On request, WPD will provide the necessary fault level and circuit information in order that these studies can be completed.

15.2 Upon completion of the Customer's earthing system installation, the Customer shall provide WPD with detailed 'as constructed' drawings for the Customer's earthing system, including details of electrode size and installed depth.

15.3 It is the Customer's responsibility to ensure that the Customer's Installation has adequate earth fault protection, and no liability will be accepted by WPD if its earth terminal is used. The Customer shall allow WPD to connect to the Customer's earthing system at no cost.

15.4 Special precautions must be taken with telecommunications plant and strict working procedures adopted in the immediate vicinity of substations where the rise of local earth potential could under severe fault conditions exceed 430V. Where this limit is exceeded the site will be classified as 'hot'.

15.5 ENA Engineering Recommendation S36, as amended, defines the criteria for classification of substations and power stations as 'Hot Sites'. For safety reasons it may be necessary for mitigation to be applied at and in the vicinity of Hot Sites. If the WPD substation/customer installation is assessed to be a Hot Site then the Customer shall consult with Openreach to establish if any mitigation is required. WPD require written confirmation that Openreach agree to Energisation of the Hot Site before WPD will Energise a Hot Site. This confirmation must be relevant to the actual installed substation/customer installation. Note that sometimes sites that are predicted to be 'cold' do become Hot Sites if the earth impedance actually achieved is higher than predicted. As this can be identified late in the connection process it is recommended that assessments at the design phase are conservative and that consultation with Openreach occurs at an early stage to avoid prolonged delays to the Premises being Energised, in the case of Openreach mitigation measures.

15.6 Before Energisation WPD will examine the Customer's earthing design to ensure that it complies with WPD's specification. The earthing system must be designed so that, if reasonably practicable, the substation does not become 'hot'. The costs of any works associated with making the Customer's Installation or WPD's substation 'cold', or for any remedial works by third parties due to either installation being 'hot', shall be borne by the Customer.

15.7 The earthing system must meet the requirements of Engineering Recommendation ENA TS 41-24 (available from the Electricity Networks Association) and any WPD specification as notified.

16. Appointing a Supplier / Meter Operator

16.1 Before a supply of electricity can be imported or exported through the new connection the Customer must ensure an electricity supplier is appointed and has registered in accordance with electricity trading arrangements. For a list of licensed suppliers please call WPD on (01208) 892288. Alternatively, you can visit the Ofgem website, www.ofgem.gov.uk/Licensing.

16.2 Prior to connection WPD will provide the Customer with an import and export Supply Number for the new electricity connection. The Customer will need to quote the Supply Number(s) to the electricity Supplier of their choice in order to arrange an electricity supply. If the Supplier fails to register the Supply Number WPD will be unable to Energise the connection.

16.3 For connections with a maximum demand above 100kW and a generation capability above 30kW, half hourly metering is mandatory. The Customer's appointed Supplier may arrange for a Meter Operator to install half hourly metering but it is usual for the Customer to appoint their Meter Operator directly.

16.4 A list of Meter Operators can be obtained from the Association of Meter Operators, www.meteroperators.org.uk. It will be necessary for the Customer to ensure in conjunction with the meter operator, that suitable metering exists/is installed for the required level of import/export capacity.

16.5 WPD provides metering services to customers in the UK and can provide half hourly metering. Please inform us if you would like WPD to be your Meter Operator.

17. Connection Agreement

17.1 Prior to Energisation of the Customer's Installation the Customer must enter into a formal Connection Agreement with WPD.

17.2 The Connection Agreement will govern the terms and conditions under which the Customer's Installation may be connected (and remain connected) to WPD's Distribution System. The Connection Agreement is based on an industry standard and terms and conditions contained therein are largely non-negotiable. Any request by the Customer to amend the Connection Agreement will require referral for legal advice and the Customer shall be responsible for costs incurred by WPD regardless of whether or not these changes or amendments are agreed and incorporated in the Connection Agreement.

WPD
General Conditions For Connection Works (“The Conditions”)

1. Definitions and Interpretation

1.1 All words and expressions defined in the Offer Letter and the Specific Conditions (if any) shall, unless the context otherwise requires, have the same meanings in these General Conditions.

1.2 Unless the context otherwise requires, the following words have the following meanings:

"Act" means the Electricity Act 1989 as amended from time to time.

"Agreement" means these General Conditions, the Offer Letter, the Specific Conditions, the Characteristics and Charge Statement or Letter of Acceptance each signed by the Customer and any schedule or annexure to the Offer Letter, and any other document in agreed form.

"Characteristics and Charge Statement" means the electrical characteristics of the proposed connection at the Connection Point and details of the Connection Charge to be completed and signed by the Customer confirming the Customer's acceptance to the terms of the Alternative Connection Offer and concluding the contract between the parties in respect of the subject matter of this Agreement.

"Conditions Precedent" means the conditions which must be fulfilled prior to the commencement of the Connection Works and continue to be fulfilled for the duration of the Agreement, as detailed in clause 2 and the Specific Conditions, if applicable.

"Connection Equipment" means all electric lines, materials, structures, equipment, plant, cables and apparatus necessary for the supply of electricity to or from the Connection Point, which forms part of the Distribution System.

"Connection Point" means the point of connection at which a supply of electricity may flow between the Distribution System and the Customer’s Installation upon Energisation.

"Connection Works" means the works carried out by WPD under this Agreement as more particularly set out in the Specific Conditions.

"Contestable Connection Works" means the works that the Customer has an option to carry out itself or by appointing a contractor as more particularly described in the Specific Conditions.

"Customer's Installation" means any electric lines, materials, structures, equipment, plant, cables and apparatus (not being Connection Equipment) installed or to be installed by the Customer, owned or operated, used or to be used by the Customer and connected or to be connected to the Distribution System pursuant to this Agreement (including, without limitation the Customer's distribution network or generating plant).

"Customer Works" means any works to be carried out by the Customer or the Customer's contractor including, without limitation Contestable Connection Works as set out in the Specific Conditions.

"Distribution System" means WPD's electricity distribution system.

"Energisation" means the movement of any switch or the insertion of any fuse or the taking of any other step so as to enable an electrical current to flow to or from the Distribution System through WPD's Connection Equipment to and, where applicable, from the Customer's Installation at the Connection Point and **"Energise"** shall be construed accordingly.

"Event of Force Majeure" means an event beyond the reasonable control of a party including but not limited to acts, defaults or omissions of sub-contractors, strike, lock out or other form of industrial action, other than by a party's own employees or agents, act of God, fire, explosion or flood, any third party obstruction preventing access to the Premises, theft and malicious damage or an electrical system emergency, provided that no event shall be treated as an Event of Force Majeure if it is attributable in whole or part to any wilful act or omission or any failure to take reasonable precautions by the affected party.

"Letter of Acceptance" means the letter in the form attached to the Offer Letter to be completed and signed by the Customer confirming the Customer's acceptance to the terms of the Alternative Connection Offer and concluding the contract between the parties in respect of the subject matter of this Agreement.

"Non-contestable Connection Works" means that part of the Connection Works which will always be carried out by WPD and which the Customer is not entitled to carry out itself or through an appointed contractor as more particularly set out in the Specific Conditions.

"Premises" the premises or development (including, without limitation, any land, building or structure, owned or occupied by the Customer) where or in relation to which the Connection Works are to be carried out.

1.3 In this Agreement, unless the context otherwise requires:

(a) words in the singular include the plural and vice versa and words in one gender include any other gender;

(b) a reference to a statute or other statutory provision includes:

(i) any subordinate legislation (as defined in Section 21(1) Interpretation Act 1978) made under it;

(ii) any repealed statute or statutory provision which it re-enacts (with or without modification); and

(iii) any statute or statutory provision which modifies, consolidates, re-enacts or supersedes it;

(c) references to:

(i) any party include its permitted successors in title and permitted assigns;

(ii) clauses and schedules are to clauses and schedules of this Agreement and references to sub-clauses and paragraphs are references to sub-clauses and paragraphs of the clause or schedule in which they appear;

(d) the headings are for convenience only and shall not affect the interpretation of this Agreement.

2. Commencement of Connection Works and Conditions Precedent

2.1 As soon as reasonably practicable after WPD has received the Customer's acceptance of the Alternative Connection Offer , the parties shall agree in writing a date for commencement of the Connection Works.

2.2 WPD shall be under no obligation to commence the Connection Works until the following Conditions Precedent have been met:

(a) the Customer has:

(i) entered into the Agreement, pursuant to the Alternative Connection Offer, by WPD by completing, signing and returning the Letter of Acceptance or Characteristics and Charge Statement, as appropriate;

(ii) completed any necessary civil works, civil engineering or building works that are necessary to enable the Connection Works to commence;

(iii) complied with its obligations under clauses 3 and 4.1; and

(iv) made any initial payments required under the Offer Letter or Specific Conditions; and

(b) WPD has, at its normal rates, obtained all necessary easements, leases and transfers as well as any off site third party wayleaves and consents to lay its cables or construct an overhead line connection. Should any of these not be granted, or granted on terms in excess of WPD's normal rates, the Connection Charge may be revised to take account of any additional cost to WPD.

2.3 If any of the Conditions Precedent have not been met by either party or waived by WPD within (6) months of the date of the Offer Letter, the Agreement shall automatically expire without prejudice to any accrued rights or obligations to either party under it.

2.4 The Customer shall not in any way obstruct or impede Connection Works or the delivery of any Connection Equipment to the Premises, and shall use its reasonable endeavours to procure that its sub-contractors or agents shall not in any way obstruct or impede the Connection Works or the delivery of any Connection Equipment to the Premises so as to prevent WPD from, or hinder or delay WPD in performing its obligations under this Agreement.

2.5 WPD shall use its reasonable endeavours to complete the Connection Works within the timescales laid out under the Offer Letter or Specific Conditions. This period for completion shall be extended to the extent that progress of the Connection Works is delayed as a consequence of any act or omission on the part of the Customer, its agents or sub-contractors or a Distribution System emergency.

3. Property Matters

3.1 Where the Customer is the owner of the Premises or any adjacent land on which the Connection Works are to be carried out it shall, where reasonably required, and at the request of WPD, for the sum of £1:

(a) grant an easement in perpetuity to WPD to carry out the Connection Works and install, lay, repair, replace, renew, alter and maintain the Connection Equipment; and

(b) enter into a lease for a term of 99 years for the benefit of WPD of any part or parts of the Premises for the siting, repairing, maintenance and access to the accommodation and the Connection Equipment, or

(c) transfer the Customer's ownership in an acceptable form to WPD of any part or parts of the Premises for the siting, repairing, maintenance and access to the accommodation and/or Connection Equipment.

3.2 Where the Customer owns a leasehold interest in the Premises or any adjacent land the Customer shall, where reasonably required, and at the request of WPD, for the sum of £1:

(a) grant an easement to WPD for a term of years expiring one day before the end of Customer's interest in the Premises for the benefit of WPD to carry out the Connection Works and install, lay, repair, replace, renew, alter and maintain the Connection Equipment and;

(b) enter into a lease with WPD for a term of years expiring one day before the end of Customer's leasehold interest in the Premises for the benefit of WPD of any part or parts of the Premises for the installation, laying, siting, repairing, replacement, renewing, altering, maintenance and access to the accommodation and the Connection Equipment;

provided that WPD shall not be required to enter into the documents set out in 3.2(a) or 3.2(b) until the Customer has obtained the consent of the freehold owner to such documents.

3.3 Where the Customer owns neither the freehold nor the leasehold interest in the Premises or the adjacent land the Customer shall use reasonable endeavours to procure that the owner of the freehold interest of the Premises and the adjacent land enters into documents set out in clause 3.1 for the benefit of WPD.

3.4 Where the Customer is the owner or occupier of the Premises or the adjacent land, the Customer shall indemnify WPD from and keep WPD fully indemnified against any proceedings, claims, demand, costs, charges and expenses WPD incurs as a result of the Customer's failure to grant or obtain for WPD the appropriate easement or property rights to carry out the Connection Works and to install and maintain the Connection Equipment.

3.5 WPD may, in its discretion, carry out the Connection Works if it has obtained a wayleave to do so in lieu of any easements. The acquiring of any wayleaves shall not diminish the duties and obligations on the Customer pursuant to this clause 3.

3.6 If the Customer or a third party prevents WPD from entering the Premises, adjacent land or other land with the result that WPD is unable to carry out the Connection Works, or the Connection Works are suspended on the Customer's instruction for which WPD is not responsible or due to alterations to the layout of the Premises, WPD shall not be deemed to be in breach of this Agreement and any additional costs reasonably incurred by WPD in consequence thereof shall be added to the Connection Charge.

3.7 The Customer shall except and reserve out from the conveyance/lease to the purchaser/lessee of the Premises, full right and liberty for WPD to place/install electric lines through the property conveyed or leased and thereafter to use, inspect, repair, replace, alter, maintain and renew the same provided that WPD shall make good any damage caused as soon as practicable and shall not break open the surface of any land covered by a building.

3.8 Any legal costs incurred in conveying any part of the Premises to WPD shall be apportioned between the parties in accordance with the Specific Conditions.

4. Compliance, consents, safety and access

4.1 The Customer shall:

(a) before the time specified for delivery of any of WPD's Connection Equipment to the Premises, obtain all consents and approvals in connection with the regulations and by-laws of any local or other authority which shall be applicable to the Connection Works on the Premises;

(b) provide all accommodation, equipment, buildings, structures, foundations, approaches or work equipment of the quality specified in the Specific Conditions, if any;

(c) ensure that the 'Co-ordinator' and the 'Principal Contractor' as defined by the Construction (Design & Management) Regulations 2007 ("**CDM Regulations**") carry out all their duties and obligations as set out in the CDM Regulations;

(d) at all times provide and maintain suitable access to the Premises for the purposes of carrying out the Connection Works or delivering, installing, laying, repairing, replacing, renewing, altering, or maintaining the Connection Equipment and on production of written identity the Customer shall allow any WPD representative to enter the Premises provided that such visits are made during normal working hours (being between 07:00-19:00 hrs., Monday to Friday except for bank holidays); and at other times with the Customer's consent.

4.2 Each party shall take all reasonable steps to ensure the safety of the other party's employees, sub-contractors and agents while the Connection Works are in progress or while WPD is maintaining or repairing the Connection Equipment.

4.3 WPD shall not be under any obligation to commence or continue to provide the Connection Works unless it is reasonably satisfied that each part of the Customer's Installation is so constructed, installed, protected and used so far as is reasonably practicable to prevent danger, and not to cause interference with the Distribution System.

4.4 The inspection, non-inspection or non-rejection of the Customer's Installation by WPD shall not constitute any warranty or representation express or implied as to the adequacy, safety or other characteristics of the Customer's Installation.

5. Performance of Connection Works

5.1 WPD shall:

(a) perform the Connection Works with reasonable skill and care and in accordance with the terms of this Agreement; and

(b) provide such information as is reasonably required by the Customer from time to time to keep the Customer informed of the progress of the Connection Works.

5.2 WPD specifically excludes all warranties, express or implied, including but not limited to any implied term, condition, representation or warranty of satisfactory quality or fitness for a particular purpose, that the Connection Works or Connection Equipment will meet the Customer's requirements except those that cannot be excluded at law.

6. Connection Charges and payment

6.1 The Customer will pay to WPD the Connection Charge. The Connection Charge has been determined on the basis that WPD will provide the Non-contestable Connection Works and those Contestable Connection Works, if any, as identified in the Specific Conditions. If the Customer wishes to provide some or all the Contestable Connection Works it shall first satisfy WPD that it (or its appointed contractor) has the necessary competence and experience to carry out such Contestable Connection Works properly and safely.

6.2 If WPD is unable to complete the Connection Works within the estimated timescales set out in the Offer Letter or Specific Conditions due to any act, default or omission by the Customer, its employees, agents or sub-contractors or the Customer's breach of the Agreement or breach of statutory duty, WPD reserves the right to increase the Connection Charge to recover any costs incurred by it as a result of such delay.

6.3 Payment of the Connection Charge shall be made in accordance with the Offer Letter or Specific Conditions. WPD shall invoice the Customer the amount stated. The Customer shall pay WPD within 28 days of receipt by the Customer of such invoice.

6.4 If the Customer makes any late payment of the Connection Charge or any part of it WPD may, at its discretion, suspend the Connection Works or postpone their commencement.

6.5 Without prejudice to any other rights and remedies which WPD may have, if the Customer fails to pay WPD by date an invoice is due, WPD may charge interest at a rate of 5% over the base rate of the Lloyds TSB, until it receives full payment of such invoice in cleared funds from the Customer.

6.6 WPD shall be under no obligation to Energise the Connection Point prior to receiving full and final payment of the Connection Charge in cleared funds from the Customer. Full payment of the Connection Charge shall be due in accordance with the payment terms set out under the Offer Letter or Specific Conditions and in any event at least 7 days prior to the Energisation date.

6.7 Where under this Agreement any party agrees to pay to any other party any sum or to furnish to any other party consideration which (in either case) is consideration for a taxable supply that sum or consideration shall be exclusive of Value Added Tax payable on it and the recipient of the supply shall pay an amount equal to such Value Added Tax in addition to any sum or consideration on receipt of a valid Value Added Tax invoice from the relevant party.

6.8 WPD shall be entitled to require security from the Customer before the commencement of the Connection Works.

7. Ownership, use and removal of Connection Equipment

7.1 The Connection Equipment shall be installed in a position agreed by WPD.

7.2 The property in the Connection Equipment shall remain with WPD who may use it to connect its other customers.

7.3 If prior to the Connection Works being completed, WPD or the Customer cancels the Connection Works or part of them WPD may require the Customer, (at no cost to WPD), to assist WPD in removing the Connection Equipment and to pay within 7 days to WPD the amount of any expenditure reasonably incurred by WPD in the expectation of the performance of such Connection Works or part of them, or otherwise arising in consequence of such cancellation to the extent not yet invoiced.

8 Customer Works and Customer Installation

8.1 The Customer shall carry out all Customer Works with reasonable skill and care and in accordance with all applicable laws, rules and regulations.

8.2 WPD shall be under no obligation to permit the Customer's Installation to be connected directly or indirectly to the Distribution System unless it is satisfied that:

(a) it will not cause danger or damage to, or undue interference with the Distribution System or the electricity supply to any third party; and

(b) if applicable, the Customer has done everything necessary to lawfully operate and use the Customer’s Installation for export of electricity to the Distribution System.

8.3 The Customer shall produce such evidence as may be reasonably required by WPD to show that the Customer has complied with its obligations under clause 8.2 above.

8.4 Save where express written representations are made by WPD or where the relevant works are carried out by WPD, neither by inspection, Energisation, connection nor in any other way does WPD give any guarantee or warranty, expressed or implied, as to the adequacy, safety or any other characteristic of the Customer's Installation or anything connected to it directly or indirectly (save for any Connection Equipment). WPD shall be under no obligation to carry out any repair or maintenance to the Customer's Installation.

9. EU Procurement Regulations

Where the EC Procurement Regulations apply to the procurement by WPD of works, goods or services which are necessary to carry out the Connection Works, WPD shall comply with such Regulations and provide any details reasonably required by the Customer to prove such compliance.

10. Liability

10.1 Each party accepts unlimited liability for death or personal injury caused by its negligence.

10.2 WPD's aggregate liability for physical damage to the Customer's tangible property (save where provided in clause 10.3) resulting from any act, default or omission (whether negligent or otherwise) of WPD, its employees, agents or sub-contractors, or from WPD's breach of the Agreement or breach of statutory duty, shall be limited to £5,000,000 per event or series of connected events.

10.3 WPD shall have no liability whatsoever, arising in contract, tort (including negligence) or breach of statutory duty, for any:

(a) defect, malfunction or otherwise in the Customer’s electrical equipment or the Customer's Installation, if applicable;

(b) defects in the Connection Equipment and the Distribution System which are a result of any Customer Works;

(c) loss of profit, business, contract, revenue, opportunity, goodwill, use of software or data, anticipated savings or for any administrative and overhead costs;

(d) indirect or consequential loss; and

(e) loss arising from any claim made against the Customer by any other person, unless such loss results directly from WPD's negligence or breach of contract in which event WPD's liability shall be limited to £5,000,000 per event or series of connected events.

10.4 Nothing in this clause 10 shall exclude or restrict or otherwise prejudice or affect the rights, powers, duties and obligations of either party which are conferred or created by the Act, WPD's distribution licence or the Electricity Safety, Quality and Continuity Regulations 2002, as amended.

11. Force Majeure

11.1 Neither party shall be deemed to be in breach of this Agreement, or otherwise be liable to the other, by reason of any delay or non-performance of any of its obligations (other than any payment obligations) under this Agreement to the extent that such delay or non-performance is due to an Event of Force Majeure. Such obligations shall be suspended while the Event of Force Majeure continues.

11.2 The party affected by an Event of Force Majeure shall immediately notify the other party in writing of the nature and extent of the Event of Force Majeure and the affected party shall use all reasonable endeavours to mitigate its effects.

11.3 If the Event of Force Majeure continues for more than 2 calendar months, the unaffected party shall be at liberty to terminate this Agreement with immediate effect by giving written notice on the other. The service of such notice shall be without prejudice to any rights or obligations that have accrued prior to termination.

12. Termination

12.1 The Customer may by 30 days' prior notice in writing terminate the Agreement at any time without cause.

12.2 Either party may by notice in writing terminate the Agreement with immediate effect at any time if the other party commits a material breach of the Agreement provided that where such breach is capable of remedy the party in breach has been advised in writing of the breach and has not rectified it within thirty (30) days of receipt of such advice/notice. For the purposes of this sub-clause a breach shall be considered capable of remedy if time is not of the essence in performance of the obligation and if that party can comply with the obligation within the 30 day period.

12.3 WPD may by notice in writing terminate the Agreement with immediate effect on or at any time on the happening of any of the following events:

(a) the passing of a resolution for the Customer's winding-up or the making by a court of competent jurisdiction of an order for the winding-up or the dissolution of the Customer;

(b) the making of an administration order or the appointment of an administrator under the out-of-court procedure under the Enterprise Act 2002 or the appointment of a receiver or an administrative receiver over, or the taking possession or sale by an encumbrance of, any of the Customer's assets;

(c) the Customer making an arrangement or composition with its creditors generally or making an application to a court of competent jurisdiction for protection from its creditors generally;

(d) the Customer ceasing to do business at any time for 30 consecutive days; or

(e) WPD being unable to commence the Connection Works within two (2) months from the date agreed between the parties due to any act, default or omission (whether negligent or otherwise) by the Customer, provided that such date shall not be earlier than 6 months from the date of this Agreement.

12.4 On Energisation this Agreement shall automatically expire save as set out in clause 13.

12.5 The provisions of this clause 12 are without prejudice to any other right or remedy either party may have against the other for breach or non-performance of this Agreement.

13. Consequences of Termination

13.1 All rights and obligations of the parties shall cease to have effect immediately upon expiry or termination of this Agreement except that termination shall not affect:

(a) the accrued rights and obligations of the parties at the date of termination or expiry; and

(b) the provisions contained in clauses 7, 8, 13, 15, 17, 18, and 19 which shall survive the expiry or termination of this Agreement howsoever caused and shall continue in full force and effect.

13.2 If on termination of the Agreement any staged payments made by the Customer exceed the actual costs incurred by WPD in carrying out the Connection Works up to and including the date of termination, WPD shall issue a credit note in respect of such excess amount and reimburse the Customer accordingly, provided that WPD shall have the right to set off from such amount any sums due to WPD by the Customer under this Agreement.

14. Variation

14.1 Each party shall be entitled to propose variations to the terms of this Agreement provided no purported variation to the Agreement shall be effective unless it is in writing and signed on behalf of both parties.

14.2 The Connection Charge shall be adjusted by such an amount as is reasonable to reflect the increased or, as the case may be, decreased cost to WPD of meeting its obligations under this Agreement as a result of the variation.

14.3 If the parties are unable to agree a proposed variation, the parties shall attempt to resolve the matter in accordance with the internal dispute resolution procedure set out in clauses 15.1 and 15.2. If the senior representatives of the parties fail to resolve the matter, neither party shall have any obligation to implement the variation.

15. Dispute Resolution

15.1 Subject to clause 15.4 if a dispute arises out of or in connection with this Agreement, the parties shall:

(a) within 7 days of written notice of the dispute being received by the receiving party in good faith seek to resolve the dispute through negotiations between the parties' senior representatives who have the authority to settle it;

(b) not pursue any other remedies available to them until at least 28 days after the first written notification of the dispute.

15.2 The appointed representatives shall use all reasonable endeavours to resolve the dispute.

15.3 Nothing in this clause 15 shall prevent any party from having recourse to a court of competent jurisdiction for the sole purpose of seeking a preliminary injunction or such other provisional judicial relief as it considers necessary to avoid irreparable damage.

16. Assignment

16.1 This Agreement shall be binding on and enure for the benefit of the successors in title of the parties but, except as set out in sub-clause 16.2, shall not be assignable by either party without the prior written consent of the other. In addition, a party to this Agreement may not hold the benefit of the Agreement or any rights under it on trust for any third party or parties.

16.2 WPD may assign the benefit of this Agreement to any company within its Group. For the purposes of this Agreement, "Group" means a company's subsidiaries, its holding companies and any subsidiaries of such holding companies, "subsidiary" and "holding company" having the meanings ascribed to those terms in Section 1159 of the Companies Act 2006.

17. General

17.1 This Agreement and any documents referred to in this Agreement set out the entire agreement and understanding between the parties in respect of the subject matter of this Agreement.

17.2 To the extent that any of the provisions in these General Conditions conflict with the provisions in the other documents which constitute this Agreement, the order of precedence shall be as follows:

(a) the Specific Conditions;

(b) the Characteristics and Charge Statement, or Letter of Acceptance (as appropriate) as signed by the Customer;

(c) the Offer Letter; and

(d) these General Conditions.

17.3 To the extent that any provision of this Agreement is found by any court or competent jurisdiction to be invalid, unlawful or unenforceable it shall not affect the enforceability of the remainder of the Agreement.

17.4 No single or partial exercise or failure or delay in exercising any right, power or remedy by either party shall constitute a waiver by that party of, impair or preclude any further exercise of, that or any right, power or remedy arising under this Agreement or otherwise.

17.5 No express term of this Agreement or any term implied under it is enforceable pursuant to the Contracts (Rights of Third parties) Act 1999 by any person who is not a party to it.

17.6 Joint and several liability

(a) where any liability or obligation is undertaken by two or more persons, the liability or obligation of each of them shall be joint and several;

(b) the release or compromise in whole or in part of the liability of or grant of any time or indulgence to any one or more of joint and several obligors shall not affect the liability of the other or others.

18. IP rights and confidentiality

18.1 All rights in the design, specification, plans or drawings contained or accompanying this Alternative Connection Offer belong to and remain with WPD and shall not be used by the Customer or any other person without WPD's written consent.

18.2 All data and information acquired or reviewed by the parties in connection with this Alternative Connection Offer is confidential and shall not be divulged to any third party without the prior written consent of the other party except insofar as may be required by law.

19. Notices

19.1 Any notice to a party under this Agreement shall be in writing signed by or on behalf of the party giving it and shall, unless delivered to a party personally, be left at, or sent by prepaid first class post, prepaid recorded delivery or facsimile to the address of the party as set out in this Agreement or as otherwise notified in writing from time to time.

A notice shall be deemed to have been served:

(a) at the time of delivery if delivered personally;

(b) 48 hours after posting; or

(c) 2 hours after transmission if served by facsimile on a Business Day prior to 3 pm or in any other case at 10 am on the Business Day after the date of despatch.

19.2 A party shall not attempt to prevent or delay the service on it of a notice connected with this Agreement.

20. Governing law and jurisdiction

The Agreement shall be governed by and construed in accordance with the laws of England and Wales and subject to clause 15 the parties irrevocably submit for all purposes to the exclusive jurisdiction of the courts of England and Wales.

Letter of Acceptance

To: From:

Western Power Distribution (East) plc
Primary System Design
Herald Way
Pegasus Business Park
East Midlands Airport
Castle Donington
DE74 2TU

Mr Smith
Building
Street
Town
Postcode

FAO Planner Tel. No. 01332 XXXXXX

Our Ref: XXXXXXX & XXXXXXX Your Ref:

Alternative Connection Offer for an electricity connection at Location.

We accept the terms of your Connection Offer dated 01/01/2015 for:

Option 1 – WPD to undertake both Non-contestable and Contestable works ☐

Option 2 – WPD to undertake the Non-contestable work only ☐

[Please tick as appropriate]

We confirm that we do require you to provide a Maximum Import Capacity of 150kVA and a Maximum Export Capacity of 10,000kVA.

We accept responsibility for all reasonable costs that WPD may incur as a result of our termination of this Agreement or any variation, cancellation of the Connection Works and agree that outstanding costs will then be invoiced by WPD for immediate payment.

Signed:

…………………………………………… for and on behalf of the Customer

Full Name………………………………………………………………………………….

Designation…….……………………………………………………………………….

Dated ……….………………………………
(THIS MUST BE SIGNED BY AN AUTHORISED PERSON)

Indemnity

Mr Smith, Company No, XXXXXX (the "**Customer**") has requested **Western Power Distribution East Midlands plc** Company No. 02366923 whose registered office is at Avonbank, Feeder Road, Bristol BS2 0TB ("**WPD**") to carry out the following works on its behalf:

Provide an electricity connection at the premises known as Location in accordance with WPD's Alternative Connection Offer dated 01/01/2015, Reference: XXXXXXX & XXXXXXX (the "**Connection Works**").

Indemnity

In consideration of WPD carrying out any action in preparation for its anticipated performance of the Connection Works, such action to include without limitation, placing an order with a manufacturer or supplier for the manufacture, supply, delivery and if appropriate installation of any plant, electrical equipment or other equipment of whatever nature which is not held in stock by WPD and which is required by WPD for the purpose of performing the Connection Works, the Customer HEREBY AGREES TO INDEMNIFY WPD and keep WPD fully indemnified from and against all expenses, losses, costs, claims and damages incurred or suffered by WPD as a result of WPD taking any such action as aforesaid to the extent not covered by a Connection Charge paid by the Customer and received by WPD, notwithstanding a decision by the Customer not to instruct WPD to carry out the Connection Works. The payment of any sum of money due under this indemnity shall be made within 14 days of issue of a written demand by WPD.

Signed:

…………………………………………
for and on behalf of the Customer

Full Name ……………………………………………………………………………………

Designation ……..………………………………………………………………………

Dated ……….………………………………

Project Definition Phase **Construction (Design and Management) Regulations 2007** **Health, Safety and Environment Information**		
Site Address		
Potential Hazard/Risk	**What action is being taken to address this potential risk?** **By whom and when?**	**Are further details attached** ***Please delete as appropriate**
Asbestos		**yes/no***
Air Pollution		**yes/no***
PCBs		**yes/no***
Oil Spillage		**yes/no***
Noise		**yes/no***
Working at Height		**yes/no***
Confined Spaces		**yes/no***
Demolition		**yes/no***
Hot Work		**yes/no***
Uneven Ground		**yes/no***
Deep Excavation		**yes/no***
Limited Access/Egress		**yes/no***
Street Works		**yes/no***
Heavy Plant		**yes/no***
Vehicle Access		**yes/no***
Parking/Traffic		**yes/no***
Site Security		**yes/no***
Earthing System		**yes/no***

Other Utilities		**yes/no***
Overhead Lines		**yes/no***
U/G Cables		**yes/no***
Rail Track		**yes/no***
Space Restrictions		**yes/no***
From Adjacent Sites		**yes/no***
To Adjacent Site		**yes/no***
Environment: **Flammable/Explosive** **Corrosive/Dusty/Wet*** **Invasive Plants** **Protected Species e.g. Bats**		**yes/no***
Radon		**yes/no***
Mining		**yes/no***
Mine Workings		**yes/no***
Ground Contamination		**yes/no***
Other hazard(s)		**yes/no***
		yes/no*
		yes/no*

Is the development subject to notification under the CDM Regulations 2007? **If yes, please provide a copy of the F10 and where available the Pre-Construction Health and Safety Information.** **N.B. WPD will take on duties of the "Client", and where applicable the "CDM Coordinator" and "Principal Contractor" for the installation of our equipment**	**yes/no***

Signature: .... Print Name:... Date: ....

Designation: (if signing for a Company):..Company: ………………..………….....……........

Appendix D – Template Alternative Connection Agreement

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

ALTERNATIVE CONNECTION AGREEMENT

THIS AGREEMENT is made the	123	day of	Month	2014

Between:	**Western Power Distribution (East Midlands) plc** Registered in England and Wales No. 2366923 Whose **REGISTERED OFFICE** is at Avonbank Feeder Road Bristol BS2 0TB (The "Company")
And	Any Company Ltd Registered in England & Wales No 123456 Any Street Any Town Any County Any Postcode (The "Customer")
Concerning the Customer's Premises known as	Any Company Ltd Registered in England & Wales No 123456 Any Street Any Town Any County Any Postcode

Address for Notices	Any Company Ltd Registered in England & Wales No 123456 Any Street Any Town Any County Any Postcode	**Western Power Distribution (East Midlands) plc** Avonbank Feeder Road Bristol BS2 0TB

The Company and the Customer shall together be referred to as the "Parties" and each a "Party".

This agreement (excluding the schedules to this agreement) shall be referred to as the "Agreement", the schedules to the Agreement shall be referred to as the "Schedules", and Schedule 3 of the national terms of connection shall be referred to as the "National Terms of Connection". The Agreement, the Schedules, and the National Terms of Connection shall together be referred to as the "Connection Agreement".

The National Terms of Connection are available to view on the website: www.connectionterms.co.uk. Alternatively the Customer may request a copy of the National Terms of Connection from the Company by written request to the address for notices given above. The Customer confirms that they have read, fully understand and accept the terms of the National Terms of Connection.

Subject to the express provisions of this Agreement:

(a) the National Terms of Connection will apply as if set out in this Agreement;

(b) references in the National Terms of Connection to "this agreement" or to "this Agreement" shall be interpreted as if references to this Connection Agreement; and

(c) expressions used in this Agreement and the Schedules shall have the same meanings as if given to them in the National Terms of Connection.

Details of the Premises, the Connection Points, the technical characteristics of the Connection Points and other matters are set out in the Schedules.

The Company agrees to Connect the Customer's Installation to the Company's Distribution System on the terms and conditions of this Connection Agreement and in consideration of the Company's agreement to do so the Customer agrees to be bound contractually by the terms and conditions of this Connection Agreement.

NOW IT IS HERBY AGREED as follows:

1. DEFINITION, INTERPRETATION AND CONSTRUCTION

1.1. In the event of any conflict between the terms of this Agreement, the Schedules or the National Terms of Connection, the documents shall have the following order of priority (in descending order):
(a) the terms of this Agreement;
(b) the Schedules; and
(c) the National Terms of Connection.

1.2. This Connection Agreement constitutes the entire agreement between the Parties in relation to the Premises. Each Party acknowledges that it has not entered into this Connection Agreement on the basis of, and has not relied on, any statement, representation, warranty, promise or term made or agreed to by any Party, (whether a Party to this agreement or not) except those expressly written out in full in this Connection Agreement. Neither Party shall have any liability in respect of any other representation, warranty or promise made prior to the date of this Connection Agreement unless it was made fraudulently.

1.3. This Agreement may be executed in any number of counterparts and by the Parties on separate counterparts, but shall not be effective until each Party has executed at least one counterpart. Each counterpart, when executed, shall be an original of this Agreement and all counterparts shall together constitute one instrument.

1.4. Subject to clause 1.5, any variation to this Agreement shall be in writing and signed by authorised signatories for the Parties.

1.5. Each Party shall effect any amendments required as a result of a change in the Electricity Distribution Licence or any Applicable Legislation and the Customer hereby authorises and instructs the Company to make any such amendment on its behalf and undertakes not to withdraw, qualify or revoke such authority or instruction at any time.

1.6. The following terms and expressions shall have the meaning set out below:

Adjusted Export Capacity	Has the meaning ascribed to it in Clause 3.2 of this Agreement
Adjusted Import Capacity	Has the meaning ascribed to it in Clause 3.2 of this Agreement
ANM Scheme	Means the overall active network management scheme including but without limitation the Company's Control Equipment.
Annual Alternative Connection Charge	Means the charge payable annually by the Customer (in accordance with clause 6.4) for the amount specified in clause 3.8(c).

Applicable Legislation	Means all laws, statutes, statutory instruments, acts, regulations, codes, judgements, orders, directives or determinations which affect the Electricity Distribution Licence or the performance of any of the Company's obligations under the Agreement.
Company's Control Equipment	Means the equipment and technical specification set out in Schedule 5
Curtail	Means: (a) to limit from time to time the maximum amount of electricity that may flow from the Distribution System through the Connection Point; or (b) to limit from time to time the maximum amount of electricity that may flow to the Distribution System through the Connection Point; or (c) in respect of the flow of electricity from the Company's Distribution System to the Customer's Installation to require this to be at a particular Power Factor or to be within a particular range of Power Factors; or (d) in respect of the flow of electricity from the Customer's Installation to the Company's Distribution System to require this to be at a particular Power Factor or to be within a particular range of Power Factors; for the purpose of active network management, 'Curtailed' and 'Curtailment' shall be construed accordingly.
Instruction	Means an instruction given by the Company to the Customer via the Company Control Equipment or verbally or in written form in accordance with the technical specifications set out in Schedule 5 in order to undertake curtailment.
Protected Export Capacity	Means in respect of a Connection Point (or Connection Points collectively) an amount of electricity (expressed in kVA) which shall not exceed the Maximum Export Capacity that the Customer is entitled to pass into the Distribution System through the Connection Point (or the Connection Points Collectively) subject to the National Terms of Connection, which the Company shall not intentionally interrupt for active network management purposes. The value of the Protected Export Capacity is described in Schedule 1. For the avoidance of doubt, the use of the term 'Protected' in this Agreement does not mean that provision of the capacity is resilient to a loss of one or more Connection Points.
Protected Import Capacity	Means in respect of a Connection Point (or Connection Points collectively) an amount of electricity (expressed in kVA) which shall not exceed the Maximum Import Capacity that the Customer is entitled to take from the Distribution System through the Connection Point (or the Connection Points Collectively) subject to the National Terms of Connection, which the Company shall not intentionally interrupt for active network management purposes. The value of the Protected Import Capacity is described in Schedule 1. For the avoidance of doubt, the use of the term 'Protected' in this Agreement does not mean that provision of the capacity is resilient to a loss of one or more Connection Points.

2. COMPLIANCE WITH SITE SPECIFIC CONDITIONS AND OPERATIONAL ARRANGEMENTS

2.1. The site specific conditions and operational arrangements applicable to the Connection Points, the Customer's Installation and the details of Curtailment are specified in Schedule 5.

3. MAXIMUM CAPACITY, POWER FACTOR AND DEFINED INTERUPTIBILITY

3.1. In addition to the Company's rights of curtailment under the National Terms of Connection, set out above, and notwithstanding clause 12 of the National Terms of Connection – 'Limitation of Capacity', the Company shall be entitled (at no cost to the Company) to instruct the Curtailment of the flow of electricity through the Connection Point in accordance with clause 3.2 in the event that:

(a) the Protected Import Capacity is less than the Maximum Import Capacity; and/or

(b) the Protected Export Capacity is less than the Maximum Export Capacity.

3.2. Subject to clause 3.1 , the Company shall be entitled to issue an Instruction to:

(a) specify a level of import capacity expressed in kVA ('Adjusted Import Capacity') may not be greater than the Maximum Import Capacity provided that the Adjusted Import Capacity shall not be less than the level of the Protected Import Capacity;

(b) specify a level of export capacity expressed in kVA ('Adjusted Export Capacity') may not be greater than the Maximum Export Capacity provided that the Adjusted Export Capacity shall not be less than the level of the Protected Export Capacity;

(c) specify a particular Power Factor, or a particular range of Power Factors, for any flow of electricity from the Company's Distribution System to the Customer's Installation; and

(d) specify a particular Power Factor, or a particular range of Power Factors, for any flow of electricity from the Customer's Installation to the Company's Distribution System.

3.3. Upon receipt from the Company of an Instruction in accordance with clause 3.2 above and for so long as this Instruction remains in force, the Customer shall not whether by act or omission:

(a) cause or permit the flow of electricity from the Company's Distribution System to the Customer's Installation to exceed the Adjusted Import Capacity;

(b) cause or permit the flow of electricity from the Customer's Installation to the Company's Distribution System to exceed the Adjusted Export Capacity;

(c) cause or permit the flow of electricity from the Company's Distribution System to the Customer's Installation at a Power Factor other than that instructed; or

(d) cause or permit the flow of electricity from the Customer's Installation to the Company's Distribution System at a Power Factor other than that instructed.

3.4. Upon receipt from the Company's Control Equipment of an Instruction to limit the maximum amount of electricity that may flow from or to the Distribution System through the Connection Point in accordance with clauses 3.2 and 3.3 above, the Customer shall respond to the Instruction within x Seconds unless otherwise agreed with the Company in writing.

3.5. If the Customer fails to comply with clause 3.3 and 3.4 above, the Company shall be entitled to De-energise the Connection Point and the Customer's Installation as is appropriate.

3.6. Without prejudice to the Company's rights under the National Terms of Connection to De-energise the Connection Point, the magnitude and/or duration of Curtailment in accordance with Clauses 3.2 and 3.3 of this Agreement shall be no longer than, in the reasonable opinion of the Company, is appropriate in the circumstances and the Company shall cease Curtailment as soon as reasonably practicable after the circumstances leading to the Curtailment have ceased to exist.

3.7. Subject to the terms of this Connection Agreement the Company shall use reasonable endeavours to ensure that the Maximum Import Capacity and the Maximum Export Capacity is available at the Connection Point during the period of this Connection Agreement subject to the Curtailment in accordance with Clauses 3.2 and 3.3.

3.8. The Customer's entitlement to a Maximum Import Capacity or Maximum Export Capacity is conditional upon:

(a) the installation by the Company (at the Customer's sole cost) of the Company's Control Equipment and the connection of the Customer's equipment to the Company's Control Equipment;

(b) the Customer maintaining the Customer's Installation and its equipment in accordance with Clause 6 of this Agreement at the Customer's sole cost; and

(c) paying the Annual Alternative Connection Charge of £xx,xxx (excluding value added tax) in accordance with clause 6.4,

to enable monitoring and carrying out of Curtailment as set out in Schedule 5.

3.9 Curtailment of the connection will occur at a varying level based on a real-time assessment on the Distribution System, with the Adjusted Import/Export Capacity being maintained between the Maximum Import/Export Capacity and the Protected Import/Export Capacity. The level of curtailment will depend on a number of factors including, but not limited to:

- NGET limitations or outages (planned or unplanned)
- Any outages (planned or unplanned) of the circuits, transformers or switchgear utilised in the normal feeding arrangement, from the point of connection, through the different voltage levels of the Distribution System, up to the grid supply point
- A reduction in the normal ability for the Distribution System to absorb generation export
- A reduction in the normal ability for the Distribution System to supply load import
- An outage (planned or unplanned) of the Active Network Management system or associated communication systems.

The Company has used historical load data, outage data, fault data and profiles for new and existing generators to provide an estimated level of constraints for this connection under three different scenarios. For the avoidance of doubt, the Company does not guarantee any availability or any level of duration or frequency of curtailment or constraints. The Company expects the Customer to have carried out their own analysis prior to acceptance.

Estimated worst case with all generation at maximum output and a reduction in current demand by 25%	Estimated [ ]% Energy constrained from [ ] MWh output over 18 months (Jan 12-June 13)
Estimated current scenario with no smart grid technology	Estimated [ ]% Energy constrained from [ ] MWh output over 18 months (Jan 12-June 13)
Estimated current scenario with smart grid technology	Estimated [ ]% Energy constrained from [ ] MWh output over 18 months (Jan 12-June 13)

4. LIABILITY FOR CURTAILMENT

4.1. Subject to Clause 15.3 of the National Terms of Connection the Company shall under no circumstances be liable to the Customer or any person for any physical damage, costs, losses, expenses, claims or compensation arising from or in connection with any Curtailment of the Generating Equipment by the Company.

5. ADDITIONAL TERMINATION RIGHTS

5.1. In addition to the termination rights set out in Clause 19.3 of the National Terms of Connection, the Parties agree that the Company may terminate the Connection Agreement by giving notice of such termination to the Customer in the event that the Customer commits a material breach of any of its obligations contained in Clause 3 of this Agreement.

6. CUSTOMER'S OBLIGATIONS

6.1. The Customer shall maintain the connection of the Customer's Installation to the Company's Control Equipment and such parts of the ANM Scheme that the Customer is responsible for, as identified in Schedule 4 so that it is fit for the purpose for which it is used, and so that neither it nor its operation or use shall be liable to cause damage to, or interference with, the Distribution System or the National Electricity Transmission System (or their operation or use or the flow of electricity through them) nor affect the sustained operation of the ANM Scheme.

6.2. The Customer shall not change any parts of the ANM Scheme that are the Customer's responsibility without obtaining the prior written consent of the Company.

6.3. The Customer shall notify the Company in writing at least 28 days prior to undertaking any maintenance of those parts of the ANM Scheme that the Customer is responsible for maintaining.

6.4 The Customer shall pay to the Company the Annual Alternative Connection Charge on Energisation and on each subsequent anniversary thereafter in advance in respect of each year of this Agreement. The Company shall issue an invoice for the Annual Alternative Connection Charge each year when the payment is due. Payment must be made within 28 days of the date of the invoice.

6.5 The Annual Alternative Connection is non-refundable in all circumstances including, but not limited to, termination of this Agreement by either Party for any reason.

7. SUBSEQUENT OWNERS

7.1. The Customer covenants that it shall not dispose of any interest in the Premises, the Customer's Installation or the Customer's Generating Equipment unless the Customer has obtained from the proposed transferee of such interest a deed of covenant in a form acceptable to the Company in its sole discretion binding the proposed transferee to this Connection Agreement and provided such deed to the Company. This clause shall not apply to the extent that the proposed transferee does not require the Connection Point to remain Energised.

Signed for : Any Customer LTD	Signed for Western Power Distribution (East Midlands) Plc
Signature ……………………………………………………………….	Signature………………………………………………………………………………
Print Name………………………………………………………………..	Print Name…………………………………………………………………………..
Designation…………………………………………………………….	Designation Contracts and Agreement Manager

SCHEDULE 1 - SPECIFIC TERMS FOR CONNECTION

Characteristics of the supply of electricity: [example data]

<table>
<tr><td>Maximum Import Capacity:</td><td>XXXX kVA</td></tr>
<tr><td>Maximum Export Capacity:</td><td>XXXX kVA</td></tr>
<tr><td>Protected Import Capacity:</td><td>XXXX kVA</td></tr>
<tr><td>Protected Export Capacity:</td><td>XXXX kVA</td></tr>
<tr><td>Import Power Factor (normal operation):</td><td>XX</td></tr>
<tr><td>Export Power Factor (normal operation):</td><td>XX</td></tr>
<tr><td>Voltage:</td><td>XXXX Volts</td></tr>
<tr><td>Phase:</td><td>Three phase</td></tr>
<tr><td>Frequency:</td><td>50 Hertz</td></tr>
<tr><td>Current:</td><td>Alternating</td></tr>
<tr><td>Last In First Off (LIFO) Queue Number:</td><td>x</td></tr>
<tr><td>Last In First Off (LIFO) Generation Breakdown:</td><td>
<table>
<tr><td>Generation Type</td><td>Generation Capacity (MW)</td><td>Number of Connections</td></tr>
<tr><td>Wind</td><td>[ ]</td><td>[ ]</td></tr>
<tr><td>Solar</td><td>[ ]</td><td>[ ]</td></tr>
<tr><td>Synchronous/Other</td><td>[ ]</td><td>[ ]</td></tr>
</table>
</td></tr>
</table>

General

The Customer will pay to the Company the Annual Alternative Connection Charge in accordance with Clauses 3.8 and 6.4 of this Agreement.

The Maximum Import Capacity stated in this Schedule 1 has been requested by the Customer and agreed by the Company.

The Maximum Import Capacity will be fixed from the date that this Connection Agreement takes effect unless increased by agreement between the Customer and the Company.

The Maximum Export Capacity stated in this Schedule 1 has been requested by the Customer and agreed by the Company.

The Maximum Export Capacity will be fixed from the date that this Connection Agreement takes effect unless increased by agreement between the Customer and the Company.

The Maximum Import Capacity, Maximum Export Capacity, Import Power Factor and Export Power Factor may be subject to Curtailment by the Company, as set out in Clause 3 of this Agreement.

Where more than one connection within a given section of the Distribution System needs to be curtailed then the connections shall be curtailed in order, with the last comer being curtailed first and the first comer being curtailed last. When the Distribution System limitation is lifted then the connections are restored to normal in the opposite order, i.e. the first comer is restored first and the last comer is restored last. This principle is known as 'Last In, First Off' (**"LIFO"**). Where a group of connections are handled in this way they deemed to be in the same **"LIFO Queue"**.

The LIFO Queue Number corresponds to the position of the Customer's Installation with respect to other alternative connections in the same LIFO Queue. Alternative connections are constrained off in the reverse order of the LIFO Queue so that connections with a higher LIFO Queue Number will not influence the constraints of the Customer's Installation.

SCHEDULE 2 - CONNECTION POINTS & ASSET USE

Connection Point:

[For example:]

The outgoing terminals of the Company's 33kV metering circuit breaker.

Connection Extension Assets – Relevant Connection Equipment:

[For example:]
33kV switchgear
1 x 33kV cable
Control, protection and metering equipment at Customer's substation
Sole use ANM Assets

Shared Use Reinforcement Assets – Relevant Connection Equipment:

[For example:]
33kV overhead line (3km reinforced)
Shared ANM Assets

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SCHEDULE 3 - GENERATING EQUIPMENT

1. DEFINITIONS

In this Schedule 3, except where the context requires otherwise, the following terms shall have the meanings set opposite them. Other terms which relate to both this Schedule and the National Terms for Connection are defined in the National Terms for Connection.

"**Authorised Person**" a person who has received an Authorisation.

"**Earthing System**" the arrangement of Earthing Electrodes and conductors connecting an electrical network to Earth.

"**Generating Plant**" an installation comprising of one or more Generating Units.

"**Generating Unit**" any apparatus which produces electricity.

"**Interface Protection**" Protection equipment installed to meet the requirements of National Engineering Recommendation G59/1 as may be updated or superseded from time to time.

"**High Voltage**" any alternating voltage exceeding 1000 volts.

"**Island Mode**" an operating mode of a Generating Plant, where the connection between the Company's Distribution System and the Generating Plant is disconnected while the Generator operates.

"**NGC**" National Grid Electricity Transmission plc.

"**On-Site Generator**" a third party, who owns and/or operates a Generating Plant on the Customer's premises.

"**Operation**" a scheduled or planned action carried out on an electrical network.

"**Parallel Mode**" an operating mode of a Generating Plant where the connection is maintained between the Company's Distribution System and the Generating Plant while the Generator operates.

"**Protection**" The provisions for detecting abnormal conditions in an electrical network and initiating fault clearance or actuating signals and indications.

2. The Company consents to the following generators being directly connected to the Company's Distribution System:

Type of Generation	Generation Unit Identification Name and/or Nonmenclature	Generation Unit Manufacturer, Make & Type	Installed Size of Generation (kW/per Unit)	No. of Units	No. of Phases	Commissioning Date	Long / Short Term Parallel or Stand-by Generation
xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx

3. General Conditions for Generation

3.1 Where the Company gives its written consent for a third party (the "On-Site Generator") to connect a Generating Plant to the Customer's Premises the Customer shall:

(a) procure that the On-Site Generator is subject to and complies in all respects with the obligations set out in this Connection Agreement as though it were party to it;

(b) procure that the Company shall have such rights and powers over the On-Site Generator's Plant, Apparatus and Premises as it would have if the On-Site Generator was a party to this Connection Agreement;

(c) ensure that the On-Site Generator does not amend, alter, renew or replace the Generating Plant, Apparatus or associated Protection without the Company's prior written consent; and

(d) Notwithstanding clause 15.4 of the National Terms of Connection, indemnify and keep indemnified the Company against all costs, losses, claims, expenses and/or liabilities that the Company may suffer or incur arising out of or in relation to the On-Site Generator provided that the Customer's liability under this indemnity shall be limited to £1,000,000 per incident or series of related incidents.

3.2 The appointment of the On-Generator shall not relieve the Customer of any obligations under this Connection Agreement, and the acts of omissions of the On-Site Generator appointed in accordance with clause 3.1 shall, for the purposes of this Connection Agreement, be deemed to be acts or omissions of the Customer.

3.3 In addition to the termination rights set out in Clause 19.3 of the National Terms of Connection, the Parties agree that the Company may terminate the Connection Agreement by giving notice of such termination to the Customer in the event that:

(a) the Customer breaches its obligations in clause 3.1 (a) to (c) (inclusive) above; or

(b) any of the events set out in Clause 19.3.3 of the National Terms of Connection occurs in respect of the On-Site Generator.

4. Site Specific Generation Conditions

4.1 The specification of the Customer's Generating Plant is in accordance with Table 1.

4.2 Under the terms of this Connection Agreement the Customer's Generating Plant may operate in Parallel Mode.

4.3 The means of connecting and disconnecting the Customer's Generating Plant is shown on drawing [XXXX].

4.4 The design and installation of the Earthing System for the Customer's Premises is the Customer's responsibility. The Customer may connect the Customer's High Voltage Apparatus to the Company's High Voltage Earthing System. It is the Customer's responsibility to ensure the earthing arrangements are adequate for the Customer's premises and no liability will be accepted by the Company if the Company's Earthing System is used.

4.5 The design and installation of the Protection for the Customer's Generating Plant is the Customer's responsibility.

- The Customer warrants to the Company that the Customer has taken all reasonable measures and in any event acted in accordance with Good Industry Practice to design and install Protection systems which adequately protect the Customer's Plant and Apparatus and the Company's Distribution System.
- The Customer's Protection and control systems shall be designed, operated and maintained so as to safely connect, operate and disconnect the Customer's Generating Plant in accordance with National Engineering Recommendation G59/2 (as may be updated or superseded from time to time).
- Protection settings on the Customer's Plant and Apparatus at the Ownership Boundary and on the Interface Protection shall be agreed with the Company. The agreed Protection and settings are specified in Table 2.
- The Customer shall allow the Company all reasonable access to witness the commissioning of the Customer's Interface Protection equipment when it is initially installed and following any future modifications to the arrangement and Operation of the Generating Plant, or Protection equipment.
- The Customer shall re-test the Interface Protection at intervals not exceeding 3 years. The Customer shall, on request by the Company, provide the Company, within ten (10) working days of the request, with records of the Customer's Protection settings, test results, and any other applicable records, accounts, or documentation.

4.6 In the event that an abnormal operating condition arises on the Distribution System or NGC's transmission system that in the Company's reasonable opinion requires the Customer's generation to be constrained off or export capacity to be reduced the Company shall instruct the Customer to immediately De-energise or implement an immediate reduction to the Maximum Export Capacity ("the Revised Maximum Export Capacity") as appropriate.

- The Company shall use reasonable endeavours to give notice of such an instruction in accordance with the provisions for De-energisation set out under the National Terms of Connection.

4.7 In the event of instruction being given to the Customer in accordance with clause 4.6 above, such instruction may be given verbally or in writing but if given verbally the Company shall confirm this instruction in writing within 2 Working Days of the verbal instruction being made. The Customer shall at the Customer's own expense immediately comply with an instruction howsoever received from the Company, to reduce the Maximum Export Capacity ("the Revised Maximum Export Capacity") at the Connection Point.

- The Customer shall not increase the Revised Maximum Export Capacity until normal operating conditions have been resumed and the Company has given notice to the Customer confirming that the reduction to the Maximum Export Capacity ceases to apply.
- Subject to Clause 15.3 of the National Terms of Connection, the Company shall under no circumstances be liable to the Customer for any costs, damages, expenses, losses (including, without limitation, third party losses, loss of profit or economic loss) incurred for the duration that the Connection Point remains De-energised or the Revised Export Capacity remains in place. The Customer shall indemnify and keep indemnified the Company against all actions, claims, costs, charges and expenses that the Company may suffer or incur arising out of or in relation to the Customer's failure to comply with the provisions of clauses 4.6 and 4.7.

4.8 For the avoidance of doubt, in the event of an Instruction being given to the Customer from the Company's Control Equipment (under normal or abnormal operating conditions on the Distribution System or NGC's transmission system) the provisions of sections 4.6 and 4.7 above will not apply.

TABLE 1: GENERATOR DETAILS

Maximum Fault Contribution From All Generating Units (kA):

Peak asymmetrical short circuit current at 10ms (ip) for a 3phase short circuit fault at the Connection Point	RMS value of the initial symmetrical short circuit current (Ik) for a 3phase short circuit fault at the Connection Point	RMS value of the symmetrical short circuit current at 100ms (Ik(100)) for a 3phase short circuit fault at the Connection Point
xxx	**xxx**	**xxx**

TABLE 2 : INTERFACE PROTECTION

Generator connected at HV [Example data]

Protection Function	CT VT Ratio	Protection Setting	Circuit Breaker Tripped
Over Current Protection	N/A	Ph Flt IDMT OC 0.5A TM=0.16 Std Inv Ph Flt HSOC 1.125A Time=0.05s Def Time Ph Flt DOC 0.275A TSM=0.1 Std Inv Ang=+30deg	Company's 33kV Incoming CB
Earth Fault Protection	N/A	Earth Fault IDMT OC I=0.1A Time multiplier=0.16 Standard Inverse Characteristic	Company's 33kV Incoming CB
Under Voltage Stage 1	N/A	Vn - 13% 2.5s Customer's	Customer's 33kV CB
Under Voltage Stage 2	N/A		Customer's 33kV CB
Over Voltage Stage 1	N/A		Customer's 33kV CB
Over Voltage Stage 2	N/A		Customer's 33kV CB
Under Frequency Stage 1	N/A		Customer's 33kV CB
Under Frequency Stage 2	N/A		Customer's 33kV CB
Over Frequency Stage 1	N/A		Customer's 33kV CB
Over Frequency Stage 2	N/A		Customer's 33kV CB
<Neutral Voltage Displacement>			Company's 33kV Incoming CB
<Rate of Change of Frequency>	N/A		Customer's 33kV CB
<Vector Shift>	N/A		Customer's 33kV CB

Vn = nominal voltage

SCHEDULE 4 – SITE RESPONSIBILITY SCHEDULES

1. DEFINITIONS

In this Schedule 4, except where the context requires otherwise, the following terms shall have the meanings set opposite them. Other terms which relate to both this Schedule and the National Terms of Connection are defined in the National Terms of Connection.
“Authorisation” the formal sanction given in writing to undertake specified tasks that has a specific meaning in Safety Management Systems.
"Authorised Person" a person who has received an Authorisation.
“Control Person” a person who is responsible for controlling and coordinating Operations on an electrical network.
“Equipment” Plant and/or Apparatus.
“Operations” a scheduled or planned action carried out on an electrical network.
“**Protection”** the provisions for detecting abnormal conditions in an electrical network and initiating fault clearance or actuating signals and indications.
“Safety Management System” the procedure adopted by the owner of an electrical network to ensure safe Operation of their electrical network and the safety of personnel required to work on that electrical network.
“Switching Schedule” a schedule which defines the agreed sequence of Operations. Provision is made on the Switching Schedule to allow the name of the operator and the time of Operation to be filled in as they are completed.
“System Control” the administrative and other arrangements established to maintain as far as possible the proper safety and security of the electrical network.
“Company’s Distribution Safety Rules” the Company’s rules and procedures that ensure the safe Operation of the Company’s Distribution System.

2. SYSTEM RESPONSIBILITIES

2.1 The person responsible for coordination of operational safety on the Company’s behalf is either:-

(a) a central Control Person, or

(b) a field Control Person who has been delegated control of part of the Company’s Distribution System by the Company’s central Control Person.

The name of the Company’s Control Person at any particular time can be obtained from the Operations Support Engineer (South West or South Wales call 02920 332887, or for the Midlands area please call 01332 827093) or other revised telephone number advised by the Company in writing.
Alternatively the Customer can write to:

South West / South Wales	Midlands
The Operations Support Engineer	The Operations Support Engineer
Western Power Distribution	Western Power Distribution
Control Centre	Control Centre
Mardy Industrial Estate	Pegasus Business Park
Lamby Way	Herald Way
Rumney	Castle Donnington
Cardiff	DE74 2TU
CF3 2EQ	

2.2 The Customer shall at all times have nominated a person or persons to be responsible for the co-ordination of safety.

2.3 The person responsible for the coordination of safety on the Customer's behalf ("the Customer's Safety Coordinator") is:-

[insert details]

2.4 Operational liaison shall be between the Company's Control Person and the Customer's Safety Coordinator.

3. OWNERSHIP BOUNDARY

3.1 The Company's responsibility for the Connection ends at the Connection Point. The Customer is responsible for providing the installation beyond this point in conformity with the appropriate Regulations and the terms of this Connection Agreement.

3.2 Where the Company agree to provide Protection for the Customer's Installation it shall remain the Customer's responsibility to ensure that the Protection the Company provide is adequate. The Company will provide details of the Protection utilised upon written request.

3.3 Ownership responsibilities are in accordance with Table A.

3.4 Each Party shall allow the other Party's representatives reasonable access to its Equipment for testing of Protection, Metering and Metering Equipment.

4. SAFETY MANAGEMENT SYSTEM

4.1 The Company's Control Person and the Customer's Authorised Person shall agree who is to carry out the Operations and the Safety Management System to be used, which shall as a minimum default to the Company's Distribution Safety Rules and to the Company's standard technique, ST:OS6E/2 (as updated or superseded from time to time) relating to "Safety Co-ordination at the Interface between the Company and Customer's Networks".
4.2 The Company's Control Person and the Customer's Authorised Person shall agree the switching Operations to be undertaken in accordance with the Switching Schedule.
4.3 All Operations shall be carried out under the respective System Control.

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TABLE A - RESPONSIBILITY SCHEDULE

Substation Name XXX

Substation Number XXXX

Equipment Number and/or nonmenclature	**Responsible Company**			
	Ownership	**Control**	**Operation**	**Maintenance**
Metering Circuit Breaker	COMPANY	COMPANY	COMPANY	COMPANY
Metering Unit	COMPANY	COMPANY	COMPANY	COMPANY
Outgoing Switch	CUSTOMER	CUSTOMER	CUSTOMER	CUSTOMER
Telecontrol Unit	COMPANY	COMPANY	COMPANY	COMPANY
110V Batteries/ Charger	COMPANY	COMPANY	COMPANY	COMPANY
48V Batteries/ Charger	COMPANY	COMPANY	COMPANY	COMPANY
Protection Panel	COMPANY	COMPANY	COMPANY	COMPANY
Signal Exchange Box	COMPANY	COMPANY	COMPANY	COMPANY
Voltage Transformer Cubicle	COMPANY	COMPANY	COMPANY	COMPANY
Security and Fire Alarm	COMPANY	COMPANY	COMPANY	COMPANY
Heating and Lighting	COMPANY	COMPANY	COMPANY	COMPANY
Low Voltage AC Supply	COMPANY	COMPANY	COMPANY	COMPANY
33kV Interconnecting Cable	CUSTOMER	CUSTOMER	CUSTOMER	CUSTOMER
Company Control Equipment	COMPANY	COMPANY	COMPANY	COMPANY

SCHEDULE 5 - SITE SPECIFIC OPERATING ARRANGEMENTS

The voltage flicker caused by the operation of the Customer's Installation shall be limited to the stage 2 limits of Engineering Recommendation P28 at the point of common coupling.

The generators shall be controlled such that it is possible, if so required, to introduce a minimum period of one minute between the start or restart of each generator.

The Company has consented that the Generator Unit(s) listed under Schedule 3 be directly connected to the Company's Distribution System. It is a requirement that the Maximum Export Capacity given under Schedule 1 shall under no circumstances be exceeded and the Customer agrees to constrain any export energy below this limit by means of an automatic management system.

The Customer's Installation should comply with the requirements of:

> Energy Networks Association Engineering Recommendation G5/4 - ”Planning Levels for Harmonic Voltage Distortion and the Connection of Non-linear Equipment to the Transmission Systems and Distribution Networks in the United Kingdom” (as may be updated or superseded from time to time);
>
> Energy Networks Association Engineering Recommendation P28 - "Planning Limits for Voltage Fluctuations caused by Industrial, Commercial and Domestic Equipment in the United Kingdom" (as may be updated or superseded from time to time); and
>
> Energy Networks Association Engineering Recommendation P29 - "Planning Limits for Voltage Unbalance in the United Kingdom" (as may be updated or superseded from time to time).

The Company shall give notice to the Customer whenever it considers it appropriate to do so, requesting the Customer to restrict the generator export or disconnect the generator from the Distribution System when abnormal running arrangements are in force. The Customer shall at its own expense comply with any notice given by the Company.

When exporting energy onto the Company's Distribution System the Customer shall, at all times and at its own expense, take all reasonable precautions to ensure that the Customer's site export operates as near as practicable to unity power factor (unless instructed to the contrary under Clause 3.2). Notwithstanding this requirement the export or import of reactive power to the Distribution System shall be permitted under transient conditions provided that the power factor of the exported is no less than 0.95 leading and unity. Generator plant and equipment must comply with the requirements of the Electricity Supply Industry's Engineering Recommendation G59/2 'Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators' (as may be updated or superseded from time to time).

The 33kV connection is made as a single connection between the Company's 33kV network and the Customer's Installation through one Connection Point. For the avoidance of doubt, no alternative connection at 33kV will be provided and the Company does not guarantee that the customer will be able to export electricity through the Connection Point at all times. The ability to export, is conditional upon the Connection Point being Energised - in accordance with the terms of this Agreement

The Connection Site is to be operated strictly in accordance with the provisions and requirements of the Electricity Supply Industry's Engineering Recommendation G59/2 entitled "'Recommendations for the connection of generating plant to the distribution systems of licensed distribution network operators' operators' (as may be updated or superseded from time to time) or other reasonable provisions as may, from time to time, be required by the Company.

The Company accepts the inclusion of its connection point circuit breaker and its associated protection in the Customer's protection scheme for the site. The inclusion of the Company's own equipment and protection into the Customer's protection scheme is the responsibility of the Customer and this facility is provided entirely at the Customer's risk. The Company shall provide the customer with details of the protection settings employed at the connection point circuit breaker. It is the Customer's responsibility to ensure that these settings provide adequate protection of the Customer's plant and apparatus.

SCHEDULE 6 - ACCOMMODATION

The Customer will provide accommodation to the Company's specification as referred to below, such accommodation to be located on the land shown coloured pink on the attached Drawing Number XXXXXX

As the Customer's Connection is or will be at High Voltage (i.e. exceeding 1,000 volts AC), the Customer shall provide, without cost to the Company:

(a) Accommodation on the Premises (where appropriate, as specified in this Schedule) in accordance with the Company's requirements for the Company's Equipment, and (where appropriate) with separately located accommodation for the Company’s Control Equipment, Metering Equipment, cable termination and ancillary equipment; and

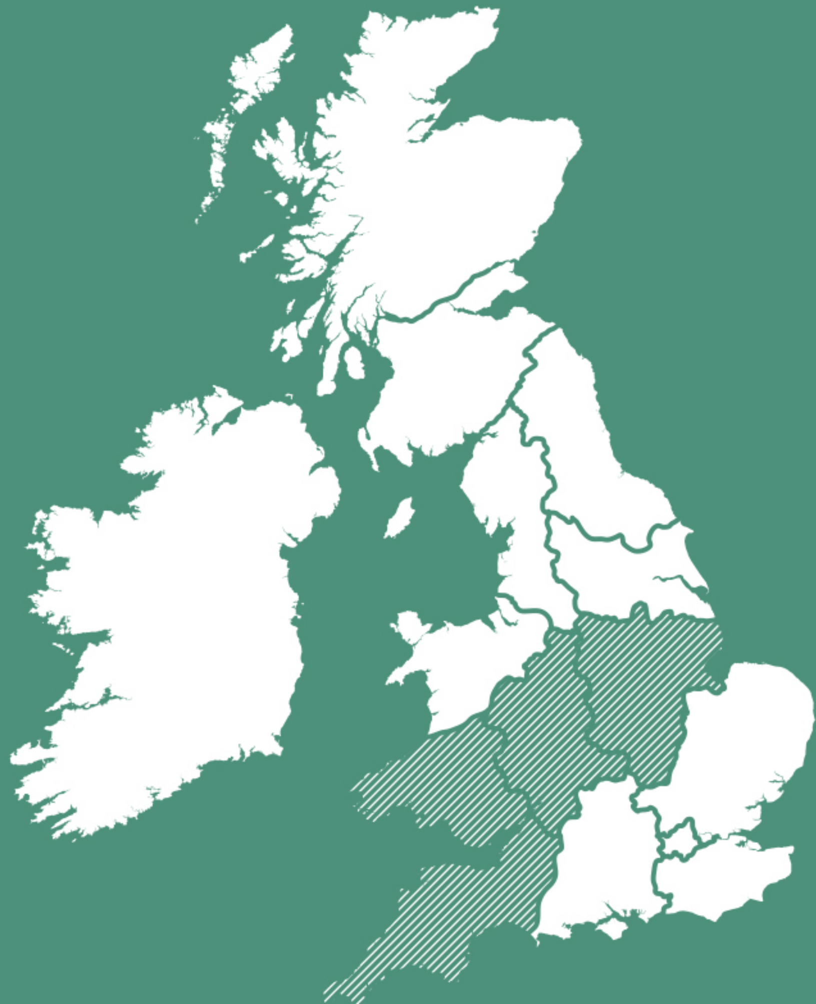
(b) where required, a 30mA RCD protected dual switch socket outlet, a luminaire and space heating to a minimum standard so as to give frost protection together with a 230 volt electricity supply; and the Customer will keep in good order repair and condition all parts of the accommodation including the interior surfaces and any boundary fences and/or cladding which enclose the accommodation.

Appendix E – Network Management Specifications for Tender

WESTERN POWER DISTRIBUTION
INNOVATION

NEXT GENERATION NETWORKS

Active Network Management
Specifications for Tender



LCN Fund
Low Carbon Networks

WESTERN POWER DISTRIBUTION
INNOVATION

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WESTERN POWER DISTRIBUTION INNOVATION

Active Network Management Tender

1. Background

In September 2013, Western Power Distribution went out to tender for an Active Network Management (ANM) system for use on the Lincolnshire Low Carbon Hub project.

The tender process was undertaken to select an ANM system using a robust, fair and consistent methodology to compare competing suppliers on the open market. An invitation to tender was distributed to all suppliers registered in the Achillies system against the following categories: XXXXXXX.

2. Selection

The winning supplier was awarded based upon evaluation criteria covering Technical Fit, Service Levels and Delivery and Financial and Commercial.

3. Specification

Western Power Distribution (WPD) requires the ability to actively manage generation new generation connections to ensure the network will continue to operate within its operational limit. Thermal and voltage constraints are a barrier to generator connection on the 132kV, 33 kV and 11 kV networks, the existence of an Active Network Management (ANM) infrastructure provides the opportunity to further control generators when these constraints arise and avoid network reinforcement.

An Active Network Management (ANM) scheme being tendered should mitigate Thermal constraints on a double circuit 132kV circuit with Dynamic line rating installed, Voltage constraints on 33kV circuits, maintaining the system within statutory limits and Thermal constraints on the 33kV circuits.

Key performance requirements for the system should be:

- Real time analysis of Thermal Limits
- Real time analysis of Voltage Limits
- Data collection and management of remote monitoring points
- Integration of real time dynamic line ratings into network models
- Ability to curtail generators off of the network
- Ability to send curtailment signals to ramp the generators down
- Ability to send a power factor set-point signal to the generator
- Ability to perform analysis on complex electrical networks involving double circuits
- Management of multiple generators according to both technical constraints and commercial rules
- Fail-safe disconnection of generators during communication and/or management system outages
- Expandable and scalable system
- SCADA compatible

The Active Network Management scheme will be required to control all new distributed generation over 250kVA and should be installed and operational no later than 31st March 2014.

The tender should cover only the design, documentation, supply, hardware installation (optional) and 2nd level support.

WPD reserves the rights to perform the installation of the ANM hardware. WPD will be responsible for limited 1st level support.

4. Specific Questions

4.1. Technical Fit

1. What are the physical footprints of your proposal and are there any limitations where the physical assets can be located?
2. How does your proposal ensure any equipment of software failures does not lead to an increased level of network risk, specifically thermal and voltage violations?
3. Can you incorporate dynamic line ratings into your Active Network Management Scheme as an alternative for fixed thermal ratings?
4. Does the dynamic line rating need to be conducted with the proposed ANM scheme – can this be calculates from other equipment and provided as a continually changing thermal limit?
5. What is the speed of the system response and generation control?
6. What is your expected system reliability and maintenance profile?
7. Can your proposal interface with GE's POWERON, a network management system used by Western Power Distribution?
8. Have you demonstrated this proposal or a similar proposal before for distribution network operation?
9. What communications protocol does your proposal require?
10. Can the existing network transducers be utilised in your proposal or do you require additional transducers to be installed?

4.2. Service Levels and Delivery

11. What is the lead time from a Purchase order to a working Active Network Management scheme? Can you confirm that the equipment can be installed and operational no later than 31st March 2014.
12. What maintenance packages do you offer?
13. What strategic spares do you hold in the UK, what is the lead time on strategic spares?
14. How much notice is required for new generation connections?

4.3. Financial and commercial

15. Will there be a reduction in cost if future systems are installed across the Western Power distribution licence areas?
16. Please confirm that you have read, understood and agree to abide by the attached terms and conditions (within the Contract document – Appendix 5).
17. Please insert your full and complete price schedule. Please provide a detailed cost breakdown of the equipment, services, applications etc., including delivery costs, into Schedule 4 of the Tender document.

WESTERN POWER DISTRIBUTION INNOVATION

5. Post Tender Learning Points

A number of issues have arisen and been resolved following the tendering process. The following are a selection of the highest priority issues (in no particular order).

- Batteries/Power supply resilience
  Local supplies are required for the generators and ANM equipment, is resilience required and are these derived from AC or DC supplies

- Constraint tools must fit the application
  Curtailment assessments carried out will either need to fit in the with ANM system principles of access and information gathering, or vice versa.

- Internet access/third party support
  What level of remote access is required and does this fit in with company Distribution Safety Rules?

- Interface of third party generators
  Which interfaces are supported and which generators/inverters are preferred.

- Communication mediums
  What are the requirements for communications between the system parts?

- Active vs apparent power managment
  It may not be necessary to manage VArs if other devices are present on the network which handle that function (D-VAr, Statcom) or if not required for the network (thermal limits).

6. Contact Details

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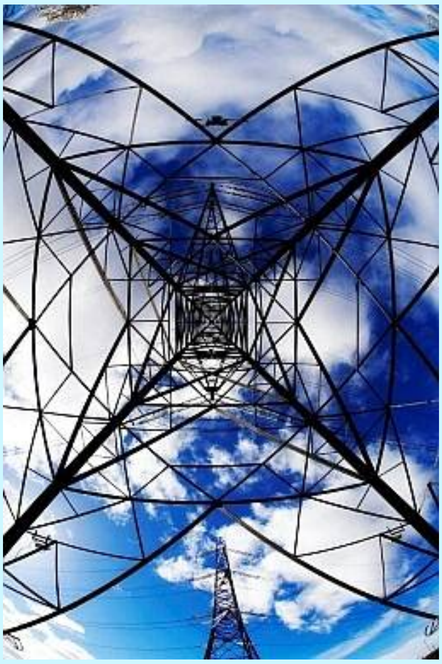
Appendix F - TNEI LLCH Constraint Analysis Tool Close Out Report

tnei
enterprise with energy



Title: LLCH Constraint Analysis Tool Close Out Report

Client: WPD Limited

Report Nº: 8557-01-R1

Date: 3rd February 2015

Part of the Petrofac Group

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CONTENTS

1 Introduction

The LLCH Constraint Analysis Tool has been developed as part of Western Power Distributions' (WPD) Lincolnshire Low Carbon Hub (LLCH) project. The Constraint Analysis Tool is intended to calculate the level of curtailment imposed on a generator due to the limitations of the network it is connected to. The tool mirrors the Skegness 33kV network which is the subject of the wider LLCH project.

The traditional approach to distribution network planning typically ensures that the network can operate within limits under a wide variety of operating scenarios, such as network configuration, demand and generation levels. Network reinforcements to ensure that overloads or voltage limit violations do not occur as a result of the new generation may be required.

The alternative approach to installing network reinforcements is to curtail the output of a generator during periods when the network would be operating outside normal limits.

The Constraint Analysis Tool performs network analysis to determine the level of curtailment imposed on a generator due to the network constraints. The analysis is based on 18 months of historical demand data for the LLCH network together with an accurate network model of the Skegness distribution system. A set of calculations are performed with the addition of a proposed generation connection. Each calculation identifies if the proposed generator causes a network constraint, if so then the generator output is curtailed until the network constraint is removed. The results presented detail the amount of generator curtailment required to ensure that no network constraints are introduced by that generator.

2 Project Overview

2.1 WPD Requirements

WPD requested that TNEI develop a web based tool to allow generators to quickly and easily determine the approximate level of curtailment that could be expected for a non-firm generator connection to the network covered by the LLCH project.

The tool was required to allow users to determine constraint volumes for generators connecting to any of the 33kV Skegness system circuits. The principal requirements were determined to be:

- The tool should be accessible through a dedicated website
- Provide a geographic map view of the analysis area
- Allow developers to connect a generator at any location inside the analysis area
- Perform the required constraint analysis for the requested generator location
- Present the constraint results to the developer
- Allow the results to be saved for future use.

In addition to the above WPD also requested that a standalone version of the analysis tool was developed in order that WPD planners may replicate the web based studies in-house.

The network constraints were specified as both thermal overloads and voltage violations in the 132kV and 33kV Skegness network group. The analysis was to be undertaken for 18 months of half-hourly demand data which included the nine separate Skegness group substation loads.

Existing generation was also to be included in the analysis network together with representative half-hourly generation output data, for example solar profiles used for PV farms.

2.2 TNEI Scope

TNEI Services were commissioned by WPD to undertake the following activities:

- Develop the analysis code
- Develop the web site
- Develop the in-house analysis tool
- Perform testing activities to confirm that the web tool and in-house tool produced consistent results
- Maintain both tools for the duration of the project

It was identified that the best way of running the web site tool would be for TNEI to undertake all web development and hosting activities. To this end TNEI rented a web server and purchased the www.lincolnshirelowcarbonhub.co.uk domain name for the purposes of making the tool readily accessible to potential developers.

TNEI were then responsible for the development of the web site and associated databases and interfaces to the analysis code.

The core analysis tool used was Ipsa 2 which is developed by TNEI for the analysis of distribution systems such as Skegness and used by several DNOs. Ipsa 2 was integrated into both the web tool and the in-house tool to perform the constraint analysis calculations.

Testing activities were undertaken to ensure that the results from both versions of the tool were identical and reasonable.

2.3 Smarter Grid Solutions Scope

TNEI commissioned Smarter Grid Solutions to perform a set of validation studies using their own in-house techniques and the web based tool. This ensured that the analysis technique developed for this project produced sufficiently accurate results when compared to an alternative independent technique.

3 Web Based Tool

3.1 Requirements

The functional requirements of the web based tool are summarised as follows:

- Easy and accessible for developers to use
- Model the addition of a single generator to the Skegness network
  - Wind, solar and synchronous generator types permitted
  - Ratings from 2MW to 30MW
  - Generator connected to the nearest 33kV circuit
  - Typical generator profile data used
- Analysis undertaken for 18 months of demand data
- Analysis undertaken with and without smart grid options
- Sufficiently accurate so as to provide estimates of generator curtailment to within 5%
- Results presented to the users in a clear manner
  - Totalised annual results for generated and curtailed energy
  - Minimum, maximum and average generation output
  - Monthly results for generated energy
  - Monthly results for hours curtailed

3.2 Web Site Design

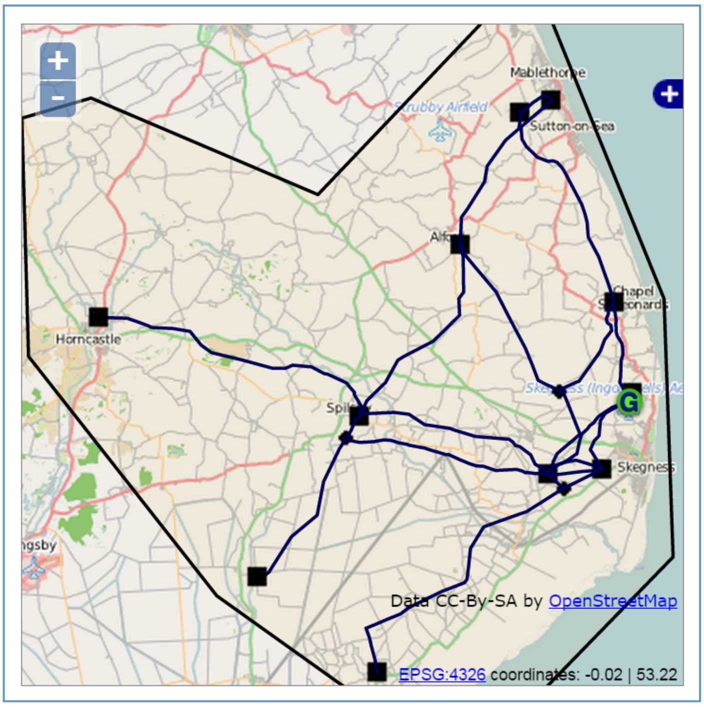
TNEI were requested to develop and host the web site independently of WPDs IT department. This allowed TNEI to configure the web server and its software quickly and easily.

The web site itself was written in html, JavaScript and PHP. User data and analysis study requests were stored in an SQL database. This enabled users to view the results of previous studies as required. Users with administrator rights are able to view all the user accounts.

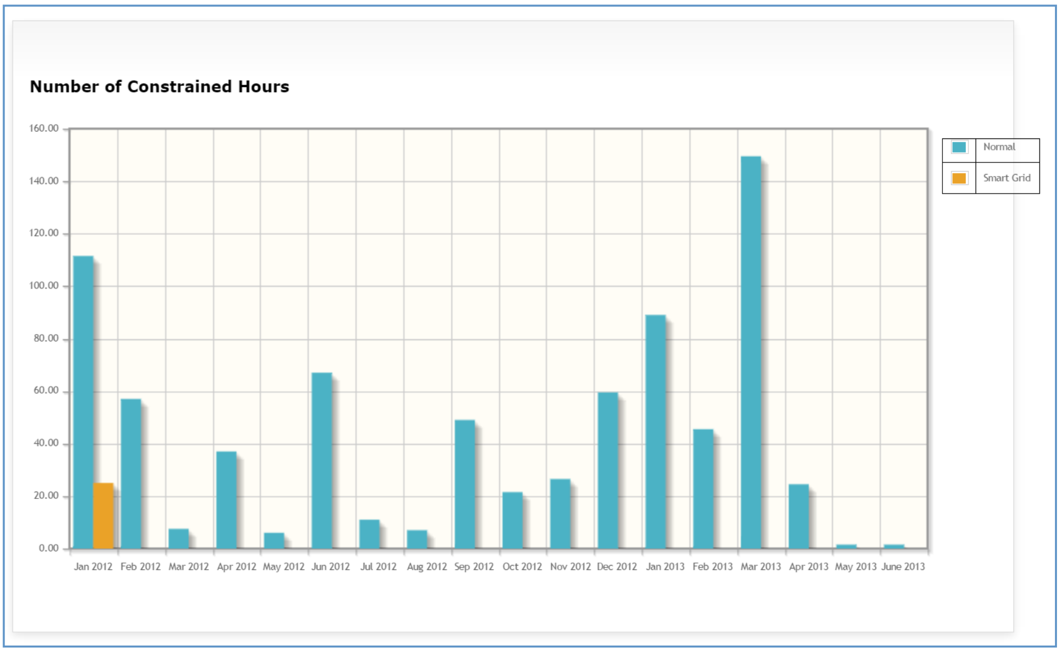
The web site incorporated geographic maps from the OpenStreetMap website. The geographic map allowed users to specify the generator location by clicking on the map itself. This resulted in a generator symbol being placed on the map.

The 33kV overhead line routes and 33kV substation locations were superimposed on the map for reference. In addition the geographic extent of the LLCH area was added. This prevented users from placing generators outside the LLCH zone.

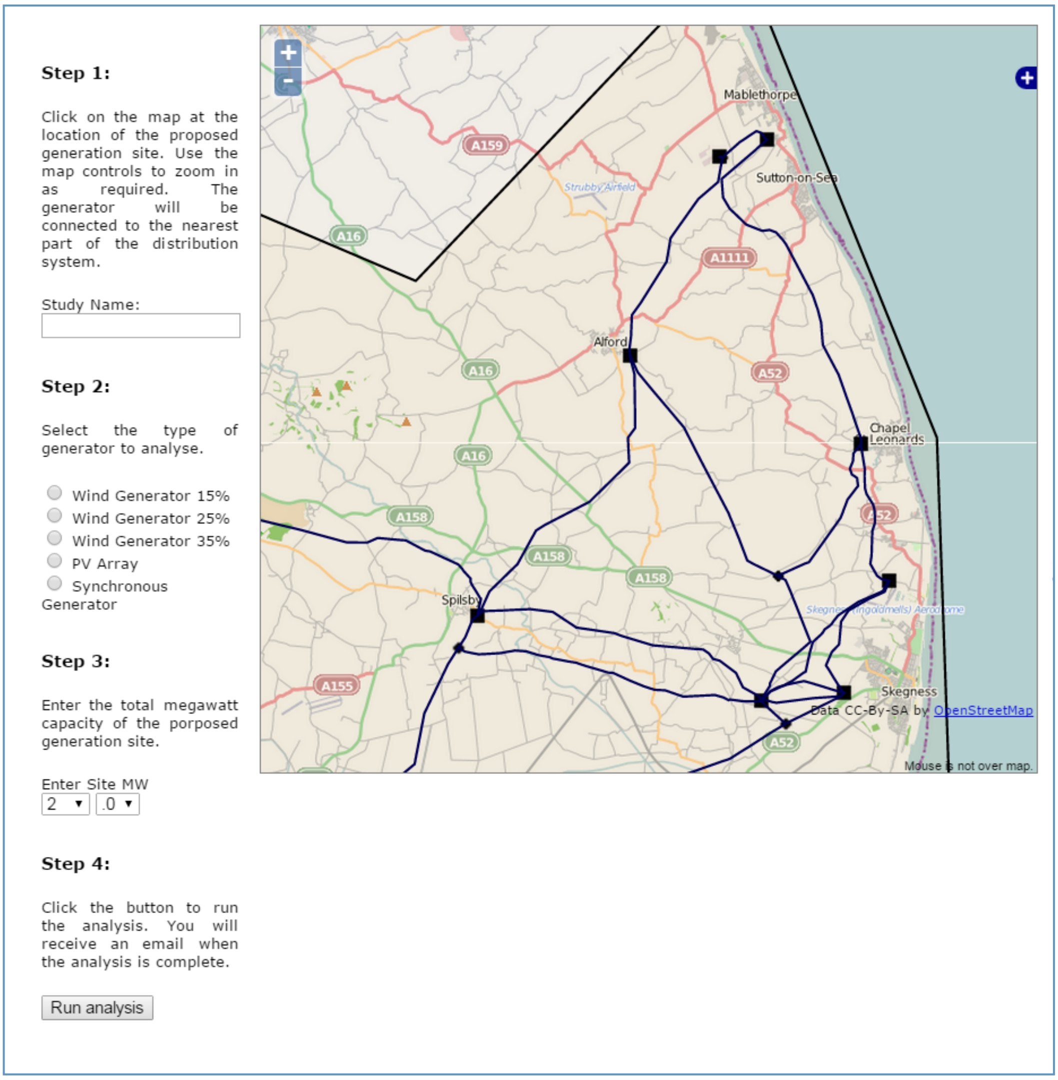
Zoom and pan controls were also enabled on the map resulting in the maps being presented as follows:



A graphing library was also used to plot the results in bar chart format as shown below:



The various controls allowed users to specify the generator parameters as well as the generator location. The data entry is simple and straightforward requiring only a generator name, location, rating and type. These controls are shown below:



Clicking the 'Run analysis' button saves the users generator data in the SQL database and returns the users to different web page showing an overview of the analysis studies they have undertaken:

View previous analysis results

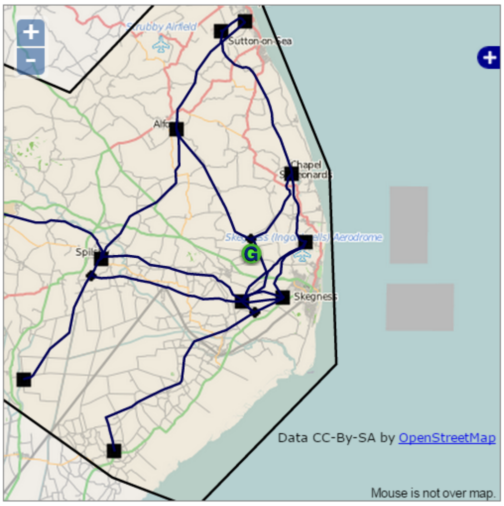
Study Name	Id	Latitude	Longitude	Generator Type	Rated MW	Status	Delete
Validation Study 7	84	53.176252	0.329701	Synchronous Generator	25	Click to view results	Delete
Validation Study 1	88	53.325947	0.263676	Wind Generator	25	Click to view results	Delete
Validation Study 2	89	53.325966	0.263708	PV Array	25	Click to view results	Delete
Validation Study 3	90	53.088568	0.018865	Wind Generator	25	Click to view results	Delete
Validation Study 4	91	53.088388	0.018908	PV Array	25	Click to view results	Delete
Validation Study 5	92	53.32554	0.264287	Wind Generator	25	Click to view results	Delete
Validation Study 6	93	53.181165	0.269577	Synchronous Generator	25	Click to view results	Delete
Validation Study 7	94	53.176239	0.329368	Synchronous Generator	25	Click to view results	Delete
abc	95	53.285863	0.260512	Wind Generator	5	Click to view results	Delete
Latest Study	154	53.24074	0.235392	Wind Generator 15%	15	pending	Delete
Latest Study	155	53.246985	0.208613	Wind Generator 15%	15	pending	Delete

The constraint analysis is then run in the background on the web server. Once the analysis is complete the user can view the results. These are displayed in tabular and graphical format as summarised below:

Constraint Results Summary

Analysis Summary

Study Name	fred	
Generator Location (latitude, longitude)	53.172394	0.271937
Connection Location (latitude, longitude)	53.17396355	0.2786898244
Connection Distance	0.4829	km
Generator Type and Rating	Wind Generator	2 MW



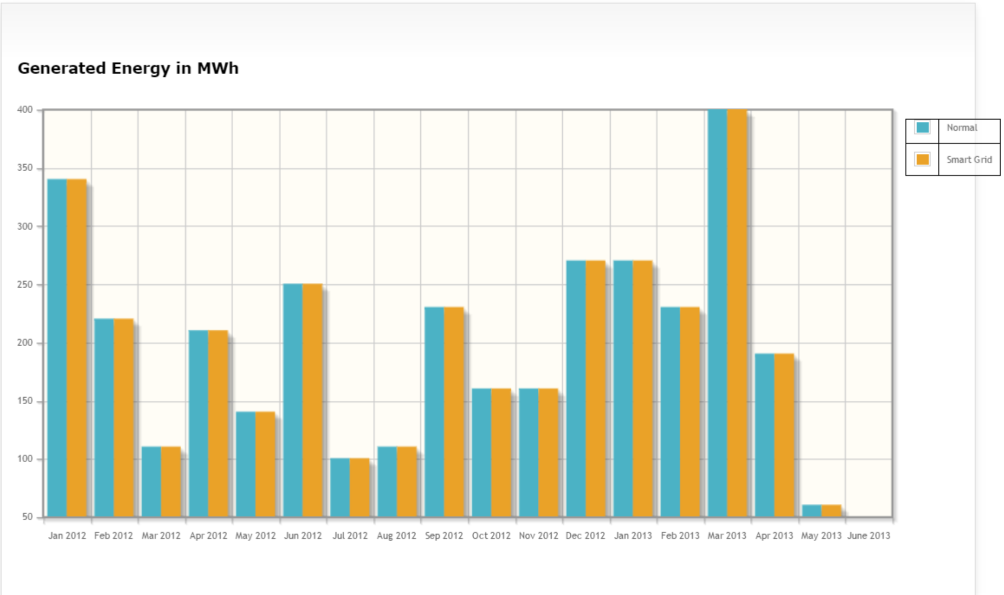
Results Summary

Result	No Smart Grid Options	With Smart Grid Options	
Generator Maximum Output	2.00	2.00	The maximum, minimum and average generator mega watt (MW) outputs over the analysis period. This is calculated from the generator profile after the generator has been constrained.
Generator Minimum Output	0.00	0.00	
Generator Average Output	0.27	0.27	
Annual Energy Generated	2300.0MWh p.a. to 2310.0MWh p.a. in 2012	2300.0MWh p.a. to 2310.0MWh p.a. in 2012	The total energy exported by the generator per annum in mega watt hours (MWh).
Annual Constrained Energy	0.0MWh p.a. to 10.0MWh p.a. in 2012	0.0MWh p.a. to 10.0MWh p.a. in 2012	The total energy the generator was prevented from exporting due to network constraints. Given in mega watt hours per annum (MWh p.a.)
Network Constraint Level	0.0% to 2.5%	0.0% to 2.5%	The percentage of the year when the generator is prevented from exporting electricity to the network.

Please note that this analysis is based on ½ hourly average data and will not account for transients in the distribution system that cannot accurately be estimated through an online modelling tool.

Please note that this online tool does not include outages for faults or planned maintenance.

This graph details the energy in mega watt hours per month that the proposed generator can export to the network.



3.3 Web Tool Analysis

3.3.1 Structure

The underlying analysis tool comprises three components:

- Power flow calculation software
    - This performs the underlying power flow calculations to determine the network voltages and power flows. The commercially available

Ipsa 2 package, developed by TNEI, is used for the power flow analysis

- Custom analysis code
  - Python based interface code was developed to perform the constraint analysis
  - This code implemented the constraint algorithm and calculated the various results
- Web database interface code
  - A Python script was required to periodically check the web site data base for new analysis requests and launch new analysis runs
  - Results from the analysis were then pushed into the web site database for displaying on the web page

3.3.2 Operation

The underlying constraint analysis identifies network constraints and then reduces the output of the proposed generator in order to mitigate the constraint. The constraints identified are:

- Steady state voltage violations
  - At 33kV and 132kV
  - Voltage limits of +/-10% at 132kV
  - Voltage limits of +/-6% at 33kV
- Thermal limits
  - Winter and summer kA and MVA ratings of overhead lines
  - Winter and summer MVA ratings of transformers

The analysis performs the following operations:

1. Add the proposed generator to the network
2. Apply the selected generator profile
3. Perform power flow analysis for all values of demands
   a. This is based on 18 months of half hourly data
4. Identify network constraints
5. Reduce the generator output when network constraints are identified
6. Repeat the power flow analysis (steps 3, 4 and 5) until all network constraints are removed
7. Report the results to the user

These operations are described in the following sections:

3.3.3 Add Generator to Network

The generator location is determined by a map location provided in latitude and longitude co-ordinates. In order to add the generator to the underlying power system model a conversion was required from the map co-ordinates to a specific pole and branch in the network.

This required that the latitude and longitude co-ordinates of every pole on the 33kV overhead lines was stored. This data set was then searched to identify the nearest pole in the network to connect the generator to.

The distance between the pole and the generator was then calculated enabling the interconnecting cable to be connected onto the closest branch in the power system model.

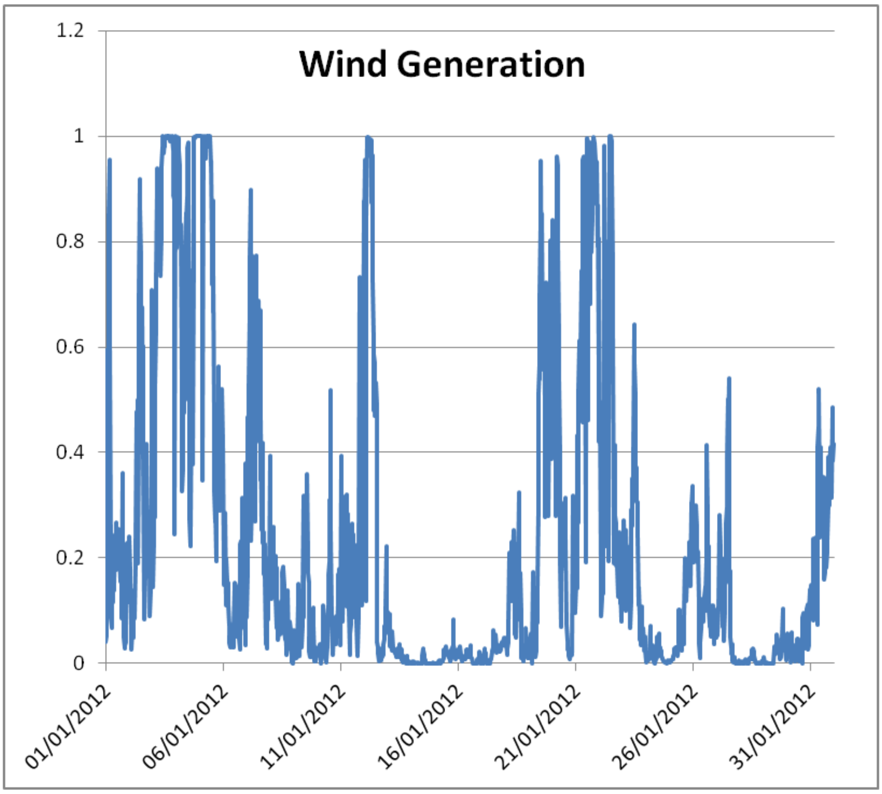
3.3.4 Generator Profiles

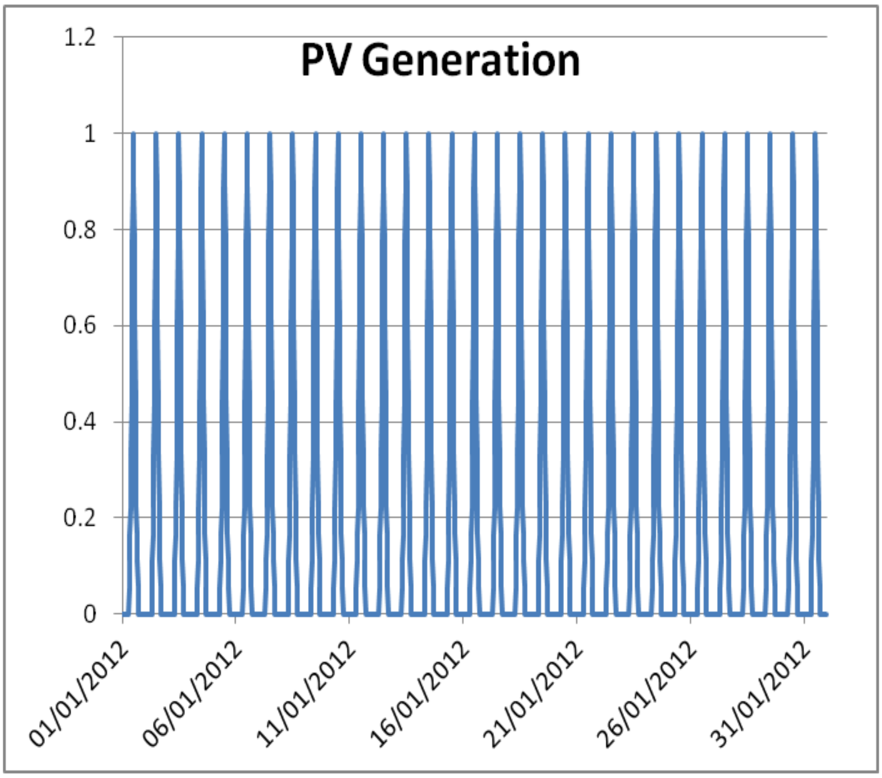
In order to allow different types of generators to be modelled five different generator output profiles were provided:

- Synchronous generator
  - Constant output at full generator rating
  - Allows the maximum possible constraints to be identified for a particular generator connection
- Solar PV
  - Only generating during day light hours
- Three wind profiles
  - Derived from historical wind speed data at Skegness meteorological station
  - Wind speed data was passed through a typical wind turbine power – speed characteristic to calculate the power output for a full year
  - This output profile was then scaled to give an annualised average output of 15%, 25% and 35%

The typical wind and PV profiles are shown below. The generator outputs are in per unit, effectively giving a factor to multiply by the generator rating.

It should be noted that the generator profiles did not include any allowance for diversity, for example all wind profiles had peaks occurring at the same times.


Wind Generation
1.2
1
0.8
0.6
0.4
0.2
0
01/01/2012
06/01/2012
11/01/2012
16/01/2012
21/01/2012
26/01/2012
31/01/2012


PV Generation
1.2
1
0.8
0.6
0.4
0.2
0
01/01/2012
06/01/2012
11/01/2012
16/01/2012
21/01/2012
26/01/2012
31/01/2012

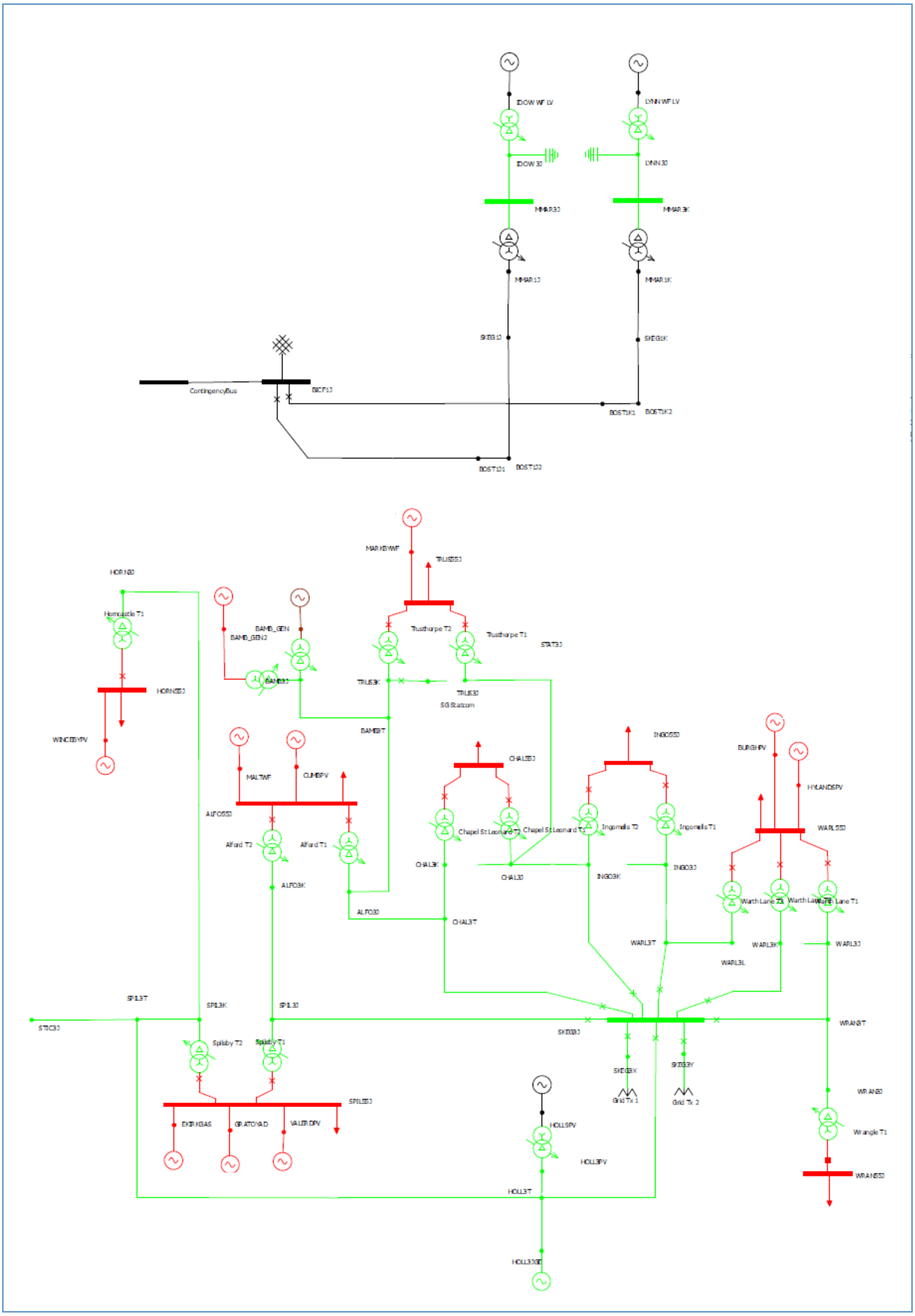
3.3.5 Power Flow Analysis

The power flow network represented the 132kV and 33kV Skegness distribution system. The 33kV to 11kV transformers were modelled with a bulk demand included at 11kV.

In order to provide a comparison between the existing WPD network and a 'smart grid' network, two different network models were used for the analysis. The smart grid network contained the following additional features that were implemented as part of the wider LLCH project:

- 3.75MVAr STATCOM device at Trusthorpe
- Operation of the network as a ring system by closing a bus section circuit breaker at Trusthorpe
- Active network management scheme to adjust:
    - 132/33kV grid transformer target voltages
    - Adjust generator power factors during network constraints

The network diagram is shown below:



In order to determine the constraints over a full year each load and generator in the network were assigned profiles. Each profile comprised a full year of MW and MVAr values for every half hour, a total of 26280 values per substation.

The generation profiles were determined as described in section 3.3.4 and applied to the proposed and all existing generators.

The 11kV demands were determined from SCADA data provided by WPD for 2012 and the first 6 months of 2013. This SCADA data was used directly in the network analysis without any data cleansing being undertaken. Checks were undertaken to ensure that the data was free from obvious errors.

With profiles assigned to all loads and generators then a power flow calculation was performed for each of the 26280 points in the profiles, one for every half hour of the year. This part of the analysis was performed exclusively by Ipsa 2.

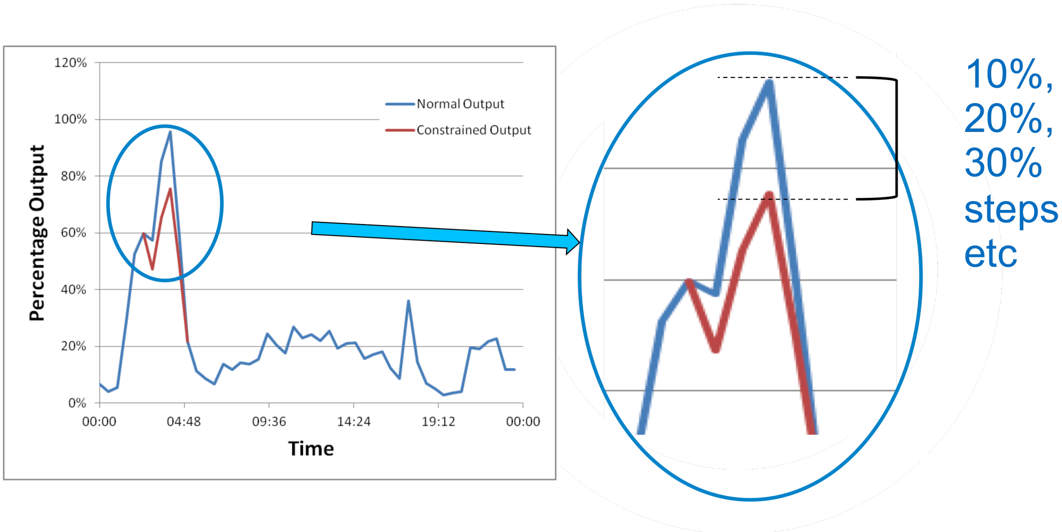
The results of this analysis comprised all the network constraints identified by Ipsa 2 for the profile data analysed.

3.3.6 Apply Generator Curtailment

The proposed generator was then curtailed whenever a network constraint was identified. The curtailment was applied to the generator for the same half hour period as the network constraint.

A simplified curtailment mechanism was used whereby the generator output was reduced in 10% steps. This gave a robust but slightly less than optimum solution as the generator would typically be curtailed more than required. This was not considered to be a significant issue as the results are based on historical wind speed and demand data, therefore the practical constraint levels would be expected to differ regardless.

The following diagram shows the effect of applying a generator constraint:



The generator constraint and network analysis was repeated until all network constraints were removed or the generator output was at 0%. Once this analysis was complete the results were processed.

3.3.7 Results

On completion of the constraint analysis the following results were calculated:

- For each month
    - Number of hours during which curtailment was applied to the generator
    - Energy curtailed in MWh
    - Energy generated in MWh
    - Minimum, maximum and average generation outputs
- For the full analysis year
    - Annual energy curtailed in MWh
    - Annual energy generated in MWh
    - Minimum, maximum and average generation outputs
    - Percentage network constraint (percentage of hours in the year during which constraints are applied to the generator)

These results were inserted into the web site data base in order that they could be displayed on the results web page.

As the analysis was based on historical demand data any results produced may not accurately reflect future performance. Therefore all results were rounded off and presented as a range of values.

For the energy results in MWh the results were presented to the nearest 10MWh. The level of network constraints was presented to the nearest 2.5%, as shown in the results table below:

Results Summary

Result	No Smart Grid Options	With Smart Grid Options	
Generator Maximum Output	2.00	2.00	The maximum, minimum and average generator mega watt (MW) outputs over the analysis period. This is calculated from the generator profile after the generator has been constrained.
Generator Minimum Output	0.00	0.00	
Generator Average Output	0.27	0.27	
Annual Energy Generated	2300.0MWh p.a. to 2310.0MWh p.a. in 2012	2300.0MWh p.a. to 2310.0MWh p.a. in 2012	The total energy exported by the generator per annum in mega watt hours (MWh).
Annual Constrained Energy	0.0MWh p.a. to 10.0MWh p.a. in 2012	0.0MWh p.a. to 10.0MWh p.a. in 2012	The total energy the generator was prevented from exporting due to network constraints. Given in mega watt hours per annum (MWh p.a.)
Network Constraint Level	0.0% to 2.5%	0.0% to 2.5%	The percentage of the year when the generator is prevented from exporting electricity to the network.

The results for both the existing and smart grid networks were presented side by side on the web site for comparison purposes.

4 Desktop Tool

4.1 Requirements

In addition to the web based tool WPD requested that a desktop version was also developed to allow planners to perform their own specific studies. The desktop tool therefore replicated all the basic functionality of the web tool but with the following enhancements:

- Specify connection location by busbar or branch as opposed to co-ordinate
  - Including user defined connection distances and cable types
  - User defined profile types
  - No geographic maps were included in the desktop version
- Specify multiple generators to include in a LIFO stack (last in first off)
- Perform analysis for a particular month as opposed to the full 18 months
- Ability to change the various analysis settings:
  - Generator constraint step size (set to 10% in the web tool)
  - Specify different voltage limits
  - Specify which branch ratings to use for each analysis month
  - Specify which profile to use for each generator
  - Specify which smart grid options to include
  - Scale all network loads up or down
  - Take network outages
- More detailed results:
  - Identify which network components were causing the constraints
  - Identify the magnitude of overloads or voltage violations
  - Identify reverse power flow through transformers

The desktop analysis tool was, for speed of development, implemented in an Excel spreadsheet. The spreadsheet was designed to run the analysis code which was contained in a separate packaged software module.

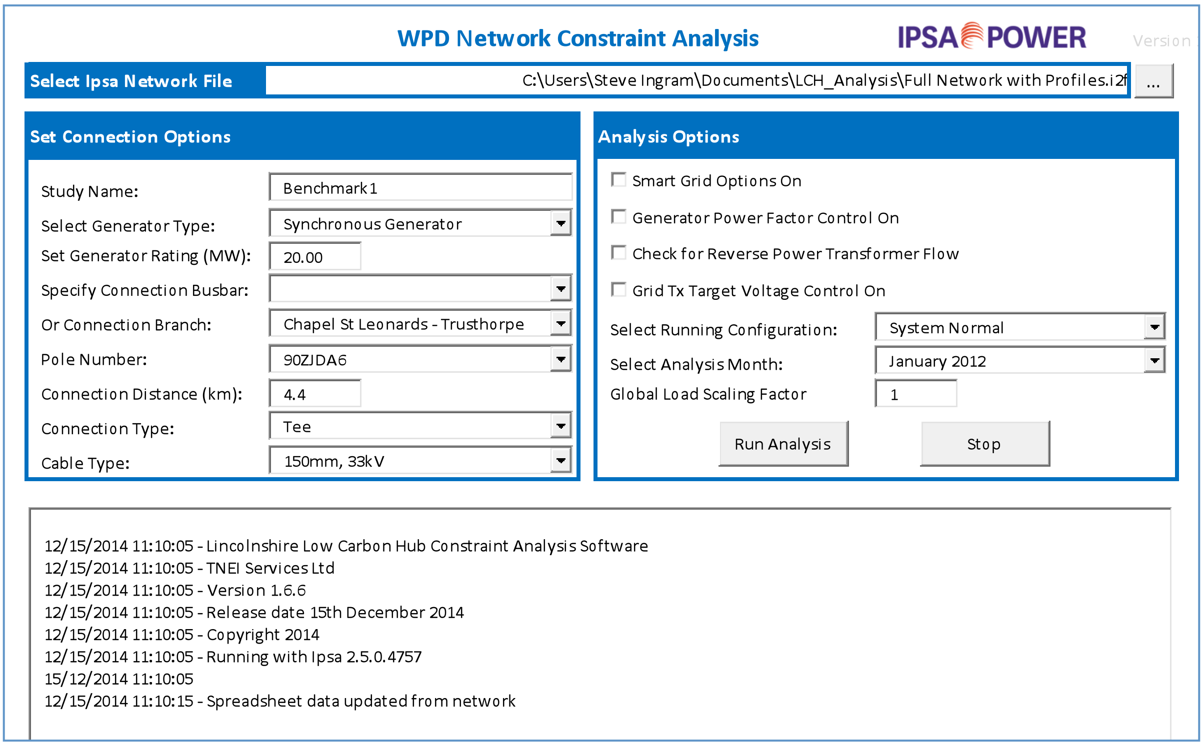
4.2 Desktop Tool Design

The majority of the changes required for the desktop tool were a result of changing from a web based tool to one driven by Excel. This required changes to the way the inputs and results were handled as well as ensuring that the analysis settings were correctly configured.

The core analysis script, written in Python, remained largely unchanged from the web based tool. The Ipsa 2 software was retained for the power flow analysis. The complete analysis code package was compiled into an executable program file which was then packaged into a Windows installer file for quick deployment on WPD computers.

The Excel spreadsheet was designed to run this analysis program using a short Visual Basic program contained in the spreadsheet.

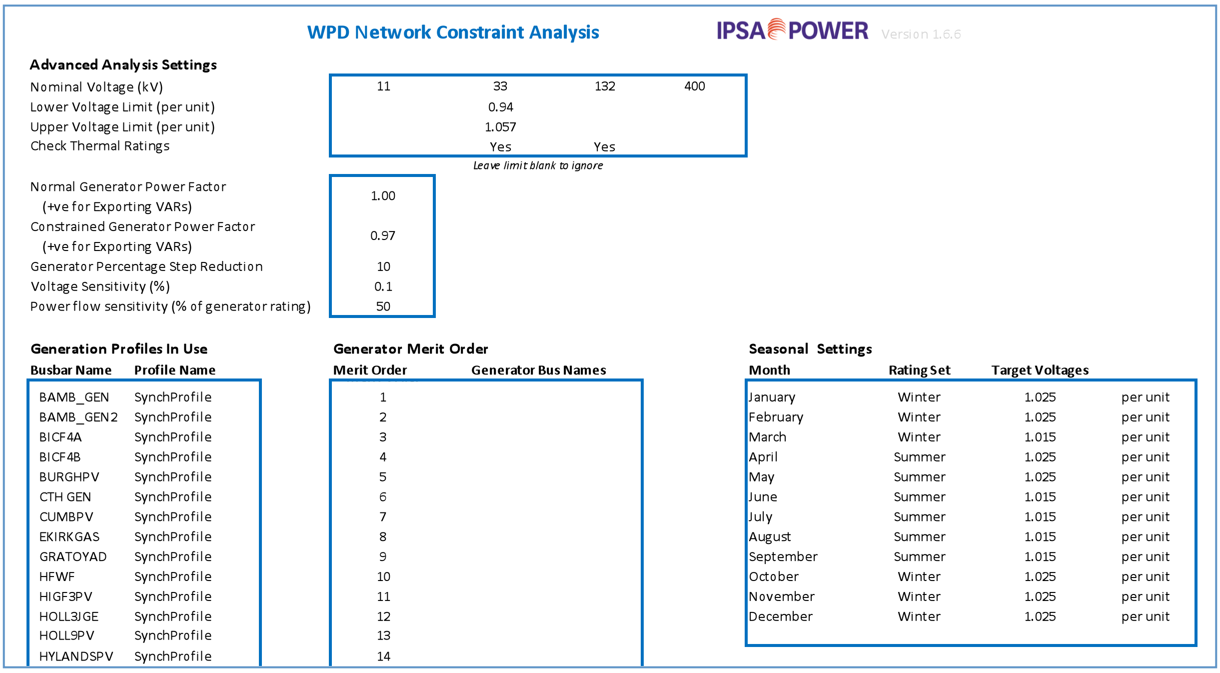
The main analysis page of the spreadsheet is shown below:



This includes the file selection, generator definition and key analysis parameters at the top. Loading an Ipsa network file allows the busbar and branch controls to be populated with a list of possible connection locations.

Controls are included to run and stop the analysis together with a progress report detailing the analysis status.

More advanced analysis settings were included on a separate sheet as shown below:



4.3 Desktop Tool Analysis

The analysis technique and code employed in the desktop tool was functionally identical to the web based tool. In order to simplify the maintenance and update of the software the code changes between the two deployments were kept to a minimum. The desktop version allowed the use of features that were not accessible to the web based tool.

One of the key differences in terms of analysis between the two was the use of a LIFO stack in the desktop version. This allowed a number of constrained generators to be modelled in the network. Each additional generator would be added in turn and analysed. The resulting constrained generator profile would then be saved in the network model enabling it to be re-used in studies for subsequent generators.

The analysis of multiple generators was performed in the following order:

- Add the new generator to the network and set it’s output to zero
- Identify any constraints for the existing generators
- If constraints are found then:
  - Curtail the last generator on (excluding the new generator)
  - Repeat the curtailment moving down the LIFO stack until the constraints are removed
  - This ensures that any constraints introduced purely by the connection of the new generator are removed. These may occur as a result of the different voltage profile due to the generator connection cable.

- Perform the full constraint analysis with the new generator, constraining as required

The ability to monitor and report on reverse power flows through transformers was also included in the desktop version. This was achieved using a custom built model for the Ipsa 2 software which monitored the power flow on a particular component. The development of this reverse power monitor was undertaken for this project.

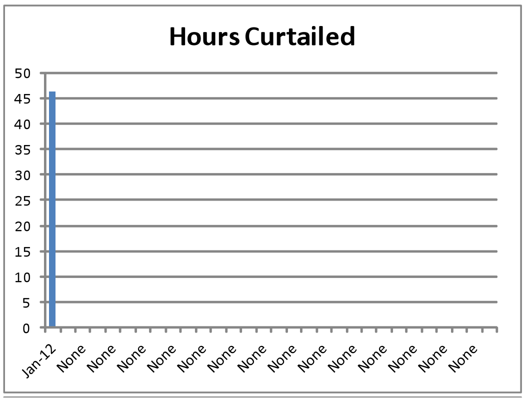
The remainder of the analysis, including the use of profiles, generator curtailment and the power flow analysis remained identical to the web based tool.

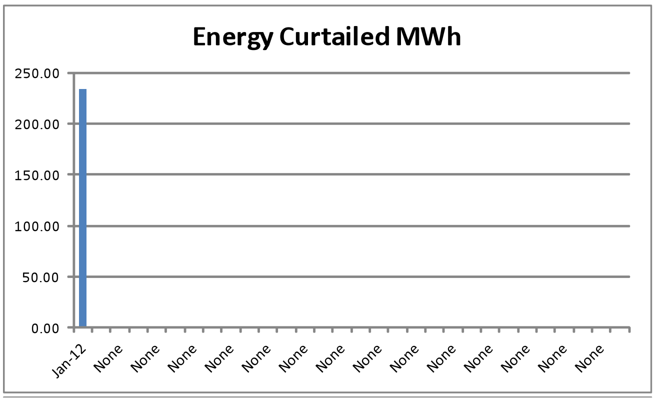
4.4 Desktop Tool Results

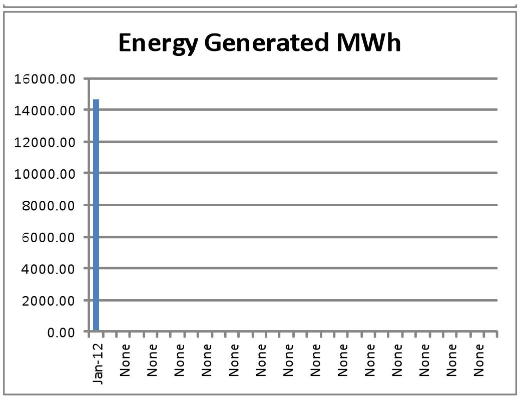
More detailed results were provided in the desktop version as these would be used for planning purposes by WPD. The extended results included details of which network components caused constraints and reverse power flows through transformers. The results obtained from the analysis were copied back into the analysis spreadsheet as shown below:

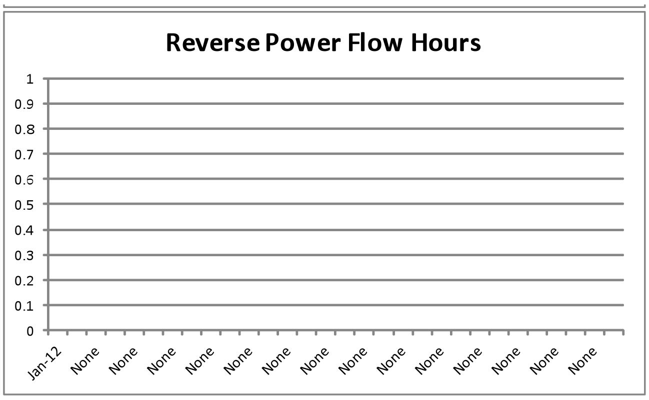
WPD Network Constraint Analysis IPSA POWER

Analysis and Results Summary			
Generator Type	Synchronous Generator	Maximum Output	20.00MW
Generator Rating	20.00MW	Average Output	19.69MW
Connection Location	53.230025degN, 0.314238degE	Minimum Output	16.00MW
Connection Distance	4.40km	Energy Generated	14646.0MWh
Connection Type	Tee	Curtailed Energy	234.0MWh
Cable Type	150mm, 33kV	Constraint Duration	6.22%
Global Load Scaling Factor	100.00%	Generator Constraint %	1.6% energy lost out of 14880.0MWh









Results by Month

Month and Year	Hours Curtailed	Energy Curtailed MWh	Energy Generated MWh	Reverse Power Flow Hours
Jan-12	46.25	234.00	14646.00	0
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				
None				

Results by Component

Month and Year	Component	Name	Times Overloaded	Max/Min Value
Jan-12	bus	Benchmark1	185	106.50%

Reverse Power Results

Transformer	Reverse Power Detected ?	Maximum Reverse Power Flow MW	Minimum Reverse Power Flow MW	Number of Hours
Alford T1	No	0.00	0.00	0
Alford T2	No	0.00	0.00	0
Chapel St Leonard T1	No	0.00	0.00	0
Chapel St Leonard T2	No	0.00	0.00	0
Horncastle T1	No	0.00	0.00	0
Ingomells T1	No	0.00	0.00	0
Ingomells T2	No	0.00	0.00	0
Spilsby T1	No	0.00	0.00	0
Spilsby T2	No	0.00	0.00	0
Trusthorpe T1	No	0.00	0.00	0
Trusthorpe T2	No	0.00	0.00	0
Warth Lane T1	No	0.00	0.00	0
Warth Lane T2	No	0.00	0.00	0
Warth Lane T3	No	0.00	0.00	0
Wrangle T1	No	0.00	0.00	0

5 Lessons Learnt

The project involved a considerable amount of development work in several areas which has resulted in a variety of both software improvements and analysis improvements. These can be split as described in the following sections:

5.1 Web Site

The web site aspect of the project was reasonably standard. Only minor issues were encountered in the deployment of the web site and no significant new learning can be identified.

One aspect which would be approached differently is the handling of the geographic data for the overhead lines and poles. The entry of the pole and branch co-ordinate data was performed manually and checked against the pole locations as shown on the OpenStreetMap website. This was a time consuming process which would require a different approach if larger network areas are to be considered. The direct use of data from a GIS system would allow this process to be automated in future.

The web site has performed the analysis activities without any significant outages or incidents. The web site results have been independently validated by Smarter Grid Solutions Ltd and found to be sufficiently representative.

5.2 Analysis Techniques

The most significant issues encountered during the development and deployment of the analysis tool are summarised below:

- Analysis implementation
- Analysis method
- Analysis testing and validation
- Miscellaneous issues

5.2.1 Analysis Implementation

The analysis required that 18 months of half hourly profiles were analysed, this required a minimum of 26280 power flow calculations for a single generator. Whilst each power flow calculation is fast, a full 18 months of analysis may take 20 to 30 seconds.

This analysis must then be repeated if constraints are identified. Since the generator is constrained in 10% steps then a maximum of 10 steps may be required in order to remove or minimise any constraints. A worst case scenario may therefore take between 200 and 300 seconds, performing 262800 calculations.

The web site analysis was typically completed in approximately two minutes and, since only one generator at a time was modelled, the speed issues were never severe.

The desktop analysis tool encountered significant speed issues with analysis runs of 30 minutes or more with a stack of LIFO generators.

The long execution times also resulted in some stability and usability issues:

- Memory issues resulting from the analysis tool using too much memory
- The use of Excel prevented users from using Excel for other purposes during the analysis

Excessive Memory Usage

During long analysis runs with larger LIFO stacks issues were encountered with memory usage. This was traced to the Ipsa 2 progress window which stored all analysis messages. Restricting this progress window to store a maximum number of lines of messages resulted in a stable memory foot print.

Slow Analysis Speed 1

Use of multi core processing allowed each analysis month to be performed on a separate CPU processor. This required a number of changes to the analysis code such that each analysis month had a specific configuration and results file.

Significant speed improvements were obtained if multiple CPU cores were available, typically a 4 times speed increase with 4 CPU cores.

Slow Analysis Speed 2

The large number of power flow calculations being undertaken ultimately prevented any further speed improvements. Each month required between 1440 and 14400 calculations per generator due to the use of half hourly profiles.

Consideration was given to the use of a smaller number of representative profiles, possibly based on typical day types. This was not investigated due to the time constraints of the project but would be required for any future work.

Slow Analysis Speed 3

The speed issues increased when a larger network and one additional year of profile data was used. Again this was due to the large volume of data and calculations required which could be mitigated through the use of a reduced set of typical profiles.

Excel Spreadsheet Interface

The desktop analysis tool was controlled from an Excel spreadsheet with results being copied back into the spreadsheet. This approach prevented users from using Excel for other purposes whilst the analysis was running. In addition the spreadsheet was tightly coupled to the underlying analysis tool meaning that code changes typically required a new version of the spreadsheet to be produced. Several issues were encountered where the process of inserting completed results into the spreadsheet failed due to incompatibilities between the analysis and spreadsheet.

Improved testing and validation was undertaken at later stages of the project to ensure that the full analysis ran correctly.

For future work it is recommended that a dedicated user interface be developed in order to remove the dependency on using Excel.

5.2.2 Analysis Method

LIFO Stack Implementation

The correct implementation of the LIFO stack calculation was found to be particularly significant, both in terms of the results accuracy and the analysis speed.

The addition of a generator to the network typically results in a change to the network voltage profile due to the change in network impedances and capacitances. This may result in the modified network operating outside voltage limits even with the new generator at zero power output. Therefore additional constraints may be imposed on existing generators simply due to the connection of additional cable or modifications to the network.

The order in which the generators in the LIFO stack were analysed was originally the oldest to newest. The execution order was as follows:

1. Add new generator and assign output profile
2. Perform constraint analysis for first (oldest) generator in the LIFPO stack
3. Curtail generator as required
4. Repeat steps 2 and 3 for all generators in the LIFO stack
5. Repeat steps 2 and 3 for the proposed generator

This resulted in long execution times and significant additional constraints for generators in the LIFO stack since all generators were always analysed.

The LIFO stack analysis was then modified to the following, correct approach:

1. Add new generator and assign output profile
2. Set new generator output to zero
3. Perform constraint analysis for last (newest) generator in the LIFPO stack
4. Check if network constraints are identified with the new generator and curtail the LIFO generator if required
5. Repeat steps 3 and 4 for the remaining generators in the LIFO stack until no network constraints are identified
6. The network is now compliant with the new generator at zero output

7. Perform constraint analysis for the new generator
8. Curtail new generator as required

This approach reduced the execution times as less analysis was required, it also further improved the accuracy of the results and the robustness of the Constraint Analysis Tool.

This issue was recognised during the development and testing of the desktop tool. This was never an issue for the web based tool since it only considered a single proposed generator at a time.

Analysis Sensitivity Settings

A number of analysis settings were made available to the end user that controlled the sensitivity of the network constraint detection. The intention was to ensure that only generators which actively contributed to a network constraint were curtailed. Generators which did not contribute to the network constraint were then not curtailed further during the analysis.

This was achieved by finding all network components whose voltage or power flow deviated by more than the sensitivity settings when a change in generator output was applied to the network.

Two power flows studies were undertaken with the new generator at 0% and 10% output. All network components were then checked to identify those whose voltages or power flow changes exceeded the analysis sensitivity settings.

The constraint analysis then proceeded but only the sensitive components were checked for new violations.

The selection of the analysis sensitivity settings was found to be important to the results produced. Use of sensitive settings resulted in network constraints being identified in adjacent 33kV network groups. This occurred due to generator power changes affecting the 132kV system voltage which then caused under-voltages in an adjacent 33kV group.

This issue was resolved by adjustment of the sensitivity settings, however it was not a straightforward process to identify and resolve it. An improved methodology could be developed to ensure that only network constraints in the same BSP or GSP group are used for the constraint analysis.

5.2.3 Testing and Validation

A number of issues were identified during the development and roll out phase of the desktop tool which resulted from incomplete or insufficient testing. This caused delays to the connection offer process and required detailed analysis to reproduce and resolve the issues.

Additional testing and validation was included in the desktop application during the later stages of the project. This allowed the results of new developments to be compared to previously validated results and any discrepancies identified.

This testing methodology should have been built into the tools at an earlier stage to ensure a more consistent and usable solution was obtained.

5.2.4 Miscellaneous Issues

- Improve the integration of geographic and network data for future web based versions. The methodology employed was not practicable for roll out across a larger network area. Links to a GIS system would ideally be required to facilitate the geographic location of network assets.
- More realistic generator profiles may be required with greater diversity for the wind profiles.
- A more accurate curtailment mechanism could be developed for the generation. This would remove the need to reduce the generation output in fixed percentage steps and may also offer speed improvements.

6 Summary

Two constraint tools, web based and desktop, have been developed and deployed for the WPD LLCH project. The tools both successfully performed constraint analysis on the network and allowed constrained generation offers to be produced.

The web based tool was successfully used by a number of developers and performed without any significant issues. It was successfully validated by Smarter Grid Solutions using a different constraint algorithm.

The analysis undertaken by the desktop tool was more complex and also required significantly more analysis time. The results obtained were of sufficient accuracy to provide constrained generation offers but the desktop solution was not sufficiently mature to be rolled out as a business tool.

The principal recommendations for future work are therefore as follows:

- Investigate the use of typical day type profiles to reduce the analysis times required
- Future desktop tools require a dedicated user interface to remove the reliance on using other software tools such as Excel
- Investigate alternate methods of identifying the relationship between constrained network components and generators in order to reduce the size of the LIFO stack
- Ensure future versions include robust testing and validation at all stages of the project
- Investigate more accurate curtailment algorithms as opposed to fixed reduction steps
- Identify if more realistic and diverse generator profiles can be used

Appendix G – Detailed summary of work carried out for the 33kV Active Network Ring

Appendix G

Skegness

- 33kV Feeders 08 (Alford T1 / Chapel St Leonards T2) and 07 (Spilsby T1 / Alford T2), were transposed to improve system security and balance power flows across the 33kV board,
- A new three ended current differential protection scheme was installed on CB07 (Alford T1 / Chapel St Leonards T2) using a Micom P543 relay and Agile P14DZ relay for backup protection,
- A new two ended current differential protection scheme was installed on CB04 (Ingoldmells / Chapel St Leonards) using a Micom P543 relay and Agile P14DZ relay for backup protection, and
- 110V batteries and charger were replaced to account for the increased demand.

Alford

- The existing outdoor 33kV oil circuit breaker at Alford was replaced a new with circuit breaker with the appropriate CTs for the ring method & current differential protection,
- The line disconnectors were replaced so the auxiliary contacts could be integrated into the protection scheme,
- New post CTs were installed on T2 to summate the transformer load and the CTs within the circuit breaker,
- A new three ended current differential protection scheme was installed on the Alford / Chapel St Leonard's circuit using a Micom P544 relay and Agile P14DZ relay for backup protection,
- A new three ended current differential protection scheme was installed on the Trusthorpe / Bambers Farm circuit using a Micom P453 relay and Agile P14DZ relay for backup protection, and
- Three phase VTs were installed in two locations to provide inputs into the protection scheme.

Bambers Wind Farm

- Installation of a three ended current differential scheme on the Trusthorpe / Alford circuit using a Micom P543 relay and Agile P14DZ relay for backup protection, and
- Matching current and voltage transformers were retrofit into the Bambers Wind Farm Ormazabal 33kV circuit breaker.
- A new 33kV 7 panel switchboard was installed as part of the Trusthorpe primary substation transformer change and LCH project. 2 x feeder circuit breakers, 3 x transformer circuit breakers (2 x primary transformers and a FACTs transformer) and 2 x bus sections,
- A new three ended current differential scheme was installed on the Trusthorpe / Alford / Bambers Farm circuit using a Micom P543 relay and Micom p122 relay for backup protection, and

- A new two ended current differential scheme was installed on the Trusthorpe / Chapel St Leonards circuit using a Micom P543 relay and Micom P122 relay for backup protection.

Trusthorpe

- A new 33kV 7 panel switchboard was installed as part of the Trusthorpe primary substation transformer change and LCH project. 2 x feeder circuit breakers, 3 x transformer circuit breakers (2 x primary transformers and a FACTs transformer) and 2 x bus sections,
- A new three ended current differential scheme was installed on the Trusthorpe / Alford / Bambers Farm circuit using a Micom P543 relay and Micom p122 relay for backup protection, and
- A new two ended current differential scheme was installed on the Trusthorpe / Chapel St Leonards circuit using a Micom P543 relay and Micom P122 relay for backup protection.

Chapel St Leonards – (As shown in Figure 12)

- Installation of a 3 Panel Switchboard,
- Reinstatement of the T1 line disconnector, cable connecting the Skegness/Alford circuit to T1 Line disconnector and removal of over sailing Ingoldmells/Trusthorpe OHL span and line disconnector,
- Three phase VTs were incorporated into the switchgear for both distance protection and check synchronisation,
- Cable connected the new 3 panel switchboard to both T1 and T2 disconnectors and Trusthorpe OHL,
- A three ended current differential protection scheme was installed on the Chapel St Leonards / Alford / Skegness circuit using a Micom P544 relay and Argus C relay for backup protection,
- A two ended current differential protection scheme was installed on the Chapel St Leonards / Trusthorpe circuit using a Micom P543 relay and Argus C relay for backup protection, and
- A two ended current differential protection scheme was installed on the Chapel St Leonards circuit / Ingoldmells using a Micom P544 relay and Argus C relay for backup protection.

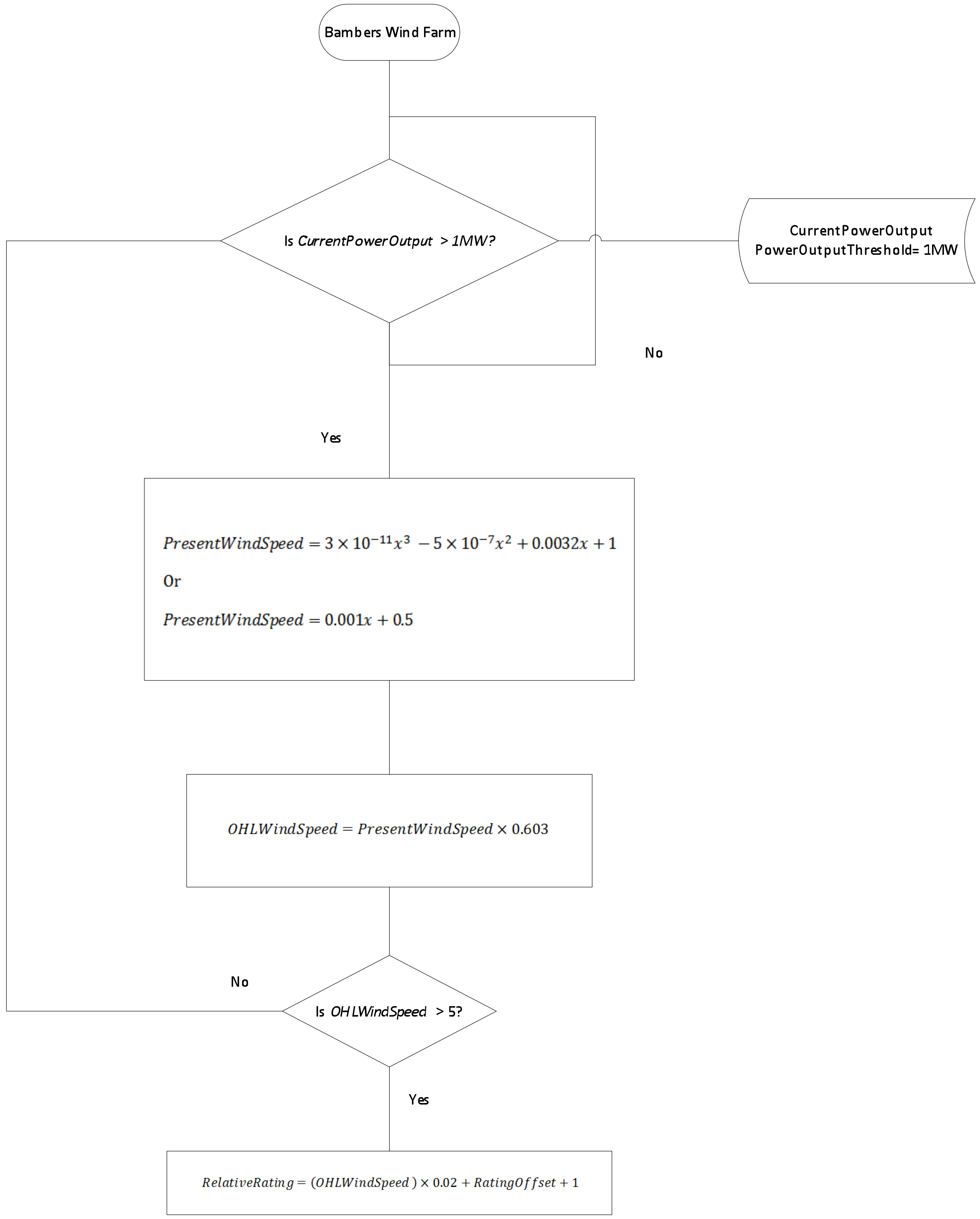
Ingoldmells

- A new bay was installed including terminal structure, Horizon 33kV circuit breaker, disconnector, cable sealing end structure, VT, disconnector and cable sealing structure,
- The existing cross bay was modified, installing a new Horizon 33kV circuit breaker and post insulator,
- Three phase VTs were installed in this location to provide inputs into the protections scheme,
- The Skegness line disconnectors were replaced to that they had auxiliary contacts fitted allowing the protection to operate as intended,
- A new two ended current differential protection scheme was installed on the Chapel St Leonards circuit using a Micom P544 relay and Agile P14DZ relay for backup protection, and
- A new two ended current differential protection scheme was installed on the Skegness circuit using a Micom P544 relay and Agile P14DZ relay for backup protection.

Appendix H – Dynamic Line Rating – Wind speed calculation

Appendix H

Dynamic Line Rating – The algorithm used to calculate relative wind speed based on the electrical output form a Wind Farm.



Appendix I – Dynamic Voltage Control – Supporting information

Appendix I

Dynamic Voltage Control could either analyse additional information locally within a substation or centrally within the Network Management System. As part of the Low Carbon Hub design, both methods were evaluated:

Local Control

A local control scheme could be located within the Grid or Primary substation, with communication established to key remote measurement points. The advantages and disadvantages of this approach are:

- ✓ Circumvents sending higher bandwidth data to a central location and the associated delays,
- • This approach would require either additional communications schemes to be installed or data to be stripped out of from the existing communication system,
- ✗ An additional control scheme would need to be installed in the grid or primary substation, this requires additional field staff training will need to maintain and support the scheme,
- ✗ The ability to understand when the network is operating abnormally is very difficult, requiring all switches and breakers to have status indication to be retrofitted with communications linking to the Grid substation intelligence,
- ✗ This requires the solution to be switched off when the network is operating abnormally.

Central Control

A central control scheme can be located within the existing NMS or interfacing into the existing NMS, with communication to key remote measurement points over the existing SCADA network. The advantages and disadvantages of this approach are:

- ✓ Allows an existing Network Management Systems (NMS) to be utilised, and to monitor when the network is operating abnormally, and for the scheme to take action based on this connectivity,
- ✓ A centralised control scheme can be maintained and supported by centralised staff without additional training,
- • A centralised control scheme can utilise the existing communications links or the existing SCADA communications links can be reinforced.
- ✓ Requires additional higher bandwidth data to be backhauled to a central location.

Due to the requirement to understand if the network was operating abnormally, Centralised Control option being progressed. This will take into consideration abnormal network configuration, determining a more optimal target voltage.

A number of design decisions were required to incorporate Dynamic Voltage Control at a substation, including:

- The requirement for the DVC algorithm to be disabled before transferring an AVC scheme from supervisory to panel mode of operation. This ensures the relay is in the Normal Target Voltage setting.
- The DVC algorithm does not need to be disabled before the AVC panel is transferred from Auto to Manual control.
- If the AVC scheme is transferred away from Supervisory to This Panel without the DVC being disabled The AVC should revert to the normal target voltage settings.
- If the AVC scheme is transferred from This Panel to Supervisory control The AVC should retain the normal Target Voltage settings until updated over SCADA.

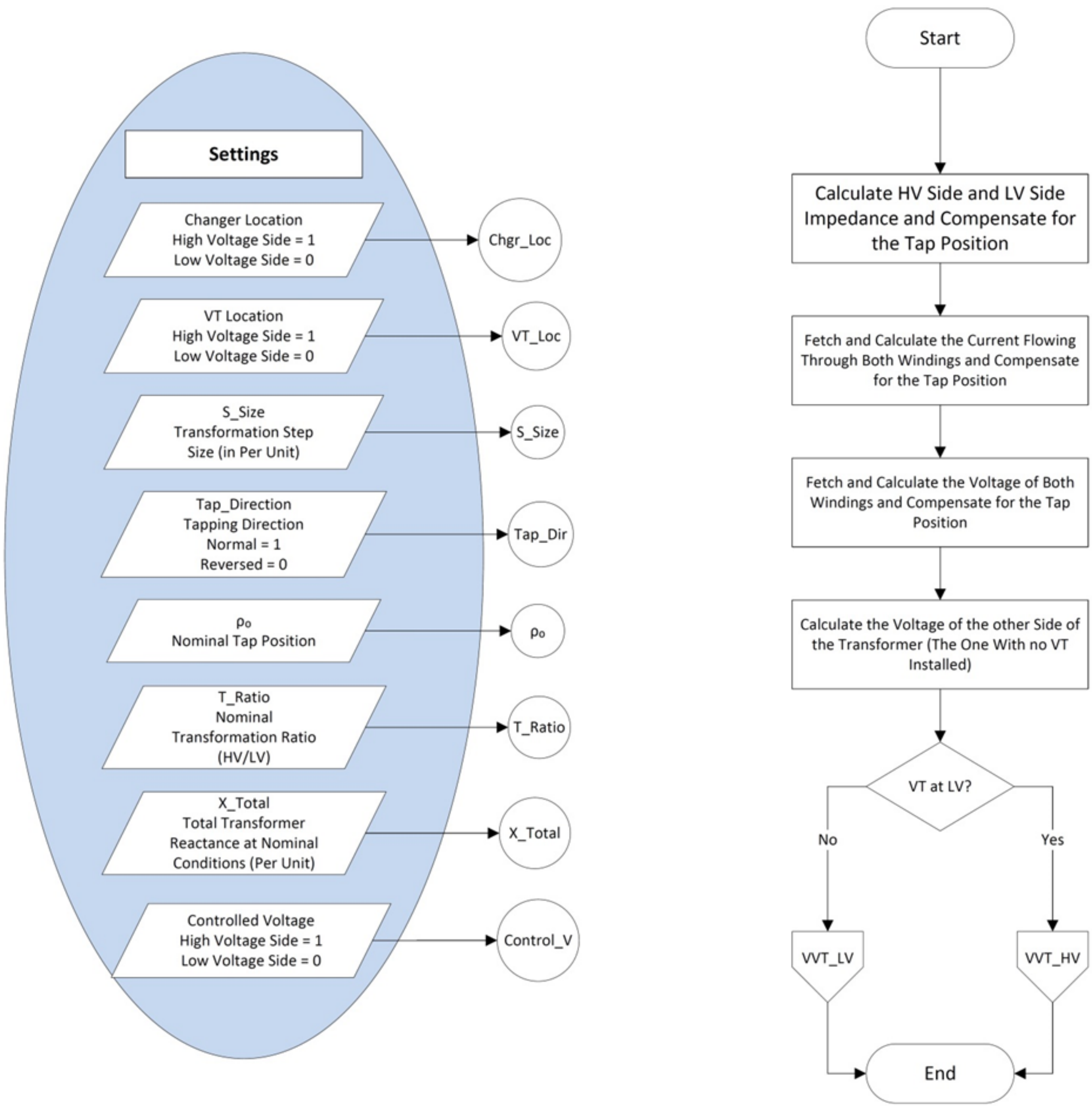
If a common function such as a new Target Voltage, Tap Lock, 3% reduction, 6% reduction is applied, these will be written to both relays from the AVC scheme by default over the relay CAN bus

Appendix J – Virtual Voltage Transformer Algorithm

Appendix J

The following Algorithm was used to calculate the voltage on either the HV or LV side of a transformer. This has been called Virtual Voltage Transformer and the corresponding script was written in Python in iHost.

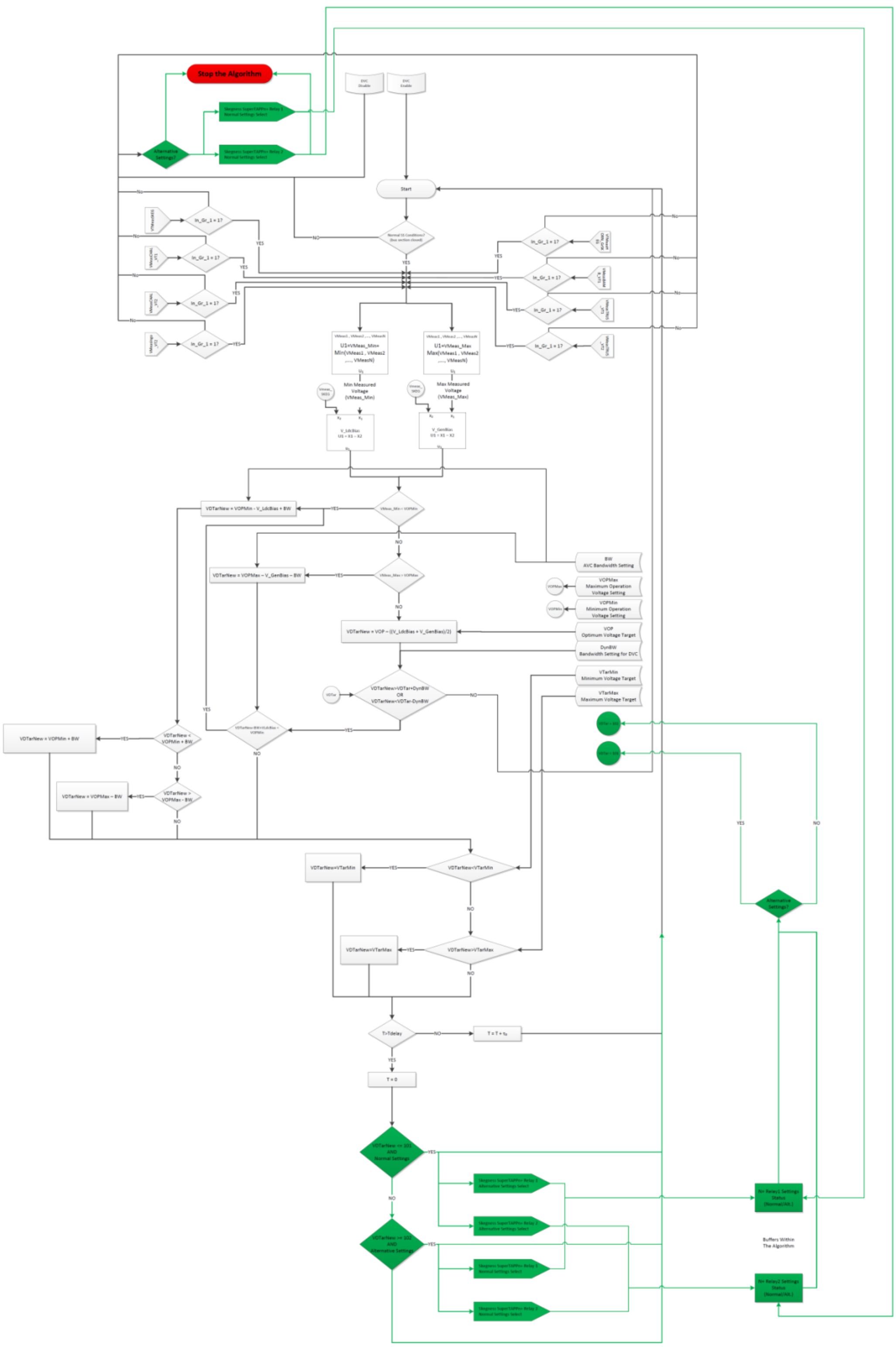
Virtual VT Algorithm

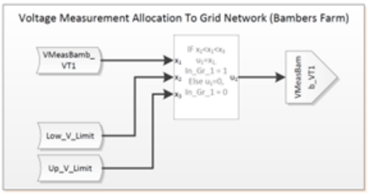


Appendix K – Dynamic Voltage Control Algorithm

Appendix K

The following Algorithms were used to compute a more optimal voltage target at Skegness Grid substation based on remote measurements. This was directly scripted within WPD's PowerOn NMS.


Stop the Algorithm
Alternative Settings?
DVC Disable
DVC Enable
Start
Normal SS Conditions? (bus section closed)
In_Gr_1 = 1?
U1=VMeas_Min= Min(VMeas1 , VMeas2 ,..., VMeasN)
U1=VMeas_Max Max(VMeas1 , VMeas2 ,..., VMeasN)
Min Measured Voltage (VMeas_Min)
Max Measured Voltage (VMeas_Max)
V_LdcBias U1 = X1 – X2
V_GenBias U1 = X1 – X2
VDTarNew = VOPMin - V_LdcBias + BW
VDTarNew = VOPMax – V_GenBias – BW
VDTarNew = VOP – ((V_LdcBias + V_GenBias)/2)
BW AVC Bandwidth Setting
VOPMax Maximum Operation Voltage Setting
VOPMin Minimum Operation Voltage Setting
VOP Optimum Voltage Target
DynBW Bandwidth Setting for DVC
VTarMin Minimum Voltage Target
VTarMax Maximum Voltage Target
VDTarNew>VDTar+DynBW OR VDTarNew<VDTar-DynBW
VDTarNew = VOPMin + BW
VDTarNew < VOPMin + BW
VDTarNew = VOPMax – BW
VDTarNew > VOPMax - BW
VDTarNew=VTarMin
VDTarNew<VTarMin
VDTarNew=VTarMax
VDTarNew>VTarMax
T>Tdelay
T = T + t_0
T = 0
VDTarNew <= 101 AND Normal Settings
VDTarNew >= 102 AND Alternative Settings
N+ Relay1 Settings Status (Normal/Alt.)
N+ Relay2 Settings Status (Normal/Alt.)
Buffers Within The Algorithm
YES
NO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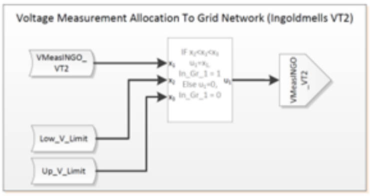
VMeasBamb_VT1
Low_V_Limit
Up_V_Limit
VMeasBamb_VT1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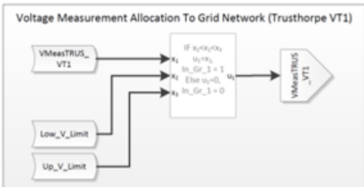
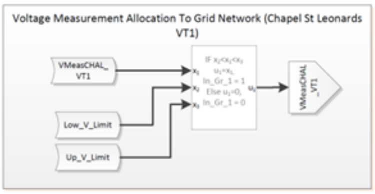
Low_V_Limit
Up_V_Limit
VMeasINGO_VT2


Voltage Measurement Allocation To Grid Network (Trusthorpe VT1)
VMeasTRUS_VT1
Low_V_Limit
Up_V_Limit
VMeasTRUS_VT1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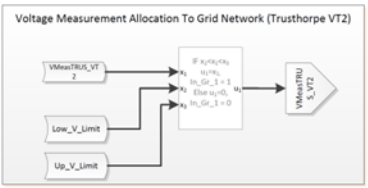
VMeasCHAL_VT1
Low_V_Limit
Up_V_Limit
VMeasCHAL_VT1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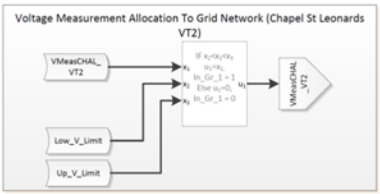
VMeasTRUS_VT2
Low_V_Limit
Up_V_Limit
VMeasTRUS_VT2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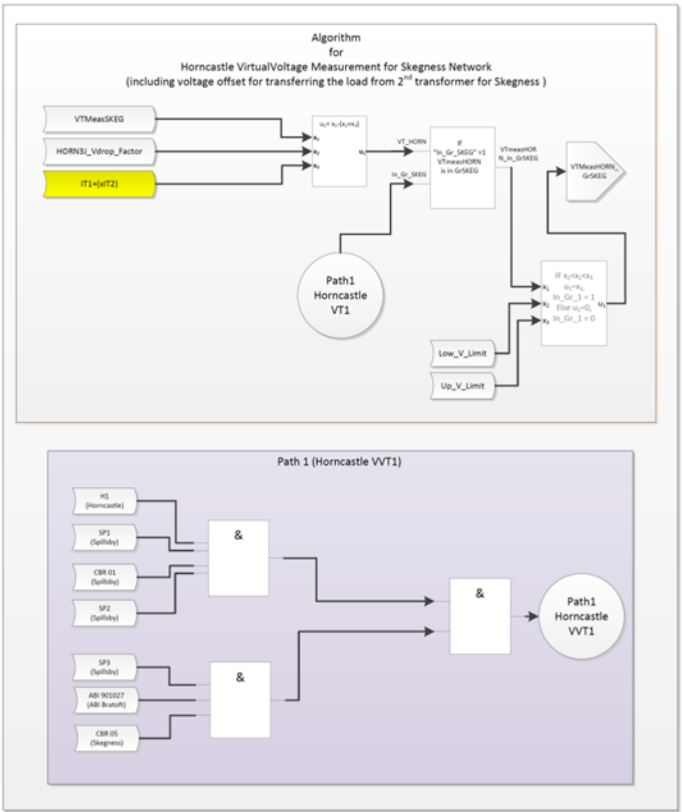
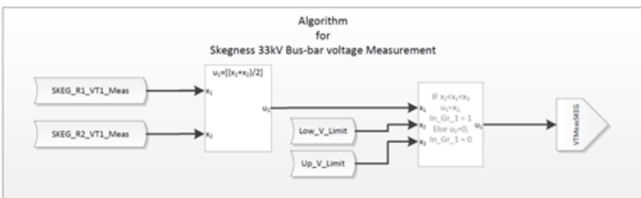
Low_V_Limit
Up_V_Limit
VMeasCHAL_VT2

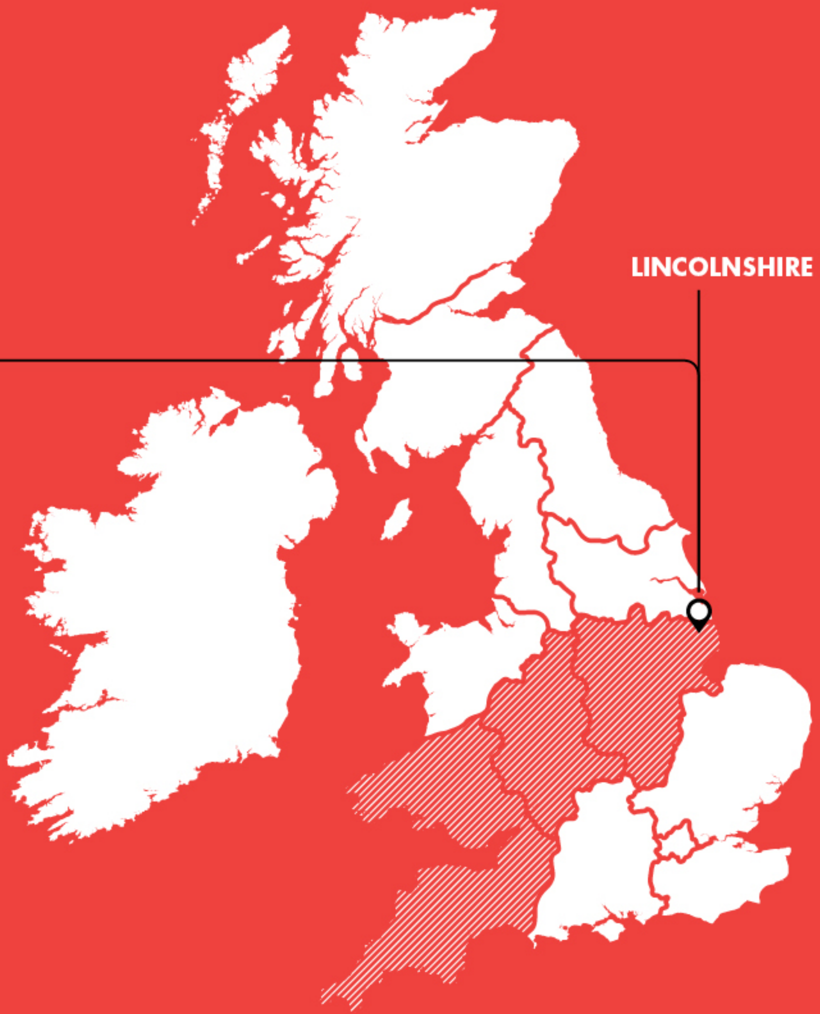

Algorithm
for
Horncastle VirtualVoltage Measurement for Skegness Network
(including voltage offset for transferring the load from 2nd transformer for Skegness)
VTMeasSKEG
HORN33_Vdrop_Factor
IT1+(xIT2)
VT_HORN
VTMeasHORN_GrSKEG
Path1
Horncastle
VT1
Low_V_Limit
Up_V_Limit
Path 1 (Horncastle VVT1)
&
&
&
Path1
Horncastle
VVT1


Algorithm
for
Skegness 33kV Bus-bar voltage Measurement
SKEG_R1_VT1_Meas
SKEG_R2_VT1_Meas
Low_V_Limit
Up_V_Limit
VTMeasSKEG

Appendix L - SDRC Disseminate Knowledge Report

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

CONNECTING RENEWABLE ENERGY IN LINCOLNSHIRE



SDRC

DISSEMINATE KNOWLEDGE AND EVALUATE THE POTENTIAL FOR SIMILAR PROJECTS THROUGHOUT THE UK.

LCN Fund
Low Carbon Networks

Report Title	:	Disseminate knowledge and evaluate the potential for similar projects throughout the UK
Report Status	:	Final
Project Ref	:	CNT2002 – Low Carbon Hub
Date	:	30.01.2015

Document Control

	Name	Date
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Reviewed by:	Roger Hey	30.01.2015
Approved by	Roger Hey	30.01.2015

Revision History

Date	Issue	Status
30.01.2015	1	Final
20.04.20415	1.1	Final

Contents

Glossary

Term	Definition
ANM	Active Network Management
AIS	Air Insulated Switchgear
ADDS	All-Dielectric Self Supporting cable
ACSR	Aluminium Conductor Steel Reinforced
BSP	Bulk Supply Point
CB	Circuit Breaker
CAD	Computer Aided Design
CAF	Cost Apportionment Factor
CT	Current Transformer
DG	Distributed Generator
DNO	Distribution Network Operator
DPCR	Distribution Price Control Review
DLR	Dynamic Line Ratings
DVC	Dynamic Voltage Control
ENTSO-e	European Network of Transmission System Operators
FAT	Factory Acceptance Test
FACTS	Flexible AC Transmission System
GIS	Gas Insulated Switchgear
GB	Great Britain
GSP	Grid Supply Point
GT	Grid Transformer
GoS	Guarantees of Standards
HDA	Hard Drawn Aluminium
IFI	Innovation Funding Incentive
ITT	Invitation To Tender
kV	Kilo Volts
LIFO	Last In, First Out
LCH	Low Carbon Hub
MCP	Max Conductor Pressure
MCT	Max Conductor Tension
MCW	Max Conductor Weight

MVA	Mega Volt Amperes
MWh	Mega Watt hour
NMS	Network Management Systems
OPPC	Optical Phase Conductor
OPV	Optimised Protection Variant
OHL	Overhead Line
PV	Photo Voltaic
RPZ	Registered Power Zone
RTU	Remote Telemetry Unit
SGS	Smarter Grid Solutions
SDRC	Successful Delivery Reward Criteria
SCADA	Supervisory Control And Data Acquisition
T1 & T2	Transformer 1 & Transformer 2
TNO	Transmission Network Operator
UHF	Ultra High Frequency
VVT	Virtual Voltage Transformer
VT	Voltage Transformer
WPD	Western Power Distribution

1 Introduction to the report

This report summarises the techniques demonstrated as part of Western Power Distribution's (WPD) Lincolnshire Low Carbon Hub, and as detailed in the Successful Delivery Reward Criteria (SDRC) 8, the project will disseminate the knowledge generated and evaluate the potential for future roll out throughout the UK based on the learning to date.

The knowledge generated has been categorised into the design, construction, operation and commercial aspects for each of the techniques. Further information associated with the project, including how the methods were designed, will be included in the Ofgem Project close down report which will be submitted to the authority before 1st May 2015

2 An Introduction to the Lincolnshire Low Carbon Hub

The Low Carbon Hub (LCH) for East Lincolnshire has been designed to test a variety of new and innovative techniques for integrating significant amounts of low carbon generation on to electricity networks, in an effort to avoid the costs that would normally be associated with more conventional methods.

The East Lincolnshire electricity network is typical of most rural areas across the East Midlands and large sections of Great Britain making it an ideal location to demonstrate how new technologies, operating procedures and commercial arrangements could be used by a Distribution Network Operator (DNO). The substation at Skegness has two 90MVA transformers, stepping the voltage down from 132kV to 33kV. Skegness supplies East Lincolnshire through seven 33kV feeders and under normal running arrangements supplies eight primary substations.

The project received £3m of funding from Ofgem's Low Carbon Networks Fund Tier 2. In this project, we are seeking to explore how the existing electricity network can be developed ahead of need and thus deliver low carbon electricity to customers at a significantly reduced cost in comparison to conventional reinforcement.

Lincolnshire, being on the East coast it is suitable for a wide range of renewable generation types, these include onshore and offshore wind farms, large scale solar Photo Voltaic (PV) and energy from bio crops. Many generators could not connect to the distribution network closest to them due to the effects the connection would have on the network operation. These connections tend to result in installing new underground cable to the Skegness grid substation where the connection will have less of an effect on the network, meaning it could operate within its design and operation limits. This can be very expensive and prevented generation connections. We received a high volume of connection enquiries from developers which made it ideal for this project.

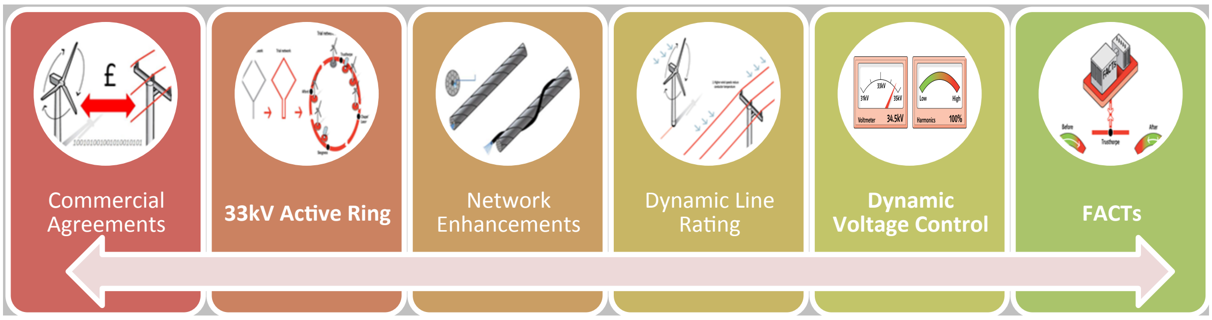


Figure 1 – LCH Methods

The project has developed the six project techniques detailed in Figure 1, demonstrating them in East Lincolnshire to increase network capacity and facilitate additional generation connections.

New commercial agreements – Innovative agreements have been negotiated with Distributed Generator (DG) customers to optimise their output and mitigate network issues (e.g. to deliver reactive power service) using real time network measurements. Potential limitations of the current regulatory framework have been identified.

33kV active network ring – The active ring allows increased control of the 33kV system and network reconfiguration based on real time power flows. Construction of the ring involved the installation of an additional circuit breakers, disconnectors and smart grid protection and control.

Network enhancements – Sections of existing overhead lines have been upgraded within the demonstration area with higher rated and lower impedance conductors to increase the network's capacity to connect DG. This work is in addition to investment already funded through the Distribution Price Control Review (DPCR) 5 settlement. For the purposes of disseminating learning, the communications required for a range of the methods above have been reported as part of this method.

Dynamic system ratings – The Skegness Registered Power Zone delivered innovative connections to offshore wind farms based on dynamic rating of overhead lines. These components have been further developed and the new techniques tested at 33kV to calculate the network capacity and operating limits based on real time asset data.

Dynamic voltage control – Building on the principles of an existing Innovation Funding Incentive (IFI) project, the 33kV target voltage has been actively varied. This was done dynamically based on real time measurements of demand and generation. Dynamic voltage control increases network utilisation whilst maintaining the system voltage within the statutory limits.

Flexible AC Transmission System (FACTs) Device –A Flexible AC Transmission system device has enabled us to control both network voltage and system harmonics of the active ring. This equipment is not normally deployed on Distribution networks for this purpose. Shunt compensation has been used to generate or absorb reactive power. This highly technical solution has been designed to increase the amount of distributed generation that can be connected.

3 Overview of the Commercial Arrangements methods

New commercial agreements – Innovative agreements have been negotiated with Distributed Generator (DG) customers to optimise their output and mitigate network issues (e.g. to deliver reactive power service) using real time network measurements. Potential limitations of the current regulatory framework have been identified

3.1 Background to existing Distributed Generation Connections

The majority of generation developers looking at new developments request a non-firm (teed connection). These connections can be made at any network voltage, from 400V (Low Voltage) to 132kV (EHV), they are not actively controlled by the DNO and often operate with a fixed power factor. A non-firm connection is a single circuit connection which operates without constraints under normal healthy, intact network conditions. However, with a non-firm connection there is an increased risk of the DG connection being restricted or disconnected from the network for certain faults or asset maintenance. In the worst case, this can result in a DG site being constrained off for the repair time after a network fault or during certain planned maintenance outages.

DG developers can also request a firm connection (looped connection). This has two separate supplies and is designed to avoid constraints during faults or asset maintenance. The high cost associated with the two separate supplies and infrequent abnormal network operation means a firm connection is rarely installed for new generation connections.

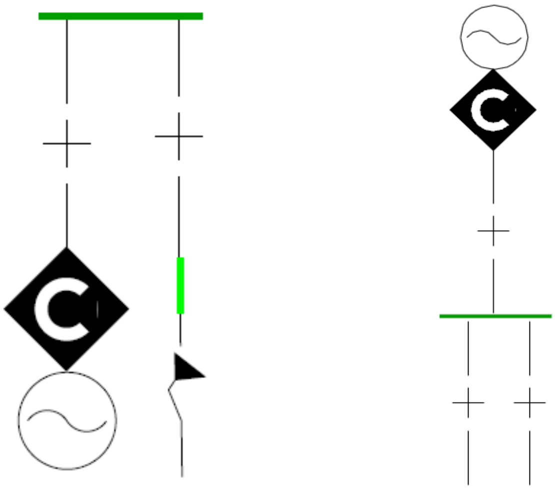


Figure 2 – Teed and looped connections

Whilst the network is intact, Non-firm Generation connections are designed to be fit and forget arrangement, the network modelling takes into account the most onerous, but credible scenarios that can occur on the network:

- The connected and proposed DG are operating at their full outputs, simultaneously;
- The demands across the distribution network are at their lowest, and
- The distribution network voltage is at the top of its operating bandwidth.

When the network is due to be rearranged as a result of planned maintenance and where the generation will cause any network asset to operate outside of its design or statutory limits, the DNO contacts the operator of the distributed generator. The site is either constrained down to a set maximum export level or disconnected from the network dependent on the severity of the constraint.

When the network operates abnormally as a result of a fault, if the generation causes the network to operate outside of its design or statutory limits, either protection relays at the substation or WPD's control room operates the DNO circuit breaker using SCADA telemetry, disconnecting the generator from the network.

This connection philosophy ensures that under normal operating conditions the network remains within its design and statutory limits and generator can operates in an unconstrained mode of operation. A fit and forget design and operation often leads to spare capacity in the system which is not utilised, as the most onerous credible scenarios detailed above do not occur regularly. The most onerous credible scenarios become even more infrequent when different intermittent generation sources are connected to the same network as they seldom operate at maximum output, at the same time.

The commercial arrangements method of the Low Carbon Hub has assessed how capacity can be unlocked effectively within networks whilst ensuring networks remain inside of the design and statutory limits at all times.

3.2 Low Carbon Hub – Commercial arrangements

The Low Carbon Hub project has demonstrated how DNOs and Generation developer can enter into new innovative commercial arrangements. These agreements can unlock additional generation capacity if the generator is willing to operate in suitable reactive power control mode and constrain active power output. Western Power Distribution (WPD) has been offering HV and EHV alternative connections in East Lincolnshire since February 2014 as an alternative to the high cost of conventional network reinforcement.

3.2.1 Contracts and Agreements

In order to offer new commercial arrangements, the project has created new Alternative Connection Documentation after researching constraint methodologies, engaging with customers and making amendments to the standard connection agreements creating a suite of Alternative Connection documents. To date, the project has offered 29 alternative connections in East Lincolnshire at the time of publication.

3.2.2 Learning Summary

Area	Knowledge Generated
Commercial	There has been and remains a strong appetite for Alternative Connections, with a large number of Generation Developers requesting and accepted by offers in East Lincolnshire as a way of unlocking capacity in areas otherwise considered constrained. Customers also expressed an interest in other geographical locations which often trigger prohibitive connection costs.
Design & Commercial	It has been shown that Last In First Out (LIFO) the best compromise when releasing capacity. LIFO was used for the method of constraining generation due to a number of factors: • The relative simplicity and clarity of the method both for the DNO and for the customer. • The broad acceptance of LIFO by our stakeholders, including generators and some financing institutions. • Our wish to protect existing generators from any impact of later-connecting generators; and • The efficiency of the underlying economic signals
Commercial	Alternative Connections are not the right choice for all new generation developers. In the same way developers evaluate the increased costs of a firm connection over the risk and consequence of constraints with a non-firm connection when the network is operating abnormally. With an alternative connection a generation developers must also evaluate the capital cost savings from an alternative connection over the potential longer term reduction in revenue from an alternative connection.
Operational & Commercial	The newly released capacity available within a network is not fixed; it is dependent on, the diversity between the generation sources, the location of new and existing generation and the willingness of generation developers to accept increasing levels of risk. This makes it very difficult to share upstream network reinforcement through a Cost Apportionment Factor (CAF) methodology.
Commercial	Any generation development will have a maximum acceptable financial cost for a network connection and associated upstream reinforcement. The maximum cost is driven by a number of other factors including other site costs, potential capacity factor and risk. Alternative Connections can offer a lower capital cost of connection but often increases the risk associated with the site.
Commercial	The location of new renewable developments is dependent on a number of factors, availability of resource, land, costs, planning risk. As such, not all generation developers are interested in developing sites in East Lincolnshire and have requested other areas they would prefer WPD offer alternative connections.
Operational	In creating alternative connection agreements, it has increased the workload in maintaining a suit of additional documents (33kV Alternative Connection Offer – Section 16, 33kV Alternative Connection Offer – Section

	15, 33kV Alternative Connection Offer – Section 16 & 15 Combined, 11kV Alternative Connection Offer – Section 16, 11kV Alternative Connection Offer – Section 15, 11kV Alternative Connection Offer – Section 16 & 15 Combined, Alternative Connection Agreement). There is a requirement to ensure these documents are developed at the same time as the standard connection agreements and ensuring any changes to either document does not result in conflicts.
Build	WPD's asset database, Crown, was modified to facilitate offering new Alternative Connection agreements. However the process of incorporate Alternative Connections into Crown was made more difficult owing to the subtle differences to standard connections such as the importance of the LIFO queue.
Design	Throughout the project there have been conflicting terms and language to describe Alternative Connections. To avoid confusing customers, the project sought to avoid terms already being used in the National Terms for Conventional connections and to standardise the language being used in connection offers and agreements.
Design	Stakeholders fed back that the alternative connection agreement should be as similar to the standard connection agreement as possible. This is helpful to both those gaining internal sign on and acceptance from their financing institutions.
Operational	Most generation developers required a meeting to discuss the finer points of the Alternative Connection offer and to discuss the three constraint analysis studies and the assumptions used within.
Design	Both the Alternative Connection Offer and Alternative Connection Agreement generated a number of difficult choices. The following decisions at the time of this report have been made: 1) Alternative Connection Offers are not interactive with each other 2) Generation developers do not need planning permission before they can apply for an Alternative connection, 3) WPD does not offer budget Alternative connections owing to the information required and the time to run the network studies; instead we use the online constraint analysis tool to provide the customer with an indication of constraints. 4) A generation developer can only secure their place on the LIFO queue after they have made a formal application and supplied all of the minimum information, 5) WPD has always aimed to provide an Alternative Connection offer within the industry Guarantees of Standards (GoS) for the respective connection. 6) WPD is not charging Design and Estimation fees for Alternative Connections 7) A Generation developer has the acceptance period of the Offer where their position in the queue is fixed. If the generation developer does not accept the connection or the offer lapses, their LIFO position is relinquished and generators further down the queue

	effectively move up. 8) If a generator requests to increase their capacity, the new capacity is modelled as a new connection and is issued a new LIFO number at the bottom of the queue. 9) An Alternative Connections can transfer to a standard firm or non-firm connection at any time by the customer funding the required upstream network reinforcement.
Operational	At the trialling stage, offering Alternative Connection offers substantially increase the connections workload as the studies are more comprehensive and many aspects of the offer letters cannot be automated. It was a difficult to process to offer both Alternative connections whilst maintaining all standard GOS without additional resource. The Future Networks Team offered all Alternative connections until a handover to the Primary and 11kV planners could be achieved.
Operation	The level of risk DG developers appeared to accept was higher than WPD initially forecast, resulting in a higher ANM capacity.
Commercial	To help both WPD staff and DG developers gain a clearer understanding of Alternative Connections a summary page and list of FAQ's have been produced and are available on the WPD website for review.

Primary System Design
Herald Way
Pegasus Business Park
East Midlands Airport
Castle Donington
DE74 2TU

Telephone: 01332 XXXXXX

Mr Smith
Building
Street
Town
Postcode

Our ref
00000000

Date
XX/XX/XXXX

Dear Mr Smith

Alternative Connection Offer for an active constrained electricity connection at Location by Western Power Distribution East Midlands plc ("WPD")

Thank you for your application requesting an Alternative Connection Offer to make a new electricity connection/augment the existing electricity connection to the Premises.

In addition to our standard Connection Offer 01/01/2015 made pursuant to and in accordance with the provisions of WPD's Distribution Licence (the " **Standard Connection Offer**"), I am pleased to provide this alternative connection offer to carry out the Connection Works for the Customer (the **"Alternative Connection Offer"**) on the basis of an active constrained electricity connection. This Alternative Connection Offer, which is based on WPD's understanding of the information provided by the Customer, comprises this letter (the **"Alternative Offer Letter"**) and the following documents:

a. Specific Conditions for Connection Works;
b. General Conditions for Connection Works;
c. Plan "Location Geographic Cable Route v1 and EHV POC 01_01_15 v1" dated 01/01/2015 showing WPD's existing Distribution System, Point of Connection location and Premises;
d. a single line diagram "Generator SLD and EHV POC 01_01_15" showing WPD's existing Distribution System and Point of Connection location;
e. a breakdown of the Connection Charge
f. the Letter of Acceptance (a form of which is attached), once signed by the Customer; and
g. a Health and Safety Questionnaire to be completed by the Customer; and
h. Three constraint analysis studies (Study 1, Study 2 and Study 3)

Figure 3 – Alternative Connection example document

3.3 Active Network Management Hardware

3.3.1 Background

The project required an Active Network Management scheme to monitor key network points and control the output of Alternative DG connections to stop the network operating outside of its design and statutory limits. The functional specification for an Active Network Management was completed with a scheme being tendered, procured, supporting policies written and installed in East Lincolnshire. The ANM scheme is capable of constraining the power output from Distributed Generators during periods when the network cannot absorb the excess generation. .The ANM software was integrated into WPD's Network Management Software (NMS).

Figure 4 – Active Network Management installed at Skegness Grid Substation

The ANM system for Skegness was required to use the current and voltage measurement points across the East Lincolnshire network to measures the following constraints:

- Thermal constraints on the 132kV double circuit from Skegness – Boston – Bicker Fen.
- Skegness GT1 & GT2 (132kV/33kV) Transformer constraints,
- Selected East Lincolnshire 33kV voltage and thermal constraints, and
- Selected East Lincolnshire 11kV voltage and thermal constraints.

3.3.2 Knowledge Generated

Area	Knowledge Generated
Design	At the time of tendering, three companies responded to WPD's ITT, with Smarter Grid Solutions representing the most economically advantageous tender based upon evaluation criteria.
Design	The connection of an ANM scheme requires an impact assessment, understanding the impact of an ANM failure scenario including communications failure. A Global trip of an ANM scheme could result in large amounts of generators being disconnected at the same time, creating a transient disturbance on the system.
Design	When assessing the installation of Active Network Management in a

	constrained area, consideration should include how future constraints may evolve across the network being studies, the adjacent distribution networks and the transmission network due to potential changes in demand and generation over the next 25 year period.
Design and Operational	The ANM equipment was installed at Skegness Grid substation to prove the concept. The ANM equipment is more suited to a temperature controlled server room then an operational substation. The communications infrastructure between Skegness grid substation and the core network is very strong. The ANM equipment will be subsequently moved to the server room.
Build	A flexible approach was required when incorporating measurement points into ANM systems. It was not possible to use a standard approach. As an example, the Skegness 132kV feeder current is being measured through an optical link to the feeder protection Relay.
Build	The ANM system has been integrated into WPD's NMS; at the request from Network Control Engineers only relatively basic controls have been enabled.
Design	The ANM communications has been built around WPD's standard communications options, however future testing and evaluation is underway to provide a range of flexible communications options which can be installed at future DG locations.
Commercial	WPD is continuing to discuss interoperable standards with ANM manufacturers. This is highly likely to result in flexible ANM specifications for ANM Areas.
Build	From the signing of contracts with Smarter Grid Solutions (SGS) to having a commissioned unit on site, the process took approximately 4 months.
Design	Significant detailed studies are required for the settings for the different measurement point thresholds and the time a generator needs to respond to ensure the system has the time to respond to transients that will occur in the system.
Build	The ANM operation and measurement set points need to be fully understood and incorporated into the constraint analysis software discussed in the next section.

3.4 Constrain Analysis Software development

3.4.1 Background

The project required WPD planners to understand the impact of Alternative Connections on the network under both normal and abnormal network conditions. DG developers also needed to understanding if an alternative connection was suitable for them before performing their own due diligence on the connection and likely future constraints. Two new constraint analysis software tools were specified, designed, tested and used as part of the project.

3.4.2 Web based tool

A simple constraint analysis tool was built for Generation Developers to estimate at a high level the number of constraints a new connection might expect in a particular location. The constraints analysis tool is hosted at www.lincolnshirelowcarbonhub.co.uk and uses a simple graphical interface and does not require any knowledge of primary system design or power flow analysis software.

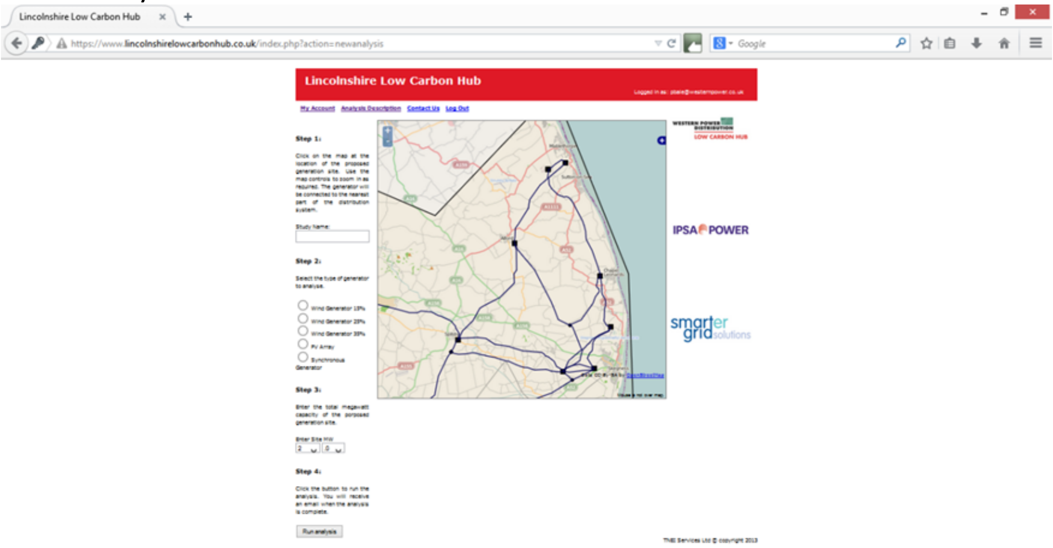


Figure 5 – Web based constraint analysis tool (screen shot)

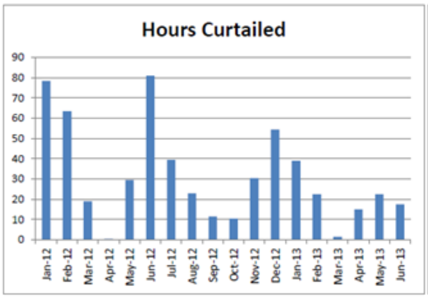
3.4.3 Desktop tool

A version of the constraint analysis tool built for Western Power Distribution's Primary network planning team uses the same data and algorithms. The spreadsheet tool requires the planner to specify the new point of coupling for the generator and cable distance between the generator and the existing network. The tool also allows primary system designers to modify different factors such as generation export, network demand profiles and the network running arrangements, showing the constraints under different network outages.

The tool estimates what the power flows and voltages would have been across the distribution network if the Active Network Management scheme and generation was in operation using historical data. The historical data and studies were manipulated to provide DG developers with three studies and an understanding of how the constraints may change for a number of different sensitivities including demand changes and the successful operation of the LCH innovative techniques.

Analysis and Results Summary

Generator Type	Wind Generator 35%	Maximum Output	4.60MW
Generator Rating	4.60MW	Average Output	1.49MW
Connection Location	degN, degE	Minimum Output	0.00MW
Connection Distance	0.10km	Energy Generated	19560.5MWh p.a.
Connection Type	Tee	Curtailed Energy	1568.9MWh p.a.
Cable Type	150mm, 33kV	Network Constraint Level	4.26%
Global Load Scaling Factor	100.00%	Generator Constraint %	7.4% energy lost out of 21129.4MWh



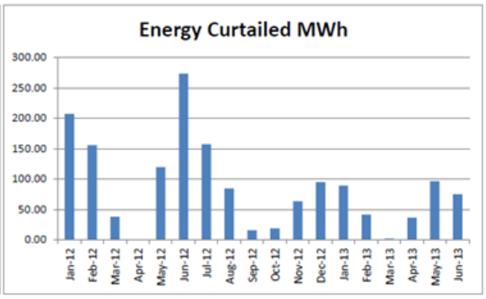


Figure 6 - Desktop tool (output screen shot)

3.4.4 Knowledge Generated

Area	Knowledge Generated
Design	A constraint estimation tools is an essential aspect of Alternative Connections. Western Power Distribution would not have been comfortable allowing a third party to run this analysis on their behalf due to the complexities encountered in the debugging stage of the software development. The tool allows the DNO to study how the network operates with Alternative Connections under both normal and abnormal network configurations understanding how power flows and voltage profiles will change at different times of the year. The Constraints analysis tool allows a generation developer to understand which areas are likely to experience both, lower and higher constraints and understand the risk of accepting an alternative connection.
Design	It is not possible for a DNO to provide an estimation of future constraints or guarantee network availability based on LIFO as there are a number of factors that are outside of a DNOs control which could either increase or decrease the constraints a generator may experience. Instead WPD has advised customers of the likely constraints based on historical network operation and run a number of scenarios using this data. **Developments which could decrease constraints:** ▪ Existing Generation with a reduced Capacity Factor. This could be due to generator maintenance or outages, weather conditions, derogation of output over time or a site being decommissioned. ▪ Existing or new Demand connections increasing their demand ▪ Network reinforcement **Developments which could increase constraints:** ▪ Connection of increasing levels of micro-generation. ▪ Existing Generation with a higher output / capacity factor. This could be due to favourable weather conditions or replanting with more efficient components. ▪ Existing demand connections reducing their demand

Design	In order for Generation developers to understand the risks associated with a connection and carry out their own due diligence, it requires the DNO to be very clear with the assumptions it made in undertaking the analysis. WPD provided customers with details of the East Lincolnshire network components, load data, network configuration data and the capacity and type of generation ahead of them in the LIFO queue. The majority of generation developers are not willing to share their basic connection application information (Capacity, generation type & point of common coupling) with other generation developers to aid their constraint analysis connections. Not having the alternative generation locations makes it more difficult for the customer to conduct their own detailed constraint analysis studies.
Operational	WPD ran three different scenarios based on the historical network data and weather data. These were intended to provide an understanding for a generation developer as how likely the constraint can change with the reduction of demand and the successful operation of the LCH smart grid technologies. The majority of parties, especially solar PV developers did not believe study one to be particularly helpful as it assumed 100% sustained output. Further studies following this route should probably consider a bell curve for Solar PV as this would provide more meaningful results.
Build	At the time of the project, it was not possible to purchase an off the shelf constraints analysis tool. Whilst the analysis could be run by a number of companies, the software was not user-friendly and could not be packaged for use by a DNO. The Low Carbon Hub Constraints Analysis tool successfully showed the software could be designed and packaged for a DNO to operate constraints analysis themselves. Developing the tool in Excel for the proof of concept tool was the best options owing to the flexibility developing the tool, solving the bugs encountered quickly and effectively.
Build	The tool was independently evaluated by Smarter Grid Solutions, a third party with their constraint analysis tool. This built confidence that the constraint analysis software was performing as expected.
Operation	If the Constraints Analysis tool had the functionality to identify limiting factors and to step through the time series data, issuing Alternative Connections would have been an easier process. Identifying the limiting factors would have allow the planning teams to understand how the network constraint points' change throughout the year, depending on the demand profiles at each primary substation and the generation profiles for each site. Stepping through the desktop tool time series data would have made debugging the tool much easier and allowed a better understanding at to how the power flows can change throughout the years and with different generation outputs. The LCH tool has this functionality, however this is currently a resource intense and time consuming process to carry out.
Commercial	It is possible to analyses networks to the granularity of ½ hourly time periods

	for a long duration. This assesses all nodes will remain within the design and statutory parameters from the 11kV bus bars to the 400kV super grid transformers. Conducting ½ hourly analysis is computationally heavy and can take several hours if carried out on a high specification laptop. A more effective method of nodal analysis would be to group time periods and run computational studies based on these groups, significantly reducing the amount of computational studies required. Using 1/2 hourly demand profiles is suitable when conducting analysis on one BSP, however when expanded up to one GSP the time to complete the analysis created delays in offering alternative connections.
Design	Adding any new generators to the network required all new generators to be remodelled to maintain an accurate estimation of constraints. By connecting a new generator the network impedance and reactive power flows change due to the additional cable installed. This can result in changes to the voltage profiles and power flows, but the decision was taken for the analysis to be re-run for all generators further up the queue to ensure the results are accurate.
Design	The tool was designed to study 33kV connections between 2-30MVA, in reality, it should have been developed for 11kV and 33kV connections between 150kVA – 30 MVA. As such the constraint analysis software that has been written which constrains generation by 10% output is not very effective for small generation sizes. Any further tool should consider how both large and small generation can be studies in the same tool.
Design	It would have been possible to use a simpler constraints analysis tool without using time series nodal analysis studies if the networks are radial and the constraints were only thermal. However if a network will develop voltage constraints or could be developed to operate meshed, It is believed a nodal analysis tool is required to provide the levels of accuracy and certainty a DNO and Generation Developer requires.
Design	The East Lincolnshire Network was a very suitable network to test constraint analysis owing to its relatively simple design with few alternative infeed. Whilst it took a considerable amount of time to debug with several iterations to the code and analysis, it was clear when the toll was producing accurate results. As the tool was fully tested, it became clear that the tool would need to conduct a very high number of sequential nodal analysis studies to calculate constraints, sometimes in excess of 4,500,000 studies. The result of this high number of studies was memory issues. These were identified and fixed. It is essential that the constraint analysis tool produces results are reliable and repeatable. If constraint analysis tool is required for a more complex network, sufficient time should be allowed to ascertain if the results from the tool are credible, and if the constraints are accurate representations of the actual level of constraints.
Operation	WPD's Internal planning staff were very receptive to the development of tools using time series data to improve the understanding of how the network operates. A full business wide training programme was rolled out to 200+ planning staff that will need to regularly conduct constraint analysis

	studies to ensure they are comfortable with the process. The Desktop tool requires a number of steps to be followed; making sure the required information is inputted. Failure to input all the information can result in the Constraint analysis tool not using the correct information and producing misleading results.
Design	The constraint analysis study documentation displays the estimated generation MWh output per month and the estimated MWh constrained per month for three different study scenarios. Generation developers have often requested additional information to understand what assumptions have been made and why. A number of Generation Developers have provided feedback that they would prefer to have one number to compare rather than all of the constraint information. The decision to provide monthly data was a conscious decision to ensure DG developers could see how the constraints changed overtime.
Design	The online tool estimates the cable distance as 130% of the straight line to the nearest 33kV asset. This accounts for the additional distance for the installation of cables in roads. The online tool provides a simple way to identify more optimal locations for future DG locations that will be less susceptible to future constraints.
Design	One of the key parameters within an ANM system is the setting of suitable limits for each measurement point, imposed to constrain and release generation within the ANM scheme, whilst ensuring all sections of the network remain within their design and statutory parameters. The trim, Trip, Sequential trip and Global trip, control generator output for critical network positions. If these settings are too low, DG sites would be constrained off prematurely and the capacity within the network will not all be released. If the settings are too high, the generation could lead to cascade trips and global trips. Artificial constraints need to be inserted to compensate for the n-1 scenarios, e.g. what are the resultant voltage profiles and power flows when a circuit or transformer trips. The network limits needed to be carefully calculated to avoid further cascade trips. There is a requirement to have the constraint analysis software matching the ANM equipment set up. Installing Active Network Management can reduce the capacity of a network, as a tolerance is required for ramp down time and communications latency.
Build	The anticipated time to write and debug the software programme was underestimated both by TNEI and WPD as the tool continued to 'fall over' in the early stages. These issues were solved over a period of a month with considerable learning generated to solve the nodal analysis issues associated with running approximately 4.5 million nodal analysis studies sequentially.

3.5 Alternative Connections - Potential for replication

3.5.1 Areas to Replicate

There are significant opportunities to be replicated beyond WPD's network areas in areas of high levels of intermittent generation as a method of unlocking further generation capacity.

Alongside the development of alternative connections as part of the Low Carbon Hub and demonstration in East Lincolnshire, the ANM policies have been written for offering alternative connections as a BaU process, WPD's 200+ planners have been trained how to offer alternative connection offers and WPD has changed its core database to facilitate the alternative connections.

WPD has already committed to rolling out the technique across all four WPD licence areas with 11 new zones opened by 2023. Each will use the Alternative Commercial agreements developed as part of this project. Further information is available on www.westernpower.co.uk/connections.aspx.
WPD will develop a constraints analysis tool for all ANM areas using the learning generated from this project (as detailed above) to build a tool that is more suitable for rollout across the business by Primary and 11kV planners.

Generation customers can now register their interest in Alternative Connections through the connections section of the WPD website. Customer feedback helps WPD to priorities the areas that Alternative connections should be offered next.

Two new simpler alternative connection offers - Timed connections and soft intertrip connections are also being offered using the same principles developed as part of the LCH.
A key requirement to Alternative Connections is the creation of robust, flexible constraint analysis software. This is essential for network with voltage constraints.

It is expected that the alternative connections will continue to evolve taking into account the learning from both East Lincolnshire and the future roll out of ANM.

3.5.2 Areas that require further work

Further work is required to understand how a standard firm or non-firm connection could be made in an ANM area requires a change in methodology to ensure the connection does not have a negative impact on the alternative DG connections, but the minimum cost scheme is offered to the customer.

WPD prefers to have at least two options for equipment and services, WPD is continuing to discuss our ANM plans with a number of manufacturers looking to developing and demonstrate ANM solutions so WPD has at least two Active Network Management providers and solutions for future applications.

Designing a network to operate with Active Network Management requires careful considerations, especially the effect on the existing protection settings. The protection philosophy was originally set up to protect demand driven networks, often with levels of redundancy built into networks.

Future Constraints analysis software would be more suitable running on a dedicated server system or in the cloud rather than a desktop PC or Laptop.
A standalone test server would have produced quicker results, reduced the time associated with fixing bugs and made it easier to ultimately adopt the final software back onto WPD’s systems when it has passed all operational trials.

4 Overview of the Ring Method

33kV active network ring – The active ring allows increased control of the 33kV system and network reconfiguration based on real time power flows. Construction of the ring involved the installation of an additional circuit breakers, disconnectors and smart grid protection and control.

4.1 Background to Network Design

The 33kV or primary network, in rural areas, is largely made up of radial feeders supplying primary substations with either one or two transformers. The existing primary network in the LLCH area is made up of two radial feeders, two transformers and 33kV normally open points at Trusthorpe, Chapel St Leonards and Ingoldmells substations. This radial network configuration is relatively simple to operate and maintain; power can only flow along one path. However these like most radial networks have presented a number of barriers to the connection of additional distributed generation. This is mainly due to voltage rise outside of statutory limits and thermal constraints across the system.

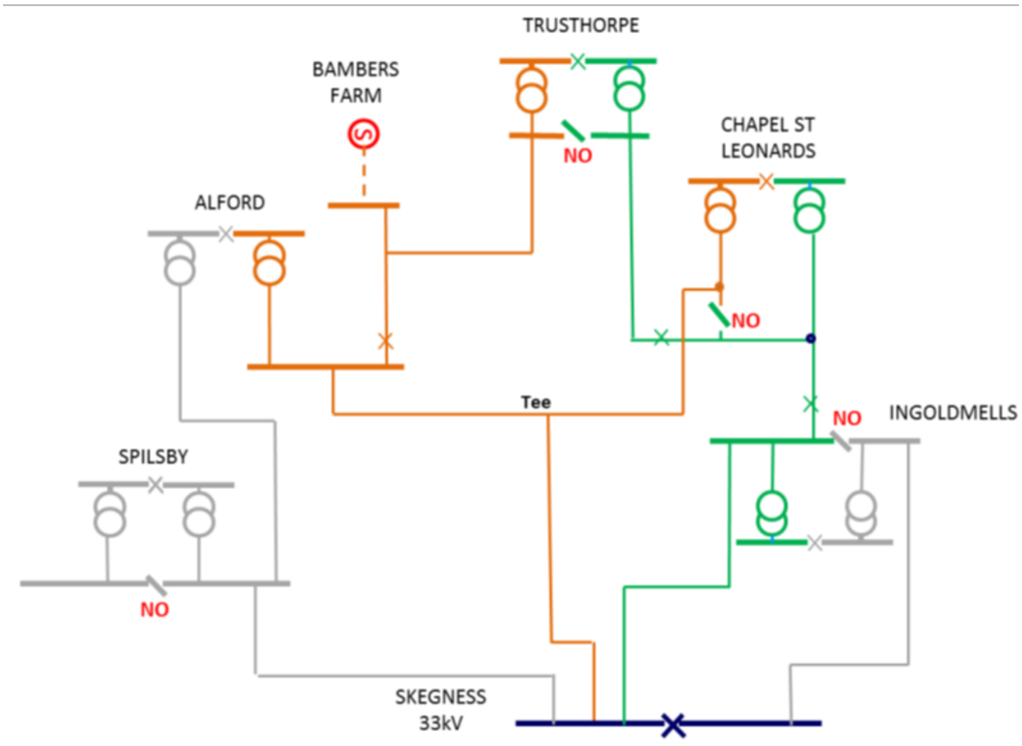


Figure 7 – Existing radial feeders

Voltage rise occurs when the Distributed Generation (DG) exceeds the network demand, causing power to flow in the opposite way it is intended and thus the voltage increases rather than decreases. This tends to be the limiting factor if increasing levels of generation requesting connection to relatively high impedance circuits. The network design solution is to reduce the network impedance; this is often solved by installing new high capacity, lower impedance cables connecting to the network closer to the grid substation.

Thermal issues occur when either a large generation sites or a number of smaller generators connect to the same piece of network, often where the circuit impedance is relatively low. The output of the combined DG can exceed the static ratings of overhead line (OHL), cables or transformers. The network design solution is often to install larger cables and transformers or to add new circuits, switchgear or transformers.

A method of network reinforcement to alleviate both voltage rise and thermal limits is modifying an existing radial network to operate meshed or in parallel. This historically has not been used; the Low Carbon Hub has demonstrated how it could be applied in the LLCH area to increase network capacity.

4.2 Low Carbon Hub – Ring Network

The creation of the 'active network ring' involved installing additional switchgear, disconnectors, cable sections, Current Transformers (CT's), Voltage Transformers (VT's), replacement batteries, new telecommunication links and new protection relays.

The following work was carried out at each substation to facilitate the meshing of two network feeders.

Skegness

- Transposed feeders 08 (Alford T1 / Chapel St Leonards T2) and 07 (Spilsby T1 / Alford T2),
- Installing a new three ended current differential protection scheme on CB07 (Alford T1 / Chapel St Leonards T2),
- Installing a new two ended current differential protection scheme on CB04 (Ingoldmells / Chapel St Leonards),
- Replacing existing 110V batteries.

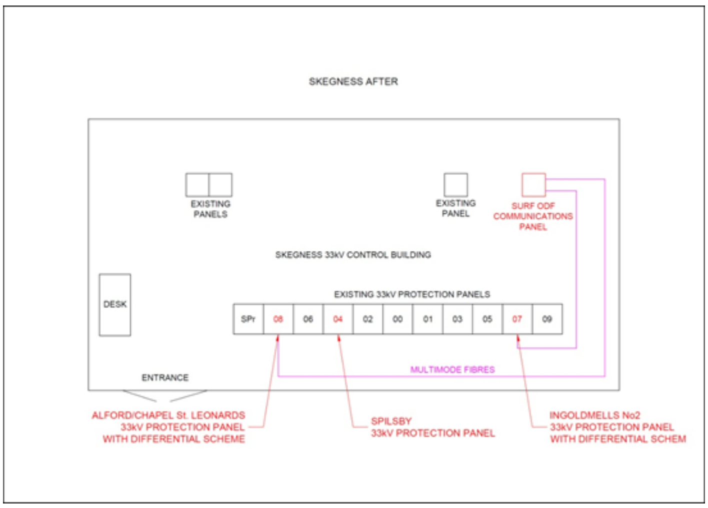


Figure 8 – Skegness Installation

Alford

- Replace the existing outdoor 33kV outdoor oil circuit breaker (CB) at Alford with an outdoor 33kV SF6 circuit breaker,
- Replace the two existing line disconnectors; with new disconnectors that have auxiliary contacts fitted,
- Post CTs were installed on T2 to summate the transformer load and the CTs within the CB bushing,
- A three ended current differential protection scheme was installed on the Alford / Chapel St Leonards circuit with distance protection backup,
- A three ended current differential protection scheme was installed on the Trusthorpe /Bambers Farm circuit with distance protection backup,
- Three phase VTs were retrofitted to both line disconnectors for use with distance protection and check synchronisation

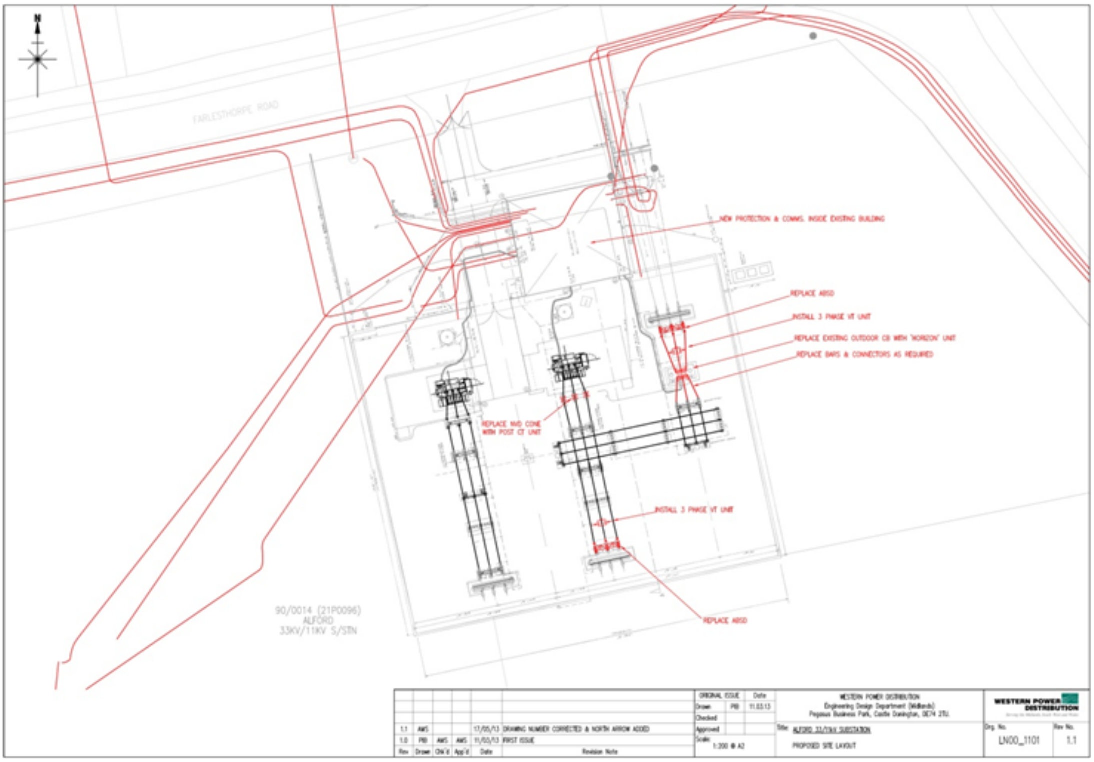


Figure 9 – Alford Installation

Bambers Wind Farm

- Installation of a three ended current differential scheme on the Trusthorpe / Alford circuit with distance protection backup,
- Retrofit appropriate CTs to the Bambers Wind Farm Ormazabal 33kV circuit Breaker.

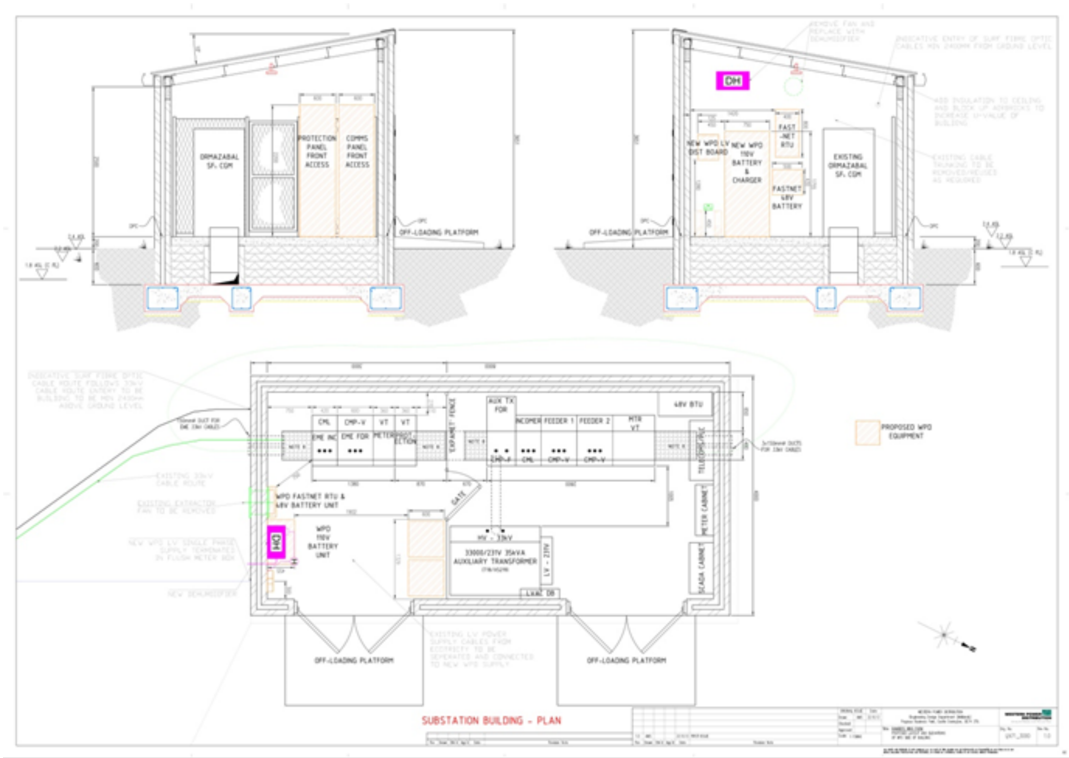


Figure 10 – Bambers Wind Farm Installation

Trusthorpe

- Install a 33kV 7 panel switchboard as part of the Trusthorpe primary substation transformer change and LLCH project. 2 x feeder circuit breakers, 3 x transformer circuit breakers (2 x primary transformers and a FACTs transformer) and 2 x bus sections,
- Installation of a three ended current differential scheme on the Trusthorpe / Alford / Bambers Farm circuit with distance protection backup,
- Installation of a two ended current differential scheme on the Trusthorpe / Chapel St Leonards circuit with distance protection backup

Figure 11 – Trusthorpe Installation

Chapel St Leonards

- Installation of a 3 circuit breakers board,
- Reinstatement of the T1 line disconnector, cable connecting the Skegness/Alford circuit toT1 Line disconnector,
- Removal of over sailing Ingoldmells/Trusthorpe OHL span and line disconnector,
- Three phase VTs were retrofitted to both line disconnectors for both distance protection and check synchronisation,
- Cable connect the new ring main unit to both T1 and T2 disconnectors and Trusthorpe OHL,
- A three ended current differential protection scheme was installed on the Chapel St Leonards / Alford / Bambers Farm circuit with distance protection backup,
- A two ended current differential protection scheme was installed on the Trusthorpe / Chapel St Leonards circuit with distance protection backup to provide adequate protection for this network.

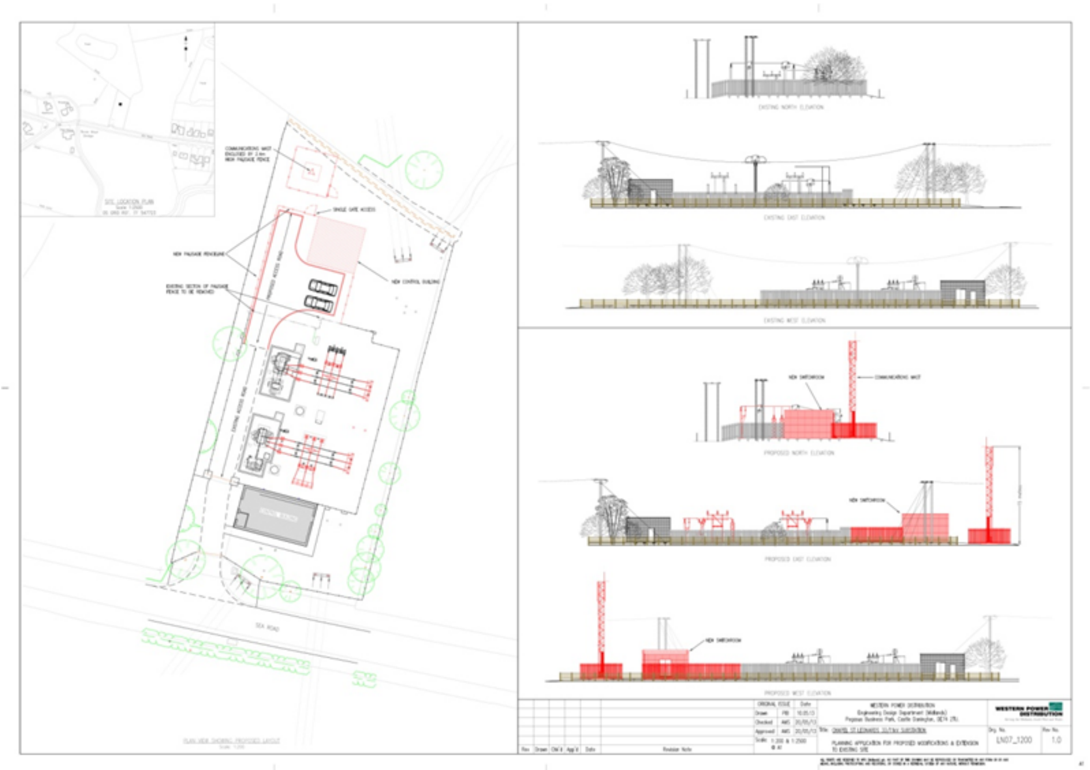


Figure 12 – Chapel St Leonards Installation

Ingoldmells

- Installation of a new bay including terminal structure, Horizon 33kV circuit breaker, disconnector, cable sealing end structure, VT, disconnector and cable sealing structure,
- Modification to the existing cross bay, installing a new Horizon 33kV circuit breaker and post insulator,
- Three phase VTs were retrofitted to both line disconnectors for both distance protection and check synchronisation,
- The Skegness circuit existing line disconnectors has been replaced with disconnectors including auxiliary contacts,
- A two ended current differential protection scheme was installed on the Chapel St Leonards circuit with distance protection backup,
- A two ended current differential protection scheme was installed on the Skegness circuit with distance protection backup will provide adequate protection for this network.

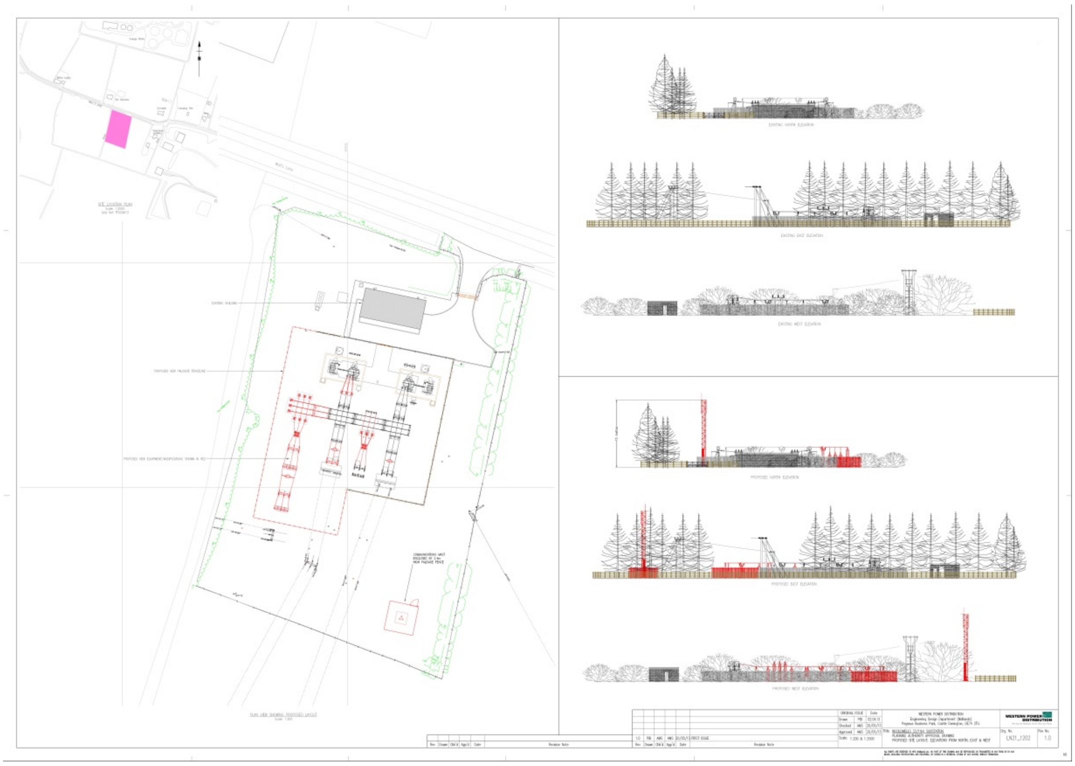


Figure 13 – Ingoldmells Installation

The installation at all sites allows the network to run as a closed ring with greater controllability enabled by increased visibility of power flows and voltage profiles. This arrangement allows WPD to reconfigure the system based on the real time status of the network. The protection scheme operates under normal conditions using a new communication network described in Section 5. The backup protection, when the communications are not operational is distance protection. A technical description of the ring network will be included in the Project Close Down report.

4.3 Knowledge Generated

Area	Knowledge Generated
Design	To create an active ring network the original project design included an additional 4.5 km of new 33kV OHL and the closing of the existing normally open point at Chapel St Leonards. This new OHL in combination with the active ring network would have created an increase in the potential capacity to connect generation. However due to local opposition, largely linked to possible new wind farms, the wayleave process became increasingly difficult. Speaking to local groups it became clear that the proposal to build the new OHL was unfeasible. Although further steps could have been taken to secure permissions (compulsory wayleaves etc.), this was deemed inappropriate for an ahead of need investment or a LCNF demonstration project. Subsequently an alternative network layout was developed that sought to maximise the potential operational capacity of the existing assets. While this did not adversely affect the majority of elements of the project, it has had a significant bearing on the design of the active ring network, and resulted in a redesign of the network layout.
Design	The public perception of new renewable generation in the area changed very quickly in-between the final submission and the detailed design of the project. The change in public opinion had a considerable impact on the ability to secure agreements.
Design	The Low Carbon Hub design was largely completed using desktop planning; learning from this project has shown that for a project of this complexity, further design works at the bid or pre project stage would have resulted in a better understanding of the project requirements. If WPD was to repeat the process, the design work & permissions for higher dependency delivery plans would be carried out prior to committing to the ring method. Where suitable alternatives do not exist, the ring network would not be expected to be selected as a suitable method. It is a requirement that any works to the network should result in the network being the same or better after completing works. This ruled out a large number of options for the ring network as the options would have reduced certain flexible elements that already existed in the network. As such, it isn't a particularly flexible technique and should be fully considered before committing to modifying an existing radial network to a ring operation.
Design	It was possible to deliver the ring network using only the existing distribution network assets by including Ingoldmells substation. Due to the new 4.5km interconnector not being built, the capacity unlock by the ring method was reduced, but the ring network has facilitated three additional generation connections.
Operation	The delivered of ring network has provided considerably more network security for both demand and generation customers after a fault due to a fault being cleared within each zone.
Design	The decision to include Ingoldmells substations and the associated OHL's

	required a number of complex decisions to be made. The inclusion of Ingoldmells significantly increased the number permutations and complexity for both normal and abnormal running arrangements leading to delays in selecting an acceptable Low Carbon Hub design that can be adequately protected. The learning from this method was that a more robust mitigation plan should have been in place in the event the new OHL could not receive wayleaves or planning permission. There is also a much higher risk associated with building Overhead Lines for renewable generation.
Design	The time taken to plan, design, carry out the works and commission new schemes is significant. Even if looking to replicate this technique again in a new area, it would be sensible to allow at a minimum of 3 months for design works per substation and 6 – 12 months for construction per substation depending on the length of the works. This means that technique is more suitable to an ahead of need network reinforcement scheme rather than reacting to a generation connection enquiry.
Design	Within the East Midlands, meshed circuits tends to be associated with 132kV urban circuits, one of the key elements of the project was required to ensure that the meshed network design was suitable for a rural 33kV schemes and not a replication of the schemes used on 132kV urban networks. Some UK rural distribution networks were designed to operate as a meshed ring, often with distance protection. Part of the Low Carbon Hub ring method was to work with the design and delivery teams when assessing how meshed network solution can be retrofitted to an existing network to increase capacity.
Design	The project aimed to show how the existing network could be altered rather than rebuilt to enhance capacity. With the project delays associated with not receiving permission for the new OHL line, it is now conceived that the use of 33kV switchboards at a number of sites would have been an economical advantageous alternative to an AIS or hybrid Air Insulated Switchgear (AIS) solution accounting for the reduced network risk during an offline build, a quicker construction phase and the result of a simpler network to operate. The learning has shown that if the delivery timescales are short and significant works are required on site, the quickest solution is the construction of an offline build as demonstrated at Trusthorpe primary substation. This approach also reduces network risk as the majority of the construction can be carried out whilst the existing network is still in service. The use of a hybrid of existing air insulated assets and new gas insulated switchboards connected with cables can lead to the operation of sites being more complex. This was carefully managed to WPD's existing design policies.
Design	The learning from the project showed that having the right current and voltage transformers in the right locations, with the correct accuracy is often a limitation to smarter solutions. Both the ring network and the DVC method has shown how additional CT's can be incorporated into existing networks (Alford, Chapel St Leonards and Ingoldmells), how additional VT's are best incorporated into AIS sites (Alford & Ingoldmells), how additional VT's are

	best incorporated into GIS sites (Trusthorpe) and how additional VT's are best incorporated into hybrid AIS/GIS sites (Chapel St Leonards). At Alford, Chapel St Leonards and Ingoldmells there was no space within the existing transformer bushing to install the matched CT's required as part of a current differential scheme. This issue was overcome by installing Post CT's. The two options available were to install slipover CT's over the transformer. This was discounted due to the reduced clearance and potential maintenance issues in the future if there is a build-up of debris between the CT and the bushing. The use of post CT's was selected, however no post CT at 33kV was rated to support any length of bus bar. As such, 66kV insulation posts were installed on both sides of the Post CT to facilitate their use whilst still maintaining the equipment rating.
Design	Both operational compounds and switch rooms do not have an abundance of space to add additional assets, if space is available careful consideration is required into how modifications can be made safely, how the entire site can be maintained and how this impacts on future works. The design of an active ring using sites with additional circuits retrofitted to them is more complex due to additional space constrains when trying to connect new switchgear. All designed were vetted to ensuring that primary substations were not sterilised by the work being completed under this project.
Operation	Meshed networks can cause particular protection issues with very rural networks and the associated low fault levels. With high levels of inverter driven generation, making differentiating between a network fault and high steady state output from the connected generation very difficult. A two and three ended current differential scheme with distance backup was selected as the best way method of protecting the network. The connection of new generation to the current differential network will be made, ensuring the network will operate with no more than three ends. This has required several new generation connections to be made as a looped connection to maintain no more than three ends.
Build	Due to the alternative nature of the Low Carbon Hub ring method rather than following standard designs resulted in the onsite team taking a much more active role in addressing issues with input from the designer rather than decisions being made by the designers and disseminated to site. Whilst the project was successfully delivered all the works within the truncated timescales safely and effectively, a longer delivery timetable would have allowed for better allocate of resources and a lower risk delivery.
Operational	The Current Differential schemes have shown to be effective method of protection the network; several links have required further investigation as a result of current imbalance alarms occurring, especially during low demand periods. The current differential relays have been adapted to account for current imbalance present on the rural 33kV network at times of minimum demand.

4.4 Ring Network - Potential for replication

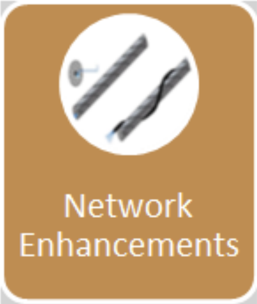
This technique has shown to increase network capacity and improve network security, but it is very dependent on the existing network infrastructure. This means it will not be a suitable method in all locations owing to the available space.

A simple meshing operating using PMAR could be achieved if the resultant power flows are maintained within the equipment ratings and the voltage and current transformers required for the protection scheme can be incorporated into the network

The process of re designing an existing radial overcurrent protected network technique does take a considerable amount of time and effort owing to the complex design works, long lead time items and the requirement for network outages. This means the techniques is more likely to be used for a long term investment ahead of need to increase network capacity rather than responding to a particular generation connection

There are often quicker, more cost effective methods of unlocking additional capacity which may limit the potential for replications across GB. If the meshing of feeders is applied across future wider areas, Future replications in Western Power Distribution would use more offline rebuilds rather than modifying an existing network to enhance capacity.

5 Overview of the Network Enhancements methods



Network enhancements – Sections of existing overhead lines have been upgraded within the demonstration area with higher rated and lower impedance conductors to increase the network's capacity to connect DG. This work is in addition to investment already funded through the Distribution Price Control Review (DPCR) 5 settlement. For the purposes of disseminating learning, the communications required for a range of the methods above have been reported as part of this method.

5.1 Over Head Line Network Enhancement

5.1.1 Background to 33kV OHL asset replacement

The design of the primary network and asset replacement programme is influenced by a number of factors:

- The current and future demand a network area will support when operating both normally and abnormally for maintenance or after credible faults on the network,
- the thermal capacity, often matching the standard transformer capacity installed across the network,
- voltage profile analysis, ensuring the network will stays within the required limits across the network, when operating both normally and abnormally,
- the thermal capacity sharing across the network under abnormal network operation, and
- the changing of the network design standards over time.

When network assets are due to be replaced either due to condition or load related reasons, a DNO is incentivised under the regulatory performance measures to install the minimum cost scheme that fits the current and credible future functional requirements such as demand growth. This ensures that assets are not over invested and subsequently stranded. However, it can also result in the replacement not being fit for an evolving, unknown future.

5.1.2 Low Carbon Hub – Network Enhancements

One of the LCH techniques was to ascertain what additional functionality should be either designed or built into networks to make them more suitable for future generation connection. The Distribution Price Control Review 5 (DPCR5) overhead line replacement programme for both load and condition reasons were routinely evaluated to ascertain if the most suitable asset for the future was being proposed. Sections of 33kV overhead lines were being replaced between Alford to Trusthorpe and between Chapel St Leonards to Trusthorpe. There were identified as key circuits which, if the impedance was reduced, would unlock additional generation capacity for both conventional and alternative connections.

In East Lincolnshire, nodal analysis modelling showed that even with the connection of relatively small new distributed generation sites near Trusthorpe, the relatively high existing network impedance and existing generation connections resulted in the network operating above upper statutory limit of 35,000V during periods of minimum demand. At the time the OHL replacement was being planned, there were no new generation applications in this area that would benefit from a larger conductor being installed.

The standard design manual for replacing rural 33kV Overhead lines is with 150mm2 Aluminium Conductor Steal Reinforced (ACSR). The circuits being replaced in the LLCH area were designed to have 300mm2 Hard Drawn Aluminium (HDA) installed with the provision for optical fibre both at the construction phase and as a retrofit activity. This conductor cross sectional area was double in size, and had half the network resistance. 10.2km of 33kV network was rebuilt with the larger design standard.

Figure 15 – Rebuilt line with fibre wrap

5.1.3 Knowledge Generated

Area	Knowledge Generated
Design	It became clear that securing wayleaves for replacement Overhead Line that the process would be longer and more protracted than planned. Engagement with Arable land owners revealed they were not willing to accept shorter span lengths, i.e. the closer spacing of overhead line poles. The circuits being replaced were constructed in the 1950's; they have a typical span length of 150 – 160m. Following WPD standard 43-40 design philosophy, 150mm^2 conductors on a single wood pole design would have an average span length of approximately 120m and 300mm^2 conductors on a single wood pole design would have an average span length of approximately 85m.

	This feedback from land owners resulted in WPD requiring a replacement line maintaining similar span lengths. WPD designed a new H pole construction with an equivalent span of 160m for similar future scenarios. The pole positions of the Overhead Lines were discussed with Landowners and residents so as to not obstruct farming practices and to reduce the visual amenity. The necessary wayleave permissions were secured on this basis.
Commercial	The additional uplift associated with rebuilding the 10.1km of overhead line to the Low Carbon Hub standard was calculated as £80,000, this increased the summer capacity from 16MVA to 41MVA and has been modelled to reduce voltage rise by 24% compared to the existing circuit during maximum reverse power flows. This could either connect an additional 12MW of distributed generation under conventional connections.
Design	The wrap causes an impact on the MCT (Max Conductor Tension), MCW (Max Conductor Weight) and MCP (Max Conductor Pressure). However the impact is only marginal it does affect the design slightly. At a maximum span length of 190m at maximum design temp the sag increases from 7.02m to 7.29m, this was taken into account to ensure clearances were still maintained, the maximum clashing span was reduced from 190m to 178m.
Design	The two OHL rebuilds received all the required wayleaves from landowners in February 2103. Local Authority permission, Flood Defence Consent from the Environment Agency, Land Drainage Consent from Lindsey Marsh Drainage Board and DECC Section 37 consent were all received by August 2013, taking approximately six months to secure.
Design	The design of the larger conductor rebuilds was studied to understand the impact on the network under both intact and plausible non-intact scenarios to ascertain what impact it will have on the resultant power flows. This also included adding different levels of generation at different points on the network to ensure the rebuilding of the circuits with a larger conductor did not present unbalanced power flows that could limit the future` capacity of the network system.
Operation	The installation of a larger conductor reduces the resistance of the circuit; the reactance of the replacement circuit was similar to the original circuit. The replacement conductor reduced the effects of voltage drop when the network is demand driven, reduces the effects of voltage rise when the network is generation driven and reduces the network losses.
Design	WPD's OHL design software models conductor sag based on tension, adding fibre wrap to an overhead line will increases the weight rather than the tension. The resultant design based on tension is more conservative but will ensure that statutory clearances are maintained.
Build	The build of the overhead line was completed in sections. After the section were completed, the optical fibre team following behind to wrap the new line. This increased the duration of the wrapping the line but reduced the disturbance on landowners.

5.2 Telecoms

5.2.1 Background to Telecommunications within Primary Substations

The requirement for advanced telecoms was identified as an enabler for a number of LCH techniques, such as part of Dynamic Line ratings, the current differential protection traffic for the ring network and the backhaul of data for the Advanced Voltage Control. Existing communications for SCADA traffic is UHF (Ultra High Frequency) radio; this has a relatively low latency and bandwidth and operates in a hub and spoke design between substations and the base. It is not suitable for the high speed and bandwidth data requirements for current differential protection traffic between primary substations. It could be a limitation for other methods where network data is required to support network operational decisions.

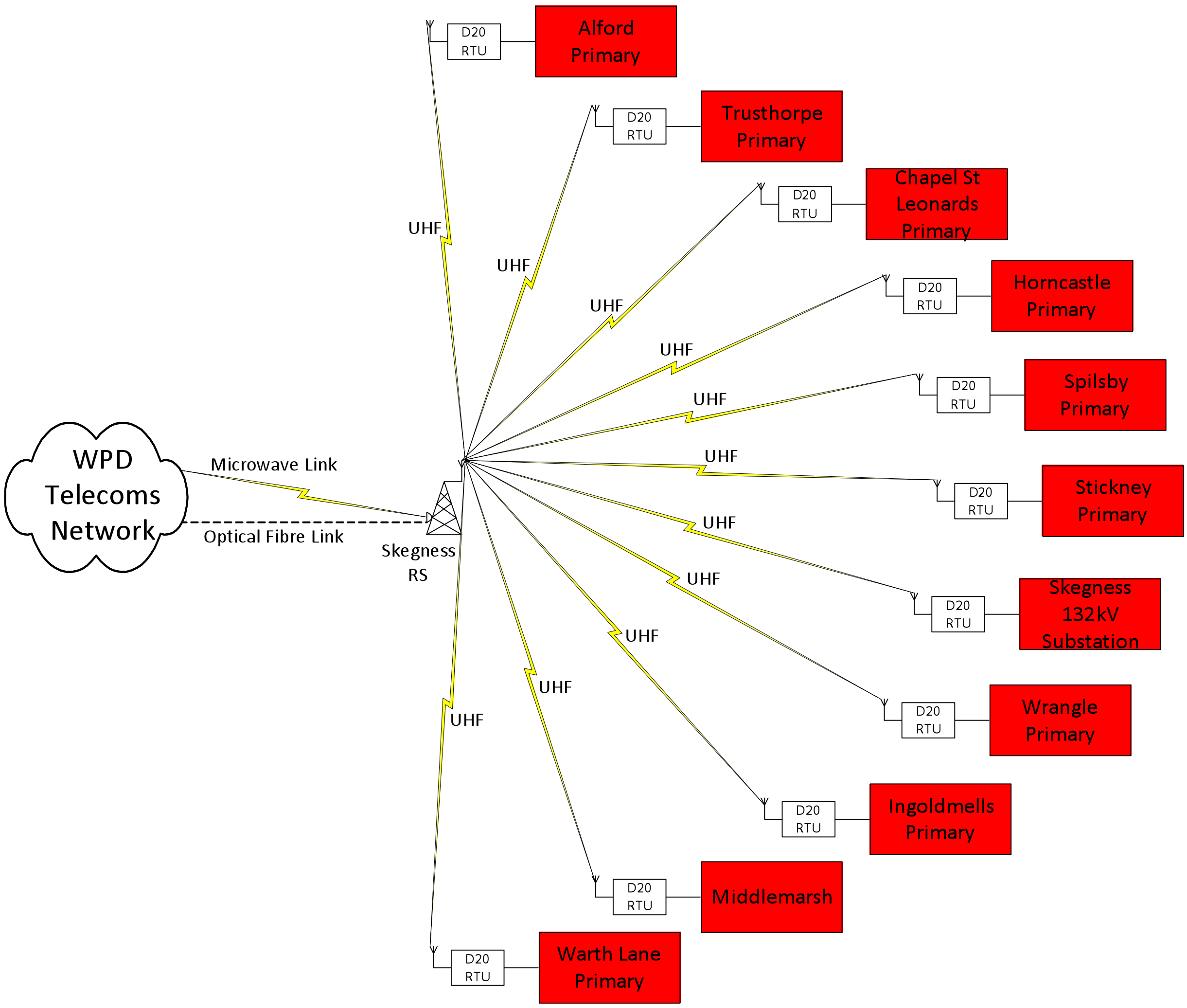


Figure 16 – Hub and spoke SCADA communications

5.2.2 Low Carbon Hub - Telecoms

A key requirement of the project was to investigate what would make a suitable telecommunications links between primary substations for network protection and other data requirements. The protection requirements for the Low Carbon Hub and advanced network operation require a reliable, low latency communications media for protection purposes.

Fitting optical fibre and microwave communication links for primary substation current differential protection schemes was a new area to WPD. As such there was a low level of risk with any new technology, the decision was made to trial both wired and wireless communications channels as part of the project to further reduce the impact of any one communication technology not operating effectively. A review of the available wired and wireless communications communication media was conducted and a report published on www.westernpowerinnovation.co.uk/documents.aspx. both wired and wireless communications.

The project installed 96 fibre SkyWrap to new and existing lines between Skegness to Alford and Alford to Trusthorpe. The project installed three microwave towers and three microwave links installed between Skegness to Ingoldmells, Ingoldmells to Chapel St Leonards and Chapel St Leonards to Trusthorpe

Figure 17 – WPD Microwave tower and link

5.2.3 Knowledge Generated

Design	There are three main options for attaching fibre to wood pole overhead lines 1) Optical Phase Conductor (OPPC) can be used, however this requires the re stringing of the centre phase, this is a high cost installation for retrofit. This also requires sufficient spare conductor to be strategically stored for repairs. The use of OPPC could lead to extended periods of time when the optical fibre is not available for protection traffic. Therefore OPPC was not considered for the project or WPD's fibre standard. 2) All-Dielectric Self Supporting cable (ADDS) is WPD's the first choice for adding fibre to an existing line wood pole line as it can be

	installed below the overhead line. However, on the existing OHL's where fibre was required on in East Lincolnshire, the ADSS could not be installed without either reducing the ground clearance which would have caused issues with the very large farm machinery or causing an unacceptable risk of clashing or increasing the height of a number of poles along this circuit. Therefore, ADSS was not an appropriate choice for the surveyed east Lincolnshire lines. 3) Optical Fibre Wrap is applied to the centre phase of the existing overhead line, the conductor provides the mechanical strength of supporting the fibre. WPD selected fibre wrap to provide communications between Skegness – Alford and Alford – Trusthorpe, installing on both new and existing OHL's. Studies showed that one of the implications of the wrap was increased sag under certain conditions, three existing spans would no longer meeting WPD's OHL policy for clearances, the issue at these locations was increasing the line height.
Operation	As a result of adding optical fibre to 33kV OHL in the East Midlands, a new policy was written for all WPD areas. Some of the key points focus on: installation, labelling, clearances, access to fibre optic equipment, subsequent work on the OH network, operational earthing, repairs / maintenance of overhead line, handling fibre optic cables, system bonding and additional loading on the Overhead Line.
Build	Microwave links were required between Trusthorpe, Chapel St Leonards, Ingoldmells and Skegness primary substations. Desktop studies showed that towers at 15 meters would allow a clear line of sight between all substations. However, line of sight tests were performed and showed issues at several sites due to obstacles preventing a clear line of sight. Further work was required to relocate the microwave towers to different locations within the substation boundaries to facilitate line of sight communications. Permitted development rights were used to secure the installation of new towers at Trusthorpe, Chapel St Leonards and Ingoldmells primary substations. 15m is the maximum height for permitted development. If the project required taller towers planning permission would have been required. Securing planning permissions for a microwave tower would have been an increased risk. There was a number of mitigation plans in the event the WPD could not have secured permission for the necessary microwave towers and links.
Operation	Whilst the use of microwave links for current differential protection has been used by other DNOs within the UK, WPD has limited operational experience of operating microwave links as the primary communication channel for current differential protection data. The links have remained stable since the installation.
Design	The use of the optimised protection variant (OPV) Mimo Max equipment was considered for the project, however the bandwidth was significantly lower than microwave links, a much higher latency meant several links could

	not be used in series whilst still maintaining a sub 6ms response required for the current differential protection.
Commercial	The cost associates with the telecoms infrastructure was much higher than forecast, the foundations for the microwave towers and the installation of 96 fibres also exceeded the project budget.
Design & Operational	There was originally concern that as a result of the Optical fibre wrap would have a negative impact on the aesthetics of the overhead line. The effects of wrapping the overhead line is not significant and would not prevent further OHL's from being wrapped.
Design & Operational	Careful consideration at the design stage is required for the application of temporary earths and the location of earthing of splicing canisters. Failure to do so can result in reduced operational functionality.
Build	Due to a UK shortage in the exterior jacket material which protects the optical fibre, the fibre installer for the project used an alternative product. This caused issues in the installation phase as the material was less pliable then the normal jacket. During the installation process the fibres became damaged and when tested, they failed the tests. This required the manufacturer to re wrap approximately 10km at their expense. The lessons learnt from this installation were captured and processes have been put in place to ensure that the same issue cannot occur again. The subsequent re wrapped circuit showed all 96 fibres passed the tests.

5.3 Network Enhancements - Potential for replication

In areas where there are clear indications Distributed Generation will be connected, the enhancement of assets should be considered as assets are due for replacement. This may include installing a lower capacity circuit or a circuit designed for fibre to be retrofitted

In areas of Active Network Management, the circuit utilisation will be very high. The replacement of assets with a lower impedance and large capacity will reduce the constraints seen by DG customers and reduce network losses. The design and build costs associated with Enhancing OHL's is relatively modest and should be applied in ANM areas if appropriate.

The rebuilding of an overhead line is a relatively quick process if the ground remains dry during the installation. The process can be delayed significantly if sections of the new overhead line are built more than 30m from the original line, the securing the necessary permissions can result in a long and protracted process.

If an overhead line is being rebuilt to increase the capacity of a line or reduce the impedance as a result of a DG connection, there is a risk that the permissions create delays in network reinforcement being carried out ahead of the generation connection.

5.4 Telecomms - Potential for replication

Further work is required to assess the long term performance of the microwave communication links to ascertain if they should be used in other locations as the primary current differential communications link.

Fibre can be retrofitted onto existing 33kV lines to facilitate increased communications between primary substations. The current high cost associated with installing fibre on wood pole is likely to prevent its extensive use across the rest of GB.

6 Overview of the Dynamic Line Ratings methods

Dynamic system ratings – The Skegness Registered Power Zone delivered innovative connections to offshore wind farms based on dynamic rating of overhead lines. These components have been further developed and the new techniques tested at 33kV to calculate the network capacity and operating limits based on real time asset data.

6.1 Background to Overhead Line Ratings

Within the UK, Overhead conductors have specific static current ratings based on seasonal weather patterns dictated by ENA Engineering Recommendation P27.

The P27 ratings determine the maximum current rating to maintain the conductor below the maximum design temperature. With increasing current flowing through an overhead line, the temperature of the conductor increases, which can either damage the overhead line and/or cause the conductor to expand reducing the proximity to the ground.

OHL static ratings assume certain conservative static environmental factors such as:

- Ambient air temperature (°C)
- Wind speed (m/s)
- Wind direction (°)
- Incident solar radiation (W/m^2)

The Engineering Recommendations is based on probabilistic ratings and ensure the overhead lines operating at the maximum current loading will operate below the maximum design temperature except for short excursions in extreme environmental conditions. The actual operating temperature of a conductor varies considerably depending on the external environmental factors and the current (A) flowing through the line.

Previous innovation projects have shown that overhead line ratings can be dynamically increased when the environmental conditions allow, i.e. during cold, windy conditions perpendicular to the Line. Dynamic Line Ratings projects previously, at the time of the bid, have shown how fixed weather stations can measure wind speed, wind direction and temperature accurately to accurately to achieve large increases in an overhead lines capacity. However weather stations were shown to be unreliable at times and whilst the OHL rating is often the first limit on a circuits capacity, other assets cannot be dynamically rated prevent and significant increases in capacity.

6.2 Low Carbon Hub – Dynamic Line Ratings

The Low Carbon Hub built on the work of the Skegness 132kV Registered Power Zone (RPZ) which delivered cheaper connections to offshore wind farms, giving Western Power Distribution Policy for 132kV tower lines. The LCH has developed a method of dynamically rated 33kV overhead lines within the NMS, calculating new maximum operating limits based on real time electrical output from Wind Farms instead of using multiple weather stations.

The method converts the Electrical Output from multiple turbines into the wind speed at the nacelle height using turbine manufacturer's data, estimates the wind speed at the overhead line height using the wind power law, and incorporates the wind speed data into the Dynamic Line rating algorithm to better estimate the actual maximum circuit rating making best use of all the available information.

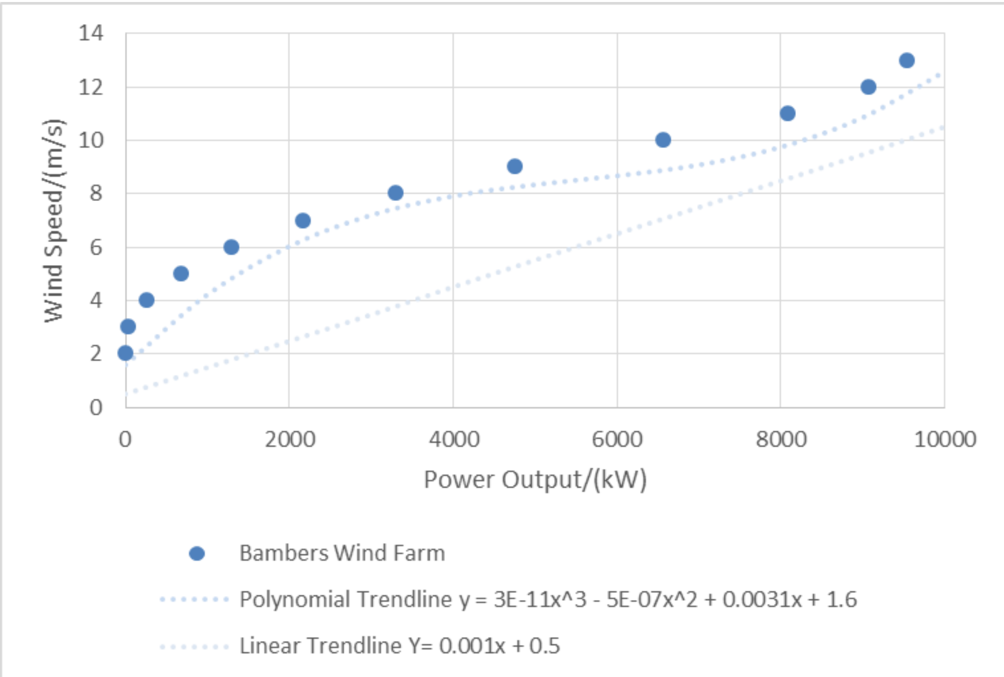


Figure 18 – Algorithm to calculate wind speed from electrical output

6.3 Knowledge Generated

Area	Knowledge generated
Design	In most rural networks, the overhead line rating is often the limiting factor when assessing the capacity of a circuit. The Low Carbon Hub project has shown that using dynamic line ratings, it is possible to dynamically calculate and increase the rating of the Overhead line where the wind speed is high and the ambient temperature is low. However there are a number of assets in a circuit such as cables, circuit breakers, disconnectors and current transformers which cannot be

	dynamically rated based on weather conditions, their ratings are fixed. In East Lincolnshire, the 33kV OHL's can typically be dynamically rated up to 113% of the static rating before the OHL is no longer the limiting component. Operating the circuit above the rating of the cables, disconnectors and current transformers could lead to premature aging and asset failure.
Design	LCH Dynamic ratings are based on enhancement the existing static ratings using the P27 fixed temperature data and calculating the wind speed data using a number of safety factors including a pessimistic direction. Whilst it is possible to measure weather conditions accurately, by installing weather stations to maximise the rating of the OHL, the large increases are not required as the circuits are also limited by the fixed asset ratings of cable sections, current transformers and circuit breaker ratings and often the statutory voltage limitations prevent the full asset ratings from being reached. This project has shown that the use of wind farm data could facilitate the modest increases in capacity available due to the other fixed asset ratings. The project has also shown that where the fixed asset ratings are not the limiting factor, wind farm data could be used in conjunction with weather stations and/or Met Office data to make the use of dynamic line ratings technique more flexible, reliable and reduce the potential points of failure in DLR techniques.
Design	At 33kV safety factors are required to account for how the line is sheltered and how this could change in the future. Sheltering can change over a relatively short period of time as both natural and manmade structures evolve. A line survey of the feeders being dynamically rated identified a new industrial building had recently been erected very close to an overhead line, this caused the line to have to be diverted due to horizontal statutory clearance issues. Even with the relocated OHL, the building still has a sheltering effect on the OHL.
Build & Operation	The algorithm was scripted within WPD's NMS and displayed as an analogue value alongside the relevant overhead circuits. The circuits have not been operating within the dynamic capacity as the current generation does not exceed the static ratings.
Commercial	There is an opportunities to incorporate the dynamic line ratings within the ANM scheme if the thermal ratings of the circuits become a constraining factor. The current accepted generation does not have any 33kV thermal constraints that can be solved with Dynamic Line Ratings.
Commercial	Dynamic Line ratings using Wind Farm data will be used most where clusters of wind farms occur close to the grid substation or when a network is being run abnormally.

6.4 Dynamic Line Rating- Potential for replication

The current generation connections show at the time of writing the report, Dynamic Line Ratings are not required in East Lincolnshire due to the locations of current and proposed Distributed Generation.

Dynamic line ratings are most likely to be replicated in rural locations where high levels of generation are causing thermal constraints. Dynamic Line Ratings can be used to increase the capacity of the line under certain conditions, however the risk and consequence of sheltering must be considered on a circuit by circuit basis.

The greatest potential for replication will be combining the electrical output from wind farms with either met office data or weather stations to calculate the dynamic rating of a line. This method is most suited to either Active Network Management areas with high levels of wind generation.

7 Overview of the Active Voltage Control method

Dynamic voltage control – Building on the principles of an existing Innovation Funding Incentive (IFI) project, Dynamic Ratings, the 33kV target voltage has been actively varied. This was done dynamically based on real time measurements of demand and generation. Dynamic voltage control increases network utilisation whilst maintaining the system voltage within the statutory limits.

7.1 Background to voltage control at Grid substations

A typical UK Grid substation arrangement will have two Grid transformers, stepping the voltage down from 132kV to a nominal 33kV, supplying a number of the primary substations where the voltage is further stepped down to a nominal 11kV. Each Grid and Primary transformer has an Automatic Voltage Control (AVC) relays at the substation which autonomously corrects for circulating current and controls the network voltage within its defined limits.

The 33kV and 11kV network voltage profiles are controlled by AVC relays with static set point voltages. These voltage set points are derived by network analysis for the creditable worst case network scenario, i.e. configuring the network for maximum voltage drop across the overhead lines, cables and transformers with no contribution from intermittent embedded generation.

7.1.1 Low Carbon Hub – Dynamic Voltage Control

The Dynamic Voltage Control scheme has demonstrated the concept of optimising AVC voltage set points in real time. The method is more effectively utilising the available analogue network data, created an algorithm to calculate a more optimal set point and has modified the existing AVC hardware and communications so the Skegness AVC's can accept new set points remotely.

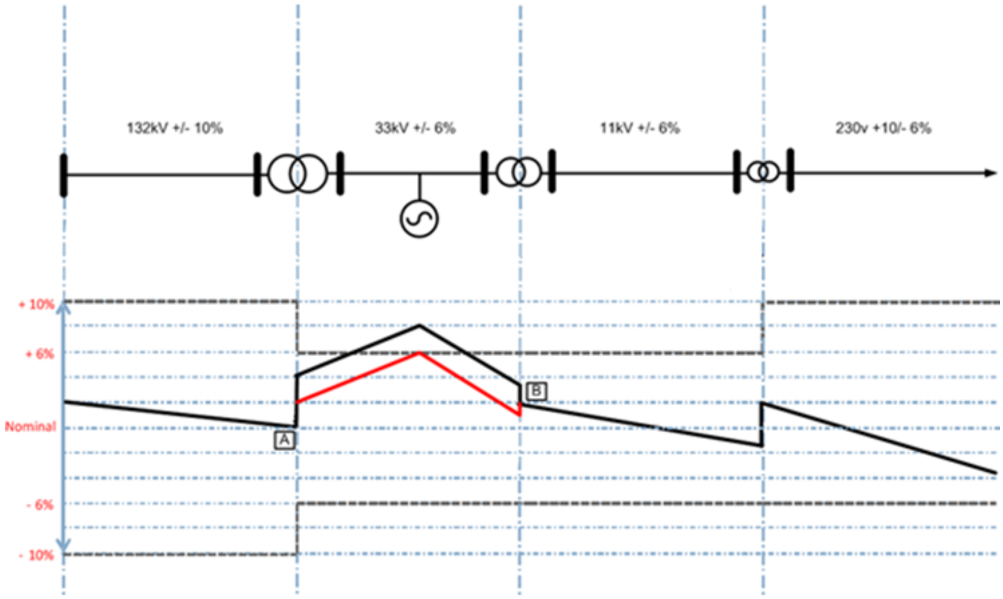


Figure 20 – showing simple network design with DVC

7.1.2 Better calculate voltages at key locations

As shown above, the majority of primary substations do not measure and recover the voltage on the primary side. It hasn’t been a key requirement as most distribution networks are predominately supplying demand. However in networks where the generation can exceed the demand, without accurate voltage sensors at key points of the network, it is very difficult to further optimise the voltage profile across the networks whilst maintaining the statutory limits. Retrofitting new Voltage Transformers and associated equipment to an existing primary substation can often be relatively difficult and expensive.

At Horncastle Primary substation, the primary voltage is being derived using the 11kV Voltage Transformer, the measured Real Power (P) through the transformer, the measured Reactive Power (Q) through the transformer, the tap position and the physical characteristics of the transformer. The recovered data is used to calculate the primary network voltage.

7.1.3 Knowledge Generated

Area	Knowledge Generated
Design	The original design was for the AVC relay to calculate the primary network voltage as a Virtual Voltage Transformer (VVT); however limitations with the processing power of the current SuperTAPP n+ AVC meant an alternative solution was required. The planed upgrade of the SuperTAPP n+ AVC is released later in 2015 will have this functionality allowing the data will be presented to the RTU as an analogue signal.
Design	The VVT data has been hosted on Fundamentals system called iHost to prove the concept After testing, the VVT will be transferred onto WPD’s iHost server.
Build	The installation of VVT can now be built into an existing standard SuperTAPP

	n+ scheme for approximately £4,000. The associated cost of installed a fixed outdoor VT is approximately £40k, although this varies at each location. This includes the purchase and installation of the 33kV VT, structure, plinth and multicores back to the RTU.
Operation	The Virtual VT through the iHost system has allowed primary system design to better understand how the primary network is operating in areas where transducers have not been available. This has confirmed the voltage profiles corresponds to the nodal analysis models and has been used to optimise the existing fixed AVC settings at Sleaford as well as Skegness.
Commercial	The data associated with the VVT is approximately 4MB per day being transmitted using GPRS. In the future the VVT data could be backhauled through the SCADA network.

7.2 Creation of an Algorithm and integration into software

Fundamentals Ltd have created an Algorithm which check the network configuration / running arrangement and voltage profiles at key locations in the a network. If appropriate, the algorithm has been designed to optimise the voltage in two ways. It can either calculate a more appropriate target voltage setting, sending the analogue set points it over WPD's SCADA network to the AVC relays at Skegness or it can determine if the AVC scheme should switch between standard and alternative settings.

7.2.1 Knowledge Generated

<table>
<tr><th>Area</th><th>Knowledge Generated</th></tr>
<tr><td>Design</td><td>Dynamic Voltage Control could either analyse additional information locally at the grid substation or centrally within the Network Management System. Both have advantages and disadvantages. As part of the Low Caron Hub design, both methods were evaluates with the Centralised Control option being progressed.
<table>
<tr><td>Local Control</td><td>Centralised control</td></tr>
<tr><td>✓ Local Control avoids the high level of information to be backhauled to a central location.</td><td>✗ Requires high levels of data to be backhauled to a central location. Recognising both GPRS and existing UHF radio links is not an ideal solution.</td></tr>
<tr><td>✗ High cost additional communications links would be required to enable the communications to all locations,</td><td>✓ Can utilise existing communications links or low cost communications links to be utilised</td></tr>
<tr><td>✗ Additional intelligence would need to be installed in the Grid substation,</td><td>✓ Allows existing Network Management Systems (NMS) to be utilised to understand</td></tr>
</table>
</td></tr>
</table>

		when the network is operating abnormally
	✗ *The ability to understand when the network is operating abnormally is very difficult, requiring all switches and breakers to have status indication to be retrofitted with communications linking to the Grid substation intelligence.*	
	Or	
	✓ *This requires the solution to be switched off when the network is operating abnormally.*	
	✓ *Avoids the high level of information to be backhauled to a central location.*	
Design	There is a requirement to understand if each voltage measurement points are being influenced by the AVC being optimised. If the system is not aware if the network is operating abnormally, there is a possibility that abnormal network configuration the voltage optimisation takes into account unrelated information and incorrectly calculate the target voltage settings.	
Design	The algorithm has been configured to turn off in the event the network is working abnormally or if the communications is not available, the relay defaults to the nominal settings to ensure the voltage will stay within statutory limits if the outage is prolonged.	
Design	The DVC has been designed to maintain statutory limits after credible n-1 scenarios, taking into account and calculating the voltage profiles after a fault when calculating and setting a more optimal voltage profile.	
Design	The DVC has been designed and configured to optimise the voltage no more than twice a day. This will allow the voltage profile to optimise for long term steady state power flows rather than short term transients in load or generation.	
Build	The way the algorithm interrogates non tele controlled isolators has been modified, allowing the open or closed state to be shown within WPD's NMS to ensure the Algorithm can detect if the network is operating abnormally.	
Build	The scripting of the algorithm has been carried out by WPD's staff as they have the detailed knowledge of how WPD's NMS is configured and interfaces with AVC's. It would have been very difficult for an independent company without significant NMS experience to carry out the final centralised scripting.	
Operation	Due to the significant change to the control of the AVC Hardware, the algorithm has been tested with bench equipment for several months before	

	to test how the algorithm interfaces with the modified hardware. This has been essential to de bug performance issues.
Operation	The algorithm can operate in the test server taking live information and the decisions it would take analysed, further de risking the operation of the network until the algorithm can be shown to be predictable and stable.
Commercial	This technique has been designed to operate independently with the ANM scheme installed at Skegness. If the DVC is operating with a more optimal voltage target, the voltage headroom across the network will be increased, reducing the impact of generation being constrained for voltage issues. If the DVC is not operational or cannot optimise the voltage profile based on abnormal operation or the voltage profiles across the network do not allow the voltage target to be amended, if any voltage violations are seen, the ANM scheme will constrain generation to reduce the effect on the network.
Design	The full AVC functionality can still be maintained at Skegness by the control engineer, including tap lock 3% and 6% voltage reduction.
Design	When the NMS issues a command over SCADA such as tap lock or voltage reduction, the NMS can only issue one instruction at a time. For existing hardwired schemes when this instruction is issued it is applied to both AVC's at Skegness.

7.3 Hardware modifications to allow remote set points

Like most AVC relays, at Skegness Grid substation, they operate autonomously, sending digital and analogue outputs to the Network Management Software. Through the NMS a Control engineer also has some basic control functions over SCADA such as locking the tap changer, manually tapping the transformer, and applying a 3% or 6% reduction in the target voltage.

As part of the Low Carbon Hub, all existing functionality has been transferred from Hardwired communications to DNP3 and further functionality such as applying new analogue target voltages manually or automatically. The project installed a new D400 RTU from G.E to allow the DNP3 functionality.

7.3.1 Knowledge Generated

Area	**Knowledge Generated**
Design	Skegness has two AVC schemes per transformer – as part of a previous innovation project. Due to the more complex AVC arrangement, There has been a requirement to keep detailed description of the trial with associated drawings; this is especially required for an innovation project as the installation is non-standard. Work has also considered a plan for the next stage, adopting the solution if successful or decommissioning if not successful.
Design & Operation	Due to the significant change to the control of the AVC Hardware, a relay was bench tested with DNP3 control through a D400 RTU for several months to show how the hardware interfaced with the NMS and the DVC Algorithm. This has been essential to de bug performance issues.

Design	There has been a reluctance to transfer away from hardwired control to DNP3. Hardwired controls are very established, well understood and easy for the local engineers to test and debug issues between the RTU and the AVC relays. However Hardwired communications is expensive to install and will limit the control and future functionality of the relay. There is a requirement for a number of design decisions to be made when incorporating Dynamic Voltage Control at a substation, including what should happen when the scheme is turned from Remote to Local control. Should the algorithm in the NMS be turned off before the AVC scheme is transferred to Local Control, should the AVC retain the dynamic target voltage, should the AVC switch back to the default target voltage.
Design and Operation	As detailed above, the NMS can only issue one command at a time over SCADA, two commands cannot be issued at the same time. A tap lock or voltage reduction instruction must be sent and carried out by both AVC relays at the same time. To operate with DNP3, A further algorithm is required within the Envoy or the SuperTAPP n+ relay so the DVC can be applied to both transformers at the same time.
Operation	The transfer away from hardwired communications will requires a different diagnostic team to respond to site in the event of a potential relay or communications fault. This will see the communications team operating closer to the protection relays or additional training for the project engineers.

7.4 Dynamic Voltage Control - Potential for replication

This technique has shown there are substantial opportunities to optimise target voltage settings by using an Algorithm to review the voltage profiles and power flows across the network. The technique has the highest potential for replication in locations where there is a significant difference between maximum and minimum demands, where there are different demand profiles across the network, when the feeders are of a similar length or have similar voltage profiles and large levels of intermittent generation connected.

The solution requires further work to find a solution that will unlock capacity for non-firm generation connections. This will require DVC to optimise the network in the event the network is operating abnormally or if the communications are not available as to unlock DG capacity the relay cannot default to the nominal settings.

The solution demonstrated in the Low Carbon Hub could be incorporated into Active Network Management scheme areas. This method would unlock capacity when the DVC is operating by optimising the voltage profile and reducing the voltage constraints. When the DVC is not operating due to Abnormal network operation or communications outages, the ANM scheme will ensure that the network remains within the statutory limits by curtailing Alternative Generation in the event the network would operate outside of the statutory limits.
The use of DNP3 for AVC control is still requires longer term testing before being considered for rollout.

8 Overview of the FACTs methods

Flexible AC Transmission System (FACT) Device –A Flexible AC Transmission system device will enable us to control both network voltage and system harmonics of the active ring. This equipment is not normally deployed on Distribution networks for this purpose. Shunt compensation will be used to generate or absorb reactive power. These highly technical solutions have been designed to increase the amount of distributed generation that can be connected.

8.1 Introduction to voltage regulation Problem

As detailed above in the Dynamic Voltage Control sections, both 11kV and 33kV the networks have been designed where the voltage is regulated at the Grid and Primary substations. The network impedance, connection of demand and generation are all managed to ensure that the voltage profiles across all feeders remain within statutory limits. Maintaining the voltage profiles within the statutory limits becomes more of an issue when network feeders have relatively high impedance and trying to support large demands or generation connected.

The use of a FACTs device is being demonstrated as an alternative to traditional network reinforcement where both steady state voltage profiles and step changes in voltage is a problem.

Using this methodology, new demand or generation connections to relatively week networks require the existing circuits to be rebuilt with a lower impedance conductor or new large capacity circuits to be installed at locations where the effect will be reduced.

As part of the Low Carbon Hub, it has created an active network with multiple in feeds from generation, the high degree of variability (both in terms of demand and generation) can result in unwanted voltage fluctuations which the traditional voltage control of a On Load Tap Changer (OLTC) is not best suited to correct due to their slow operation.

8.2 Low Carbon Hub – DStatcom

As identified at the bid stage, Flexible AC Transmission (FACTs) system comprises of a family of technologies which can be used to rectify a number of issues automatically. The project reviewed the most appropriate device and size in the FACTs family, working with TNEI it was confirmed that a Shunt Thyristor valve or Voltage Source Converter device would best regulate the steady state and transient network voltages. The technical report covering the FACTs device was published 30th July 2014 and is available on the project website www.westernpowerinnovation.co.uk website in the documents section.

WPD issued an ITT (Invitation to Tender) for a Shunt connected device required to meet the functional specification EE/200 – 36kV Static Synchronous Compensator for the Lincolnshire Low Carbon Hub. The tender received 4 responses, the S&C 3.75MVAr DStatcom was procured as the most advantageous economical tender.

The DStatcom was connected in parallel with the electricity network at Trusthorpe to operate as a controllable current source (an arrangement often referred to as 'shunt compensation'). This allows reactive power to be generated or absorbed by altering the capacitance or inductance and is a means of controlling power factor or network voltage. The solution will be designed in such a way to maximise the amount of generation that can be connected.

Figure 21 - DStatcom at Trusthorpe primary substation

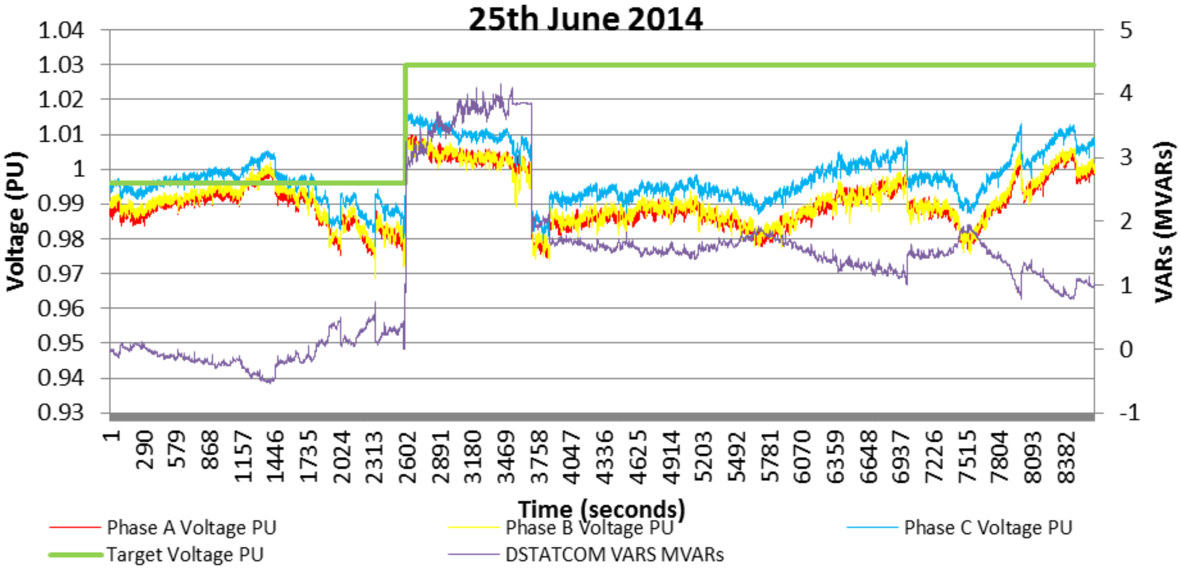
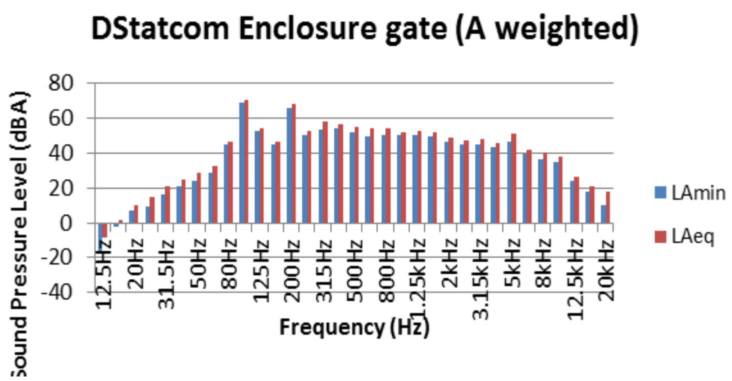


Figure 22 - DStatcom performance

8.3 Knowledge Generated

Area	Knowledge Generated
Design	The DStatcom being a high value asset sensitive to flood water damage and Trusthorpe being in a flood zone required the device to be elevated by 800mm to ensure if a flood occurred the device would not be affected.
Build	Integration of new technology such as the DStatcom has required WPD to be make amendments to other areas of the business such as the use of alternative RTU’s to handle 32 bit analogue DNP3 signals.
Operation	There was a number of difficulties experiences during the design and build stages surrounding delivery of drawings and response to technical queries. To overcome this issue it is recommended that the design and build occurs earlier in any future project to reduce the dependencies. It is also recommended a future contract would stipulate earlier receipt of drawings and diagrams linked to financial payments. This may have overcome the issues encountered on the Low Carbon Hub.
Commercial	DNO substations are often in relatively close proximity to customers, as such DNOs have worked with manufacturers over many years to minimise the audible noise produced from equipment such as transformers. The DStatcom is often installed in areas much further from customers; where the noise has attenuation and is not an issue.
Operation	The WPD DStatcom complies WPD’s noise policies, however unless additional noise mitigations are put in place - the audible noise generated by the DStatcom installed in Trusthorpe is likely to limit their use in substations in close proximity to customers. The additional noise generated by the DStatcom is both around the 150Hz, generated by fan the cooling fans, and at the 5kHz generated by the power electronics. The higher frequency noise is very noticeable close to the device but attenuates before the boundary of the substation. The 150Hz noise generated by the cooling fans will be the limiting the installation of these devices within close proximity of customers.  Figure 23 - Noise performance whilst at 100% electrical output

	S&C have explored with an expert what passive noise attenuation filters could be installed to reduce the noise within the container. It has been estimated that the noise could be reduced by approximately 10dB.
	The impedance characteristics of the DStatcom transformer used to couple the LV device to the 33kV network was a special design and manufactured to very tight tolerance. This ensures that the DStatcom has the required reactive power capacity at the required network voltage. WPD would only consider purchasing both the DStatcom and the associate transformer together, with the contract specifying the required reactive power performance at the point of common coupling.
	A DStatcom is very effective at boosting voltage during network outages to maintain statutory limits during periods of low generation if installed on a relatively weak network at the ends of feeders, relatively long electrical distances from the voltage controlling substation. • When the DStatcom is operating at 100% capacitive mode (exporting reactive power) the voltage is boosted by 3%. • When the DStatcom is operating at 100% reactive mode (importing reactive power) the voltage is reduced by 5%. • The DStatcom can operate at 263% of the nominal output (3.75MVAr) for two seconds in the event of a network disturbance.
	DStatcom have predominately been designed around the incorporation into large wind farms. In their containerised form the DStatcom is substantially smaller and lighter than many other assets being installed on the site, meaning access and lifting is rarely going to be an issue. In a UK substation the DStatcom is likely to be the largest and heaviest piece of equipment that needs to be lifted in a primary substation. Access to some of the most rural sites may require different solution to be progressed to overcome difficulties for delivery and installation of the DSTATCOM & associated Transformer
	The DStatcom is a relatively complex item that will likely require long term service plans and access to spare parts. This is unlikely to be a function a DNO could perform themselves.
	The DStatcom purchased was designed and built in America; it has been designed to different design standards then the UK. A refit of the control room has been arranged to make better use of the space and rectify an issue identified at the Factory Acceptance Test (FAT).

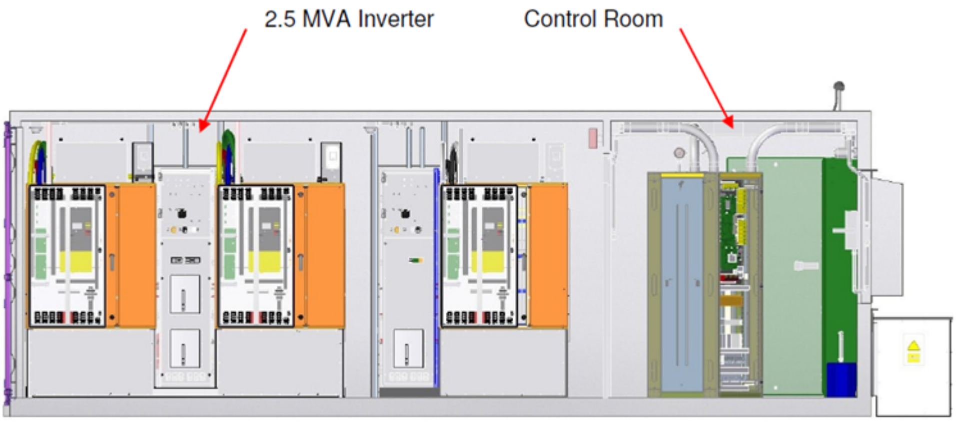


Figure 24 – DStatcom enclosure

The use of a Voltage control mode with a dead band would allow the DStatcom to regulate the voltage only when it exceeds pre-defined limits, reducing the running time of the power electronics and regulating the network voltage only when it approached the statutory limits. This mode would also reduce network losses. An example of a voltage control mode with a dead band is shown in figure 25.

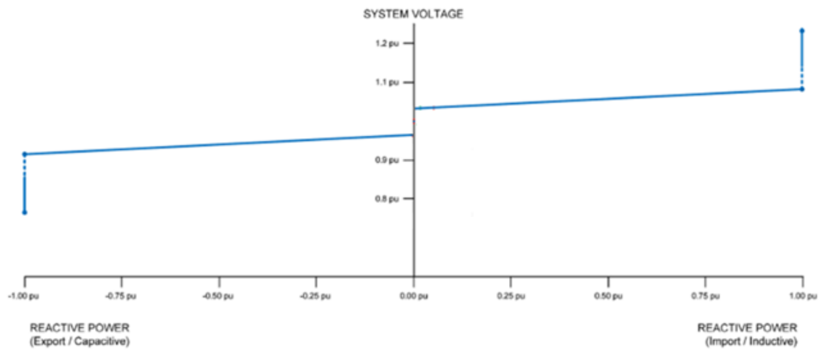


Figure 25 – DStatcom PV mode with a dead band

8.4 FACTS - Potential for replication

8.4.1 Areas to replicate

There is a significant opportunity to replicate the DStatcom installing in locations where either steads state or transient voltage control is an issue. WPD have supported Scottish Power and shared learning to help them assess where DStatcom could be used to solve network issues.

When using a Statcom for voltage control, the device will be much more effective in weaker network locations, the further electrically from the transformers controlling the network voltage the greater the effect the Statcom will have.

The design of Statcoms will need to evolve to make them more suitable for inclusion into a DNO substation, especially when there are being installed in close proximity to customers and audible noise could be an issue.

In the future it is likely that the DStatcom could be used for a number of purposes at different times, including voltage stability, reducing network losses and controlling the flow or reactive power between the DNO and TNO, helping the DNO to comply with the new ENTSO-e regulations.

8.4.2 Areas that require further work

Software tools to configure Voltage Target & Slope settings - The installation of a DStatcom requires the operator to understand how the voltage profiles changes over a range of different demand and generation sensitivities to appropriately configure the target voltage setting and slope settings. A software tool, such as the constraints analysis tool using historic demand and generation data may be required to support the configuration of devices such as a DStatcom.

9 Conclusion

The Low Carbon Hub has answered all the key questions identified at the bid stage and resulted in significant new learning for GB DNOs. The project has identified where and how the techniques could be applied to unlock capacity for future generation connections and where further work is required. The project will result in a number of innovative techniques that can be replicated by WPD and other DNOs to aid the quicker and more cost effective connection of new generation to the network.

9.1 Learning for future projects

Aspects we would repeat

- Designing and delivering innovative solutions alongside the main business teams has resulted in a better project with an improved level of engagement from the rest of the business,
- Where applicable, WPD will continue to quickly roll out solutions developed through innovations projects for use across the network, and
- WPD will continue to design and deliver ambitious innovation projects to generate the required learning for roll out of innovative solutions.

Aspects we would do differently

- When designing future bids, a more detailed design would be completed ahead of a bid submission or an increased level of contingency would be included so the project had the required funds and time to deliver the project, and
- Future innovation projects would not aim to deliver as many methods / techniques in the same area, at the same time.

9.2 Summary of key LCH learning

1. Active Network Management will be replicated and rolled out in areas where distribution network voltage and thermal constraints limit the connection of future Distributed Generation. Most other DNOs have included Active Network Management in their innovation plan,
2. A constraint analysis software package that is suitable for rolling out and adoption by planning teams need to be developed, taking the lessons learnt already learnt from the LCH demonstration. The Low Carbon Hub tool has proven the concept and that any future constraint analysis software will have a trade-off between the accuracy of the results and performance,
3. The project has shown the 33kV active ring method is less appropriate for roll-out due to the high costs and effort associated with delivery. It is expected that in simple meshing scenarios could be achieved by adapting the existing network and for more complex meshing scenarios, an offline rebuild would be most appropriate solution. Further work is required to understand when it is appropriate to mesh simple 33kV sections,

4. Certain assets, such as 33kV OHLs in ANM areas, should be enhanced ahead of need where there is a clear indication the functionality will be utilised in the future,
5. Dynamic line ratings are less suitable for 33kV and 11kV networks due to the lower height of the conductors and the risks associated with sheltering,
6. Dynamic Voltage Control requires future work before it will be ready for wider area deployment without Active Network Management. The Low Carbon Hub has proven the concept and how it could be incorporated into an ANM enabled area,
7. Statcoms will increasingly be used in key distribution locations to improve voltage control and to facilitate further generation connections, and
8. A range of suitable communication solutions continues to be a barrier to wide scale rollout of innovation projects.

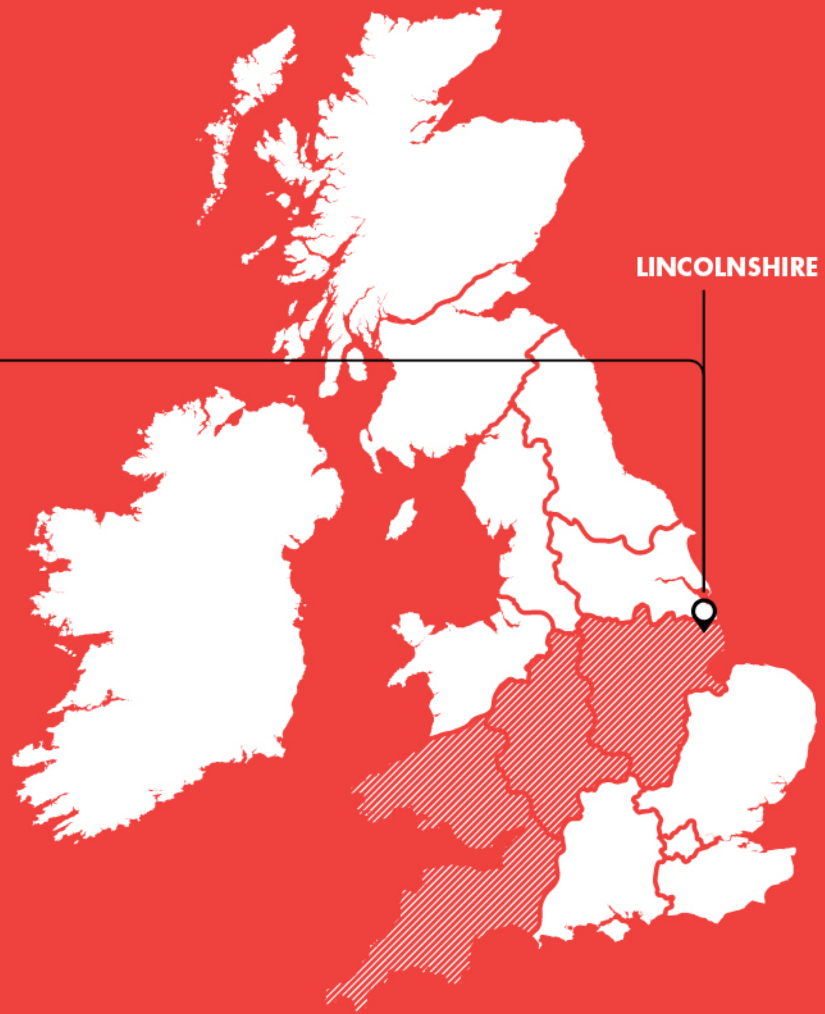
Documents such as policies mentioned in this report are available on the project website www.westernpowerinnovation.co.uk or by request through WPDinnovation@westernpower.co.uk.

Appendix M – DStatcom Technical Report

WESTERN POWER DISTRIBUTION

LOW CARBON HUB

CONNECTING RENEWABLE ENERGY IN LINCOLNSHIRE



DStatcom Technical Report

July 2014

LCN Fund
Low Carbon Networks

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Contents

Glossary

Term	Definition
AVC	Automatic Voltage Control
DG	Distributed Generation
DStatcom	Distribution Static Compensator
ESQCR	Electricity Safety, Quality and Continuity Regulations
FACTS	Flexible Alternative Current Transmission Systems
LLCH	Lincolnshire Low Carbon Hub
PSU	Power Supply Units
PV	Photo Voltaic
SVC	Static Var Compensator's
VSC	Voltage Source Converters

1 Introduction

This report will provide a background to the Lincolnshire Low Carbon Hub (LLCH), Western Power Distribution's Tier 2 Low Carbon Networks Fund Project; focussing on the DStatcom installed in Trusthorpe primary substation. Explain what is meant by Flexible AC Transmission Systems (FACTS), and the reasons WPD selected a DStatcom from the FACTs family. Throughout this report we will share the key planned and unplanned lessons learnt through all stages of the DStatcom method. The report will start at the pre-procurement process, finishing with the lessons learnt to date during the operational phase.

2 What is the Low Carbon Hub

The Low Carbon Hub for East Lincolnshire has been designed to test a variety of new and innovative techniques for integrating significant amounts of low carbon generation on to electricity networks, in an effort to avoid the costs that would normally be associated with more conventional methods.

The project received £3m of funding from Ofgem's Low Carbon Networks Fund Tier 2. In this project, we are seeking to explore how the existing electricity network can be developed ahead of need and thus deliver low carbon electricity to customers at a significantly reduced cost in comparison to conventional reinforcement.

Lincolnshire, being on the east coast makes it suitable for a wide range of renewable generation types, these include onshore and offshore wind farms, large scale solar Photo Voltaic (PV) and energy from bio crops. Many generators cannot connect to the distribution network closest to them due to the effects the connection would have on the network operation. These connections tend to result in installing new underground cable to areas closer to Skegness where the effect on the network is less, meaning it could operate within its design and operation limits. This can be very expensive and prevent generation connections. We have received a high volume of connection enquiries from developers which made the location ideal for this project. Figure 1 shows the range of innovative techniques being trialled as part of this project.

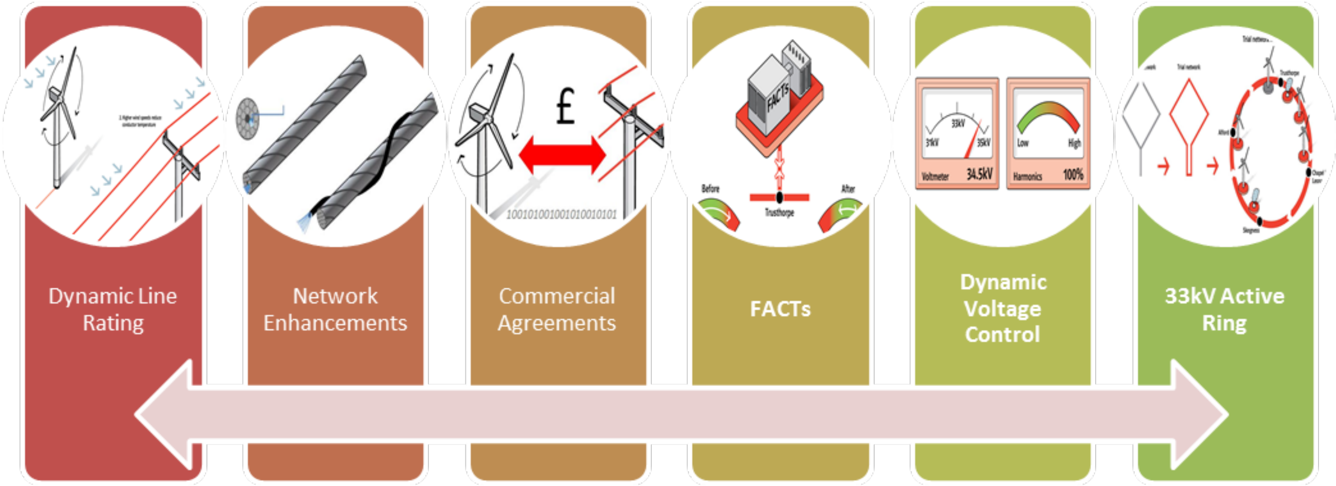


Figure 1 - Project techniques

3 The Extra High Voltage (EHV) Network East Lincolnshire

The electricity network in East Lincolnshire is typical of most rural areas across the East Midlands and large sections of Great Britain. The substation at Skegness has two 90MVA transformers, stepping the voltage down from 132kV to 33kV. Skegness supplies East Lincolnshire through seven 33kV feeders and under normal running arrangements supplies eight primary substations. Figure 2 - EHV network in East Lincolnshire shows a geographical representation of the EHV network in East Lincolnshire. Appendix 1 shows the single line equivalent of the network.

The maximum measured demand at Skegness occurs around Easter and is historically around 71MVA. The minimum demand generally occurs between July and August and is approximately 23MVA.

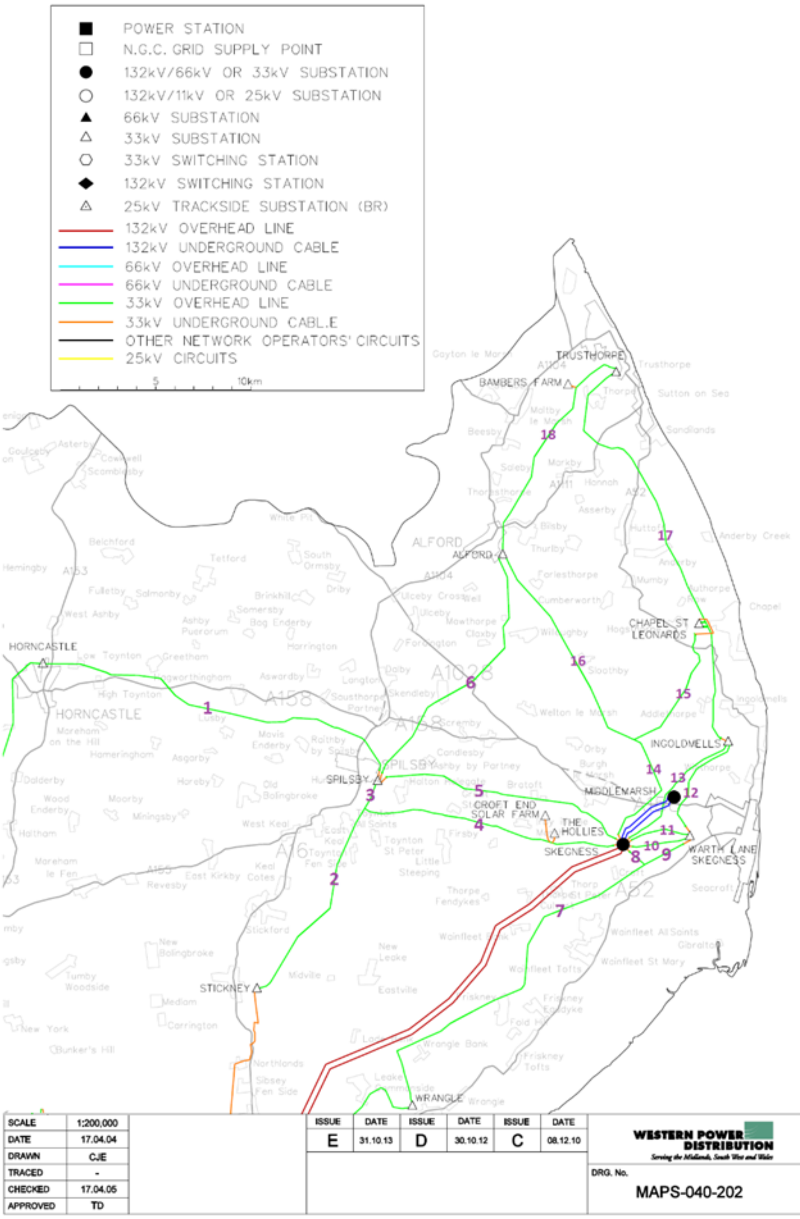


Figure 2 - EHV network in East Lincolnshire

As already mentioned above, East Lincolnshire is an ideal location renewable generation. However studies often show that before additional generation can connect to the network, significant levels of conventional network reinforcement must be carried out to keep the network voltage within the statutory limits as set out in the Electricity Safety, Quality and Continuity Regulations (ESQCR). ESQCR requires network voltages to remain within 31kV to 35kV or ± 6% of 33kV.

The two worst credible scenarios are planned for, maximum demand with no generation and maximum generation at periods of minimum demand. Long and relatively high impedance 33kV circuits, high levels of already connected DG and large differences between maximum and minimum demands makes voltage regulation using conventional AVC relays at the grid substation increasingly more challenging.

To account for a maximum voltage drop across the network which can exceed 7.5% the Skegness transformers Automatic Voltage Control (AVC) relays are configured to keep the voltage at 1.03 ± 0.01 Per Unit (PU) or 34 ± 0.33kV. This leaves little voltage head room for DG before the upper statutory limit is reached.

FACTS technology can be used to increase the control of voltages at the ends of feeders, as an alternative to conventional network reinforcement.

4 Background to FACTS

Flexible Alternating Current Transmission Systems, also known as FACTS devices covers a range of technologies connected in shut, series and a combination of both shunt and series. The technology can be used to improve voltage control and transfer of power through AC power systems under both steady state and transient conditions. First developed primarily to solve the issues associated with EHV Transmission Networks, the technology has continued to evolve.

High costs and modest connection of Low Carbon Technologies at the distribution networks level has meant historically FACTs technology have not been deployed by Distribution Network Operators (DNOs). The adaption of passive distribution networks to Active networks with two way power flows, the advancement of Voltage Source Converters (VSC), reliability improvements in power electronics, creation of modular units, cost reduction and improvements in both control systems and computing technology means FACTs devices can be considered for an ever increasing number of distribution network purposes.

The FACTs subsets are shown in Figure 3.

	Conventional (Switched)	FACTS-Device (Fast, Static)	
	R, L, C, Transformer	Thyristorvalve	Voltage Source Converter (VSC)
Shunt-Devices	Switched Shunt-Compensation (L, C)	Static Var Compensator (SVC)	Static Synchronous Compensator (STATCOM)
Series-Devices	(Switched) Series-Compensation (L,C)	Thyristor Controlled Series Compensator (TCSC)	Static Synchronous Series Compensator (SSSC)
Shunt & Series-Devices	Phase Shifting Transformer	Dynamic Flow Controller (DFC)	Unified/Interline Power Flow Controller (UPFC/ IPFC)
Shunt & Series-Devices		HVDC Back to Back (HVDC B2B)	HVDC VSC Back to Back (HVDC VSC B2B)

Figure 3 - FACTs Technology

Principle Benefits

- Shunt Devices are principle used to optimise voltage control under steady state and transient conditions,
- Series Devices are principle used to optimise power flow optimisation under steady state and transient conditions,
- Shunt and Series Devices are principle used to optimise voltage and power flows (real and reactive) optimisations under steady state and transient conditions

5 East Lincolnshire problems being solved through FACTS

In creating an active network with multiple in feeds from generation, a high degree of variability (both in terms of demand and generation) can result in unwanted voltage fluctuations on the electricity network. A Flexible AC Transmission (FACTs) system device can rectify these issues automatically. The weakest network areas, areas furthest from the Grid substation with long relatively high lines are susceptible to both voltage rise and large step changes in voltage if further generation is connected to the surrounding networks. The conventional network reinforcement required to solve these issues is often prohibitively expensive and if undertaken very timely, it can take many years and still not result in receiving the required permissions and consents.

6 Shunt Compensation

Large shunt compensation devices have primarily been installed for power factor correction, alongside non-synchronous Distributed Generation and on transmission networks for voltage stability and reactive power management. Within the UK only a handful of SVC or Statcom devices have been install for DNO use, primarily on island networks to mitigate step change issues.

The Low Carbon Hub, project required shunt compensation to be procured and installed in parallel with the electricity network at one of the weakest points of the network to operate as a controllable current source. A Distribution Static Compensator (DStatcom) device was selected above a Static Var Compensator. A Static Var Compensator's (SVC) reactive power output is linked to the network voltage; a DStatcom is independent and provides a better transient performance. The DStatcom allows reactive power to be generated or absorbed by altering the capacitance or inductance and is a means of controlling power factor or voltage. The solution was procured and designed in such a way to maximise the amount of generation that can be connected.

7 Pre Procurement & System Studies

Before starting a competitive procurement process using an Invitation to tender, an equipment specification policy was written (EE SPEC:200) and a series of internal and external studies were completed. This ensured the procured DStatcom would be fit for purpose and could be effectively integrated into the distribution network.

Studies included:

- A sensitivity analysis for the DStatcom, varying both the size and location of the device.
- Load and power flow analysis for a range of demand and generation profiles both intact and abnormal network configurations.
- Fault current studies.
- Protection coordination studies.
- Network Transient Recovery Study.

The studies concluded the DStatcom could be integrated into the distribution network and the optimal size DStatcom for the steady state and transient response to control voltage was at least ±3MVAr under steady state conditions.

8 Procurement

The outcome of a "Most Economically Advantageous Tender" a 3.75MVAr DStatcom was procured from S&C Electric. S&C Electric provided a turnkey solution including a containerised DStatcom, a 5MVA step up transformer and a 1m flood frame, installation of equipment and commissioning.

9 DStatcom Design

The DStatcom has three 1.25MVA Inverters installed within a container measuring 8.23m x 2.81m x 3.1m. In a separate section of the container, the main controller DStatcom and Human Machine Interface. The DStatcom is connected to a 5MVA, 480V to 33,000V step up transformer through flexible LV cabling.

Figure 4 shows a cut out along the side of the DStatcom container.

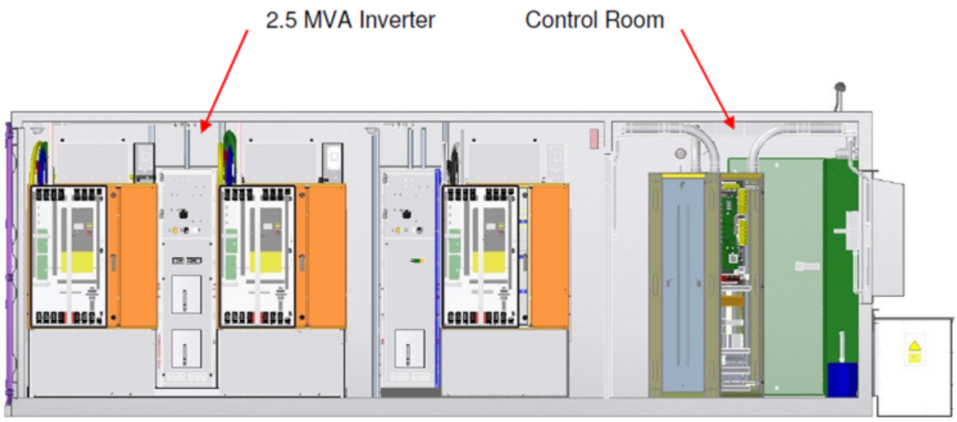


Figure 4 - DStatcom Enclosure

The power electronics (Inverter tray) uses pulse width modulation to chop an 800V DC source into an AC waveform. The power electronics are configurable and can produce an AC voltage in phase with the AC network of variable magnitude. Figure 5 shows a simplified single line diagram including the key components of the DStatcom, the DC bus bar, power electronics, line inductor, low pass filters, LV AC breaker and 480V to 33,000v step up transformer.

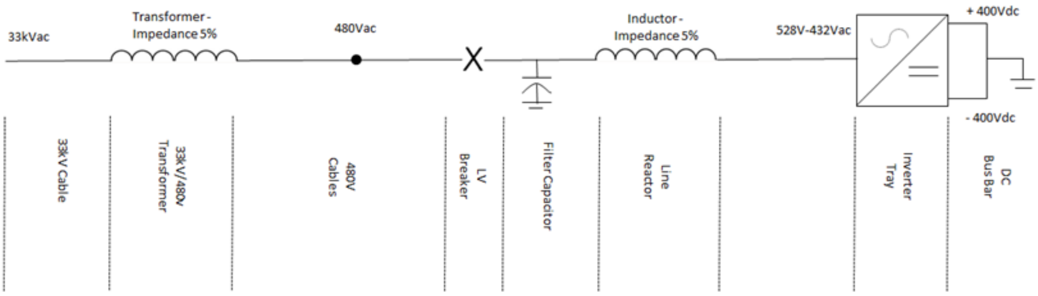


Figure 5 - DStatcom simplified Single Line Diagram

In capacitive mode, the power electronics produce an AC waveform where the voltage magnitude is higher than the nominal network voltage; a current is induced through the line inductance and transformer. Reactive power will flow from the DStatcom into the distribution network and the voltage will be raised.

In inductive mode, the power electronics produce an AC waveform where the voltage magnitude is lower than the nominal network voltage; a current is induced through the transformer and line inductor. Reactive power will flow from the distribution network into the DStatcom and the voltage will be lowered.

Low pass filers remove the high frequency noise associated with the power electronics and produces a sinusoidal waveform. Figure 6 shows the sinusoidal voltage waveform of the DStatcom during the Factory Acceptance Testing.

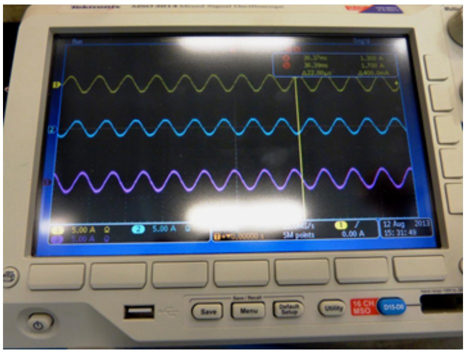


Figure 6 - DStatcom electrical output during Factory Acceptance Testing

10 DStatcom at Trusthorpe Primary Substation

The pre procurement studies showed Trusthorpe Primary substation as the most optimal location for the installation of the DStatcom. As shown in Figure 2, the overhead lines supplying Trusthorpe primary substation are 26.2km and 26.3km from Skegness grid substation. The impedance lines and location of embedded generation means Trusthorpe is an optimal location for the DStatcom due to the range between voltage rise and voltage drop.

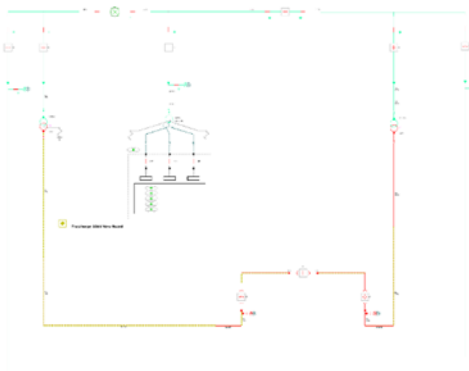


Figure 7 - DStatcom connection at Trusthorpe Primary – Single Line Diagram

The installation of the DStatcom was carried out in conjunction with the replacement of the primary transformers. As shown in Figure 7 the DStatcom has been installed between two bus sections with a transformer breaker protected using an overcurrent and earth fault relay. This allows the DStatcom to be operated whilst connected to either radial feeders or whilst the network is operating as a ring.

The civil works were carried out by Western Power Distribution. The installation of the flood frame, DStatcom container and DStatcom Transformer was completed by S&C Electric.

Figure 8 shows the DStatcom was installed in its own enclosure within Trusthorpe primary substation.

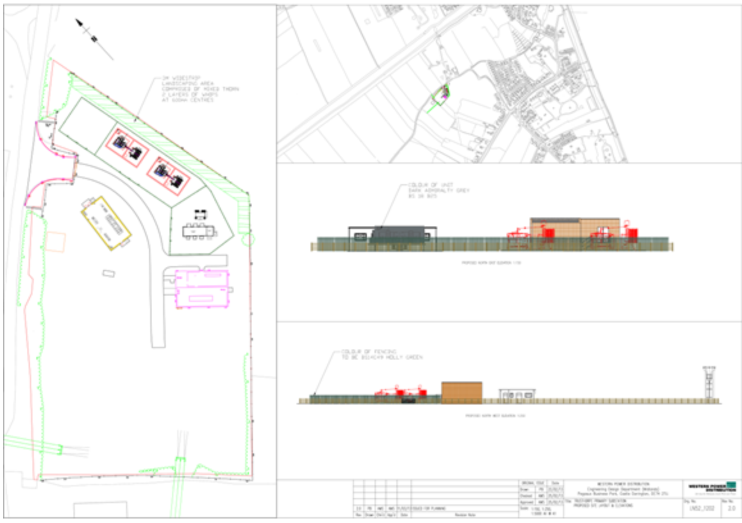


Figure 8 - DStatcom at Trusthorpe primary substation – Geographic & Photo

11 Policies, Standards & Training

In addition to the Equipment specification used during the procurement phase, four further policies have been written so the DStatcom can be safely and effectively integrated into the Distribution system to regulate the network voltage.

1) Policy overview of DStatcom Equipment at Trusthorpe Primary substation.
2) Operational Safety considerations when working on or around the DStatcom Equipment at Trusthorpe Primary Substation
3) Maintaining and Working on DStatcom Equipment at Trusthorpe Primary Substation
4) Operation and Control of DStatcom Equipment at Trusthorpe Primary Substation

These policies have been distributed to all WPD employees, and specialist training sessions have been run for Network Control Engineers, Engineering specialist and operational staff working in East Lincolnshire.

12 Control System Integration

The DStatcom's control system has been integrated into WPD's PowerON software. Through the D20 RTU installed on site the following controls, analogues, indications and alarms are visible within PowerON:

Controls

- Start / Stop of the DStatcom
- Change between VAR or Volt mode
- Change the target VAR's setting
- Amend the Volt slope setting
- Amend the Target Volts setting

Alarms

- DStatcom Warnings alarm
- DStatcom Inhibit alarm
- DStatcom Trip Alarm

Indication

- DStatcom Enabled / Disabled
- LV and HV breaker status
- DStatcom Inverter availability

Analogues

- EHV voltage
- Inverter VAR output

The primary method of starting, stopping and amending DStatcom settings is through PowerON. In the event of a loss of communications with PowerON, the DStatcom is fully automatic and will continue to regulate the voltage. The protection panel within Trusthorpe 33kV switchroom contains a local enable / disable functionality to stop the DStatcom in the event of the communications between PowerON and Trusthorpe at the same time as wanting to disable the DStatcom.

The local Human Machine Interface (HMI) within the DStatcom is primarily used for the Interrogation of performance, (It records 10 second snapshots) alarms, and resetting alarms. The DStatcom has no connection to the internet and cannot be remotely controlled outside of PowerON.

13 Integrating into WPD's main business

The DStatcom is currently in a trial mode supported by the Innovation and Low Carbon Networks team until the end of the project. A review of the DStatcom and associated equipment will be performed at the end of LCH project in February 2015, before deciding if it will be supported by the main business or if the trial phase will be extended. The DStatcom maintenance will be carried out by S&C Electric under a permit to work by WPD.

14 DStatcom Performance – Electrical

The DStatcom has been configured to operate in Volt mode, with a target voltage and a defined slope of operation. During the 25th June 2014, as shown in figure 10, the operating parameters were changed three times.

The first period from 00:00 to 8:00, the voltage set point was 0.996PU with a slop setting of 8%. During this period the DStatcom target was close to the actual network voltage with the output loosely coupled to the distribution network. An 8% change from the set point voltage would be required to export / import at 100% reactive power.

The second period from 8:00 - 11:00, the voltage set point was 1.03 PU with a slope setting of 2%. During this period the DStatcom was targeting a voltage above the actual network voltage exporting reactive power into the distribution network. When the network voltage was more than 2% below the set point voltage, the unit exported 100% reactive power into the network.

The third period from 11:00 – 24:00, the voltage set point was 1.03 PU with a slope setting of 8%. During this period the DStatcom was targeting a voltage above the actual network voltage, exporting reactive power into the distribution network. The network voltage would have needed to be more than 8% above or below the nominal voltage before the unit would export or import at 100% reactive power.

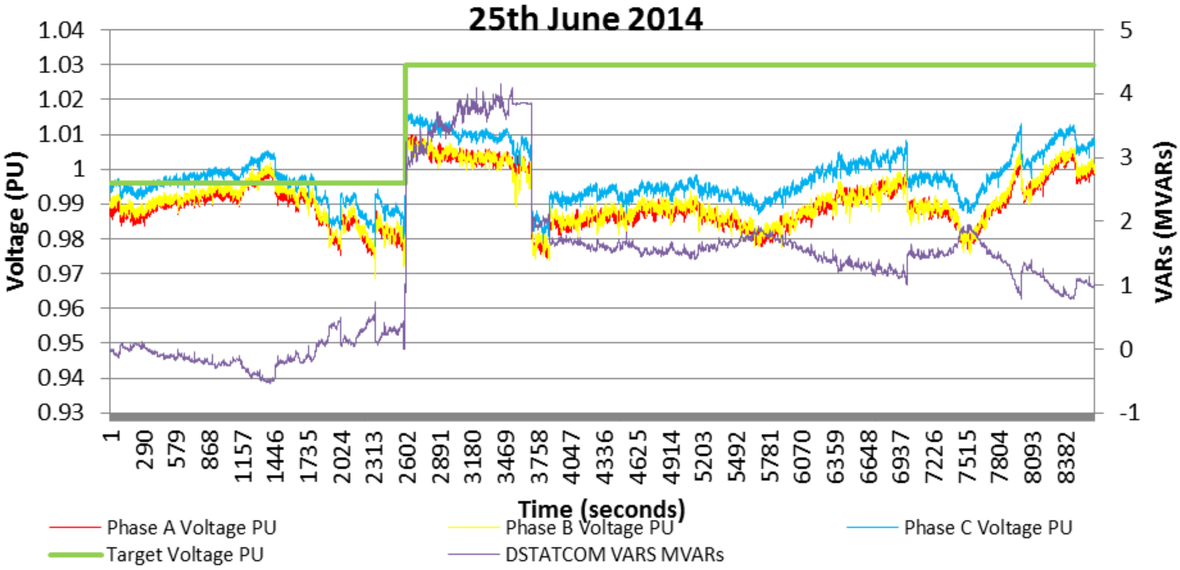


Figure 9 - DStatcom performance

Operational analysis has shown at Trusthorpe, if the DStatcom exports 3.75MVAR into the distribution network the voltage can be raised by up to 3%. If the DStatcom imports 3.75MVAR of reactive power, the network voltage can be reduced by up to 5%. Appendix 2 shows the performance of the DStatcom on the 24th June 2014 and 26th June 2014.
The voltage profiles, reactive power flows and primary network tap changer control has produced results that coincide with the nodal analysis studies undertaken in the pre procurement phase.

15 DStatcom Performance – Noise

Whilst operating at the maximum sustained reactive power output of 3.75MVAr, the audio noise emitted from the DStatcom is substantially above the background readings. The noise readings taken during the 25th June 2014 between 8:00 and 11:00 highlight the extent of the noise issues. The DStatcom is air cooled and has variable speed fans. These fans cool the power electronics and produce the most noise when the DStatcom is operating near its rated capacity where there is a high ambient temperature.

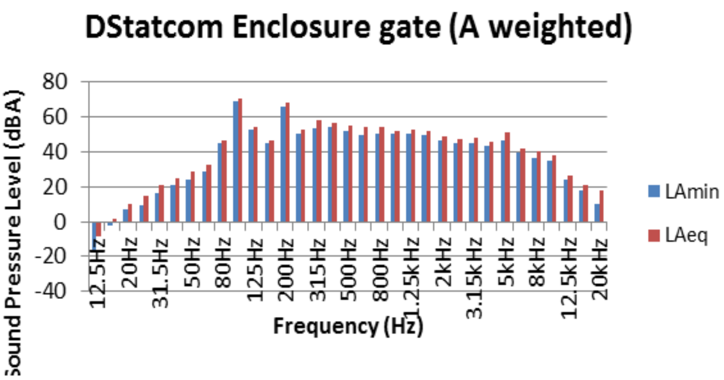


Figure 10 - Noise performance whilst at 100% electrical output

This is presently being mitigated by not operating the DStatcom above 75% of the installed capacity, maintaining the noise within an acceptable limit. A range of suitable noise suppression solutions are being investigated with the manufacturer and eternal parties. The DStatcom will not operate above 75% electrical output, until a suitable solution to the noise issues are mitigated.

16 DStatcom Performance – Modifications

Since the installation and commissioning of the DStatcom, three areas of further work have been identified.

1) Replacement of three 15V Power Supply Units

Since the installation and commissioning of the DStatcom, two inverters have suffered spurious trips due to a malfunctioning 15V Power Supply Units (PSU) installed on each inverter. These PSU’s will be replaced in August 2014 under warranty. Each occurrence has resulted in the DStatcom operating with two inverters until the alarms are investigated and reset.

2) Modification to the LV ABB Breakers

S&C have informed WPD that a modification the LV breakers' earthing is required to enhance the reliability of the system. The earths will be separated; this modification to the LV ABB Breakers will be carried out in March 2015 under warranty.

3) Modifications to the control room, splitting the Control unit into two front access racks.

The Control room requires a modification to install two front access racks into the control room. The current Master controller unit installed in a diamond formation will be replaced by two front access panels. This will be carried out in March 2015 under warranty.

17 Requirements before a DStatcom could be used as a BAU solution

To date, the electrical performance has shown the DStatcom to be a very effective way to regulate network voltages and a number of lessons learnt, through this incorporation of a DStatcom. Further aspects may be required or knowledge gained before the DStatcom could be used as a future widespread business as usual technique to regulate network voltages.

1) Use of software tools to configure Voltage Target & Slope settings

The installation of a DStatcom requires the operator to understand how the voltage profiles changes over a range of different demand and generation sensitivities to appropriately configure the target voltage setting and slope settings. A software tool, such as the constraints analysis tool using historic demand and generation data may be required to support the configuration of devices such as a DStatcom.

2) Reliability

If the problem the DStatcom is solving is critical without the DStatcom and requires high performance and availability, a number of further considerations may be required, such as:

- Purchasing or having access to strategic spares of key items like the DStatcom Transformer and inverter trays.
- Installing a larger DStatcom made up of multiple units where it is possible to have n-1 or n-2 redundancy.
- Installing two separate smaller DStatcom devices at separate sites.

3) Cost

The whole life cost of the DStatcom including maintenance, replacement components and losses to compare to the whole life cost of a conventional network solution.

4) Noise

If installing a DStatcom where audible noise could become an issue, a number of further considerations may be required, such as:

- A liquid cooled or hybrid cooled device
- An air cooled DStatcom with low noise fans
- A noise enclosure / wall to reduce the effect of noise
- Installing a larger DStatcom, limiting the performance to prevent high fan noise

5) A DStatcom - Volt mode with a dead band

The use of a Voltage control mode with a dead band would allow the DStatcom to regulate the voltage only when it exceeds pre-defined limits, reducing the running time of the power electronics and regulating the network voltage only when it approached the statutory limits. This mode would also reduce network losses. An example of a voltage control mode with a dead band is shown in figure 12.

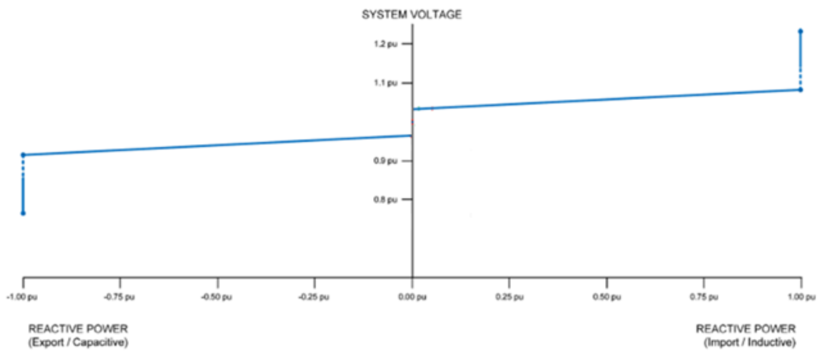


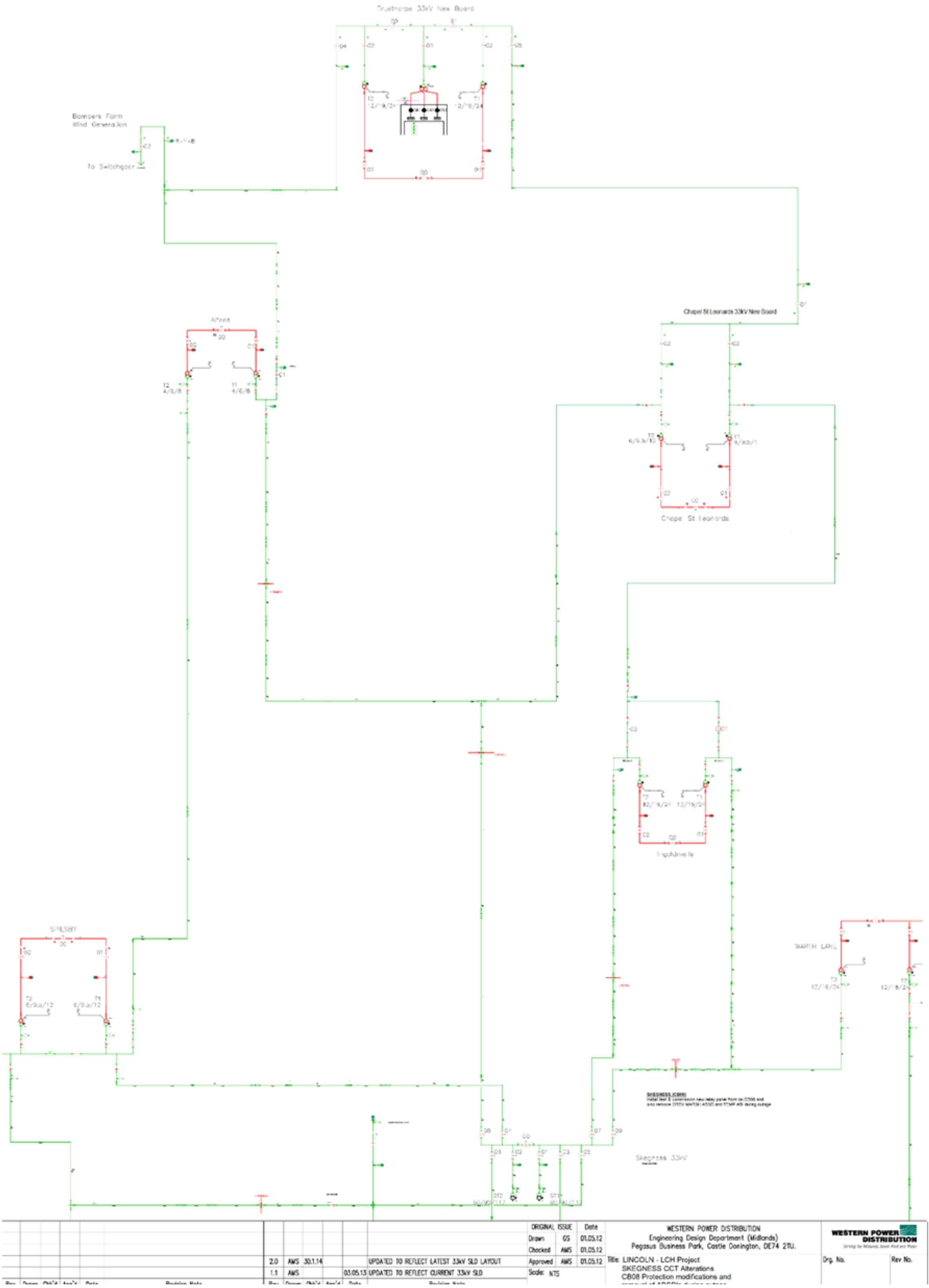
Figure 11 - Volt mode with a dead band

18 Summary

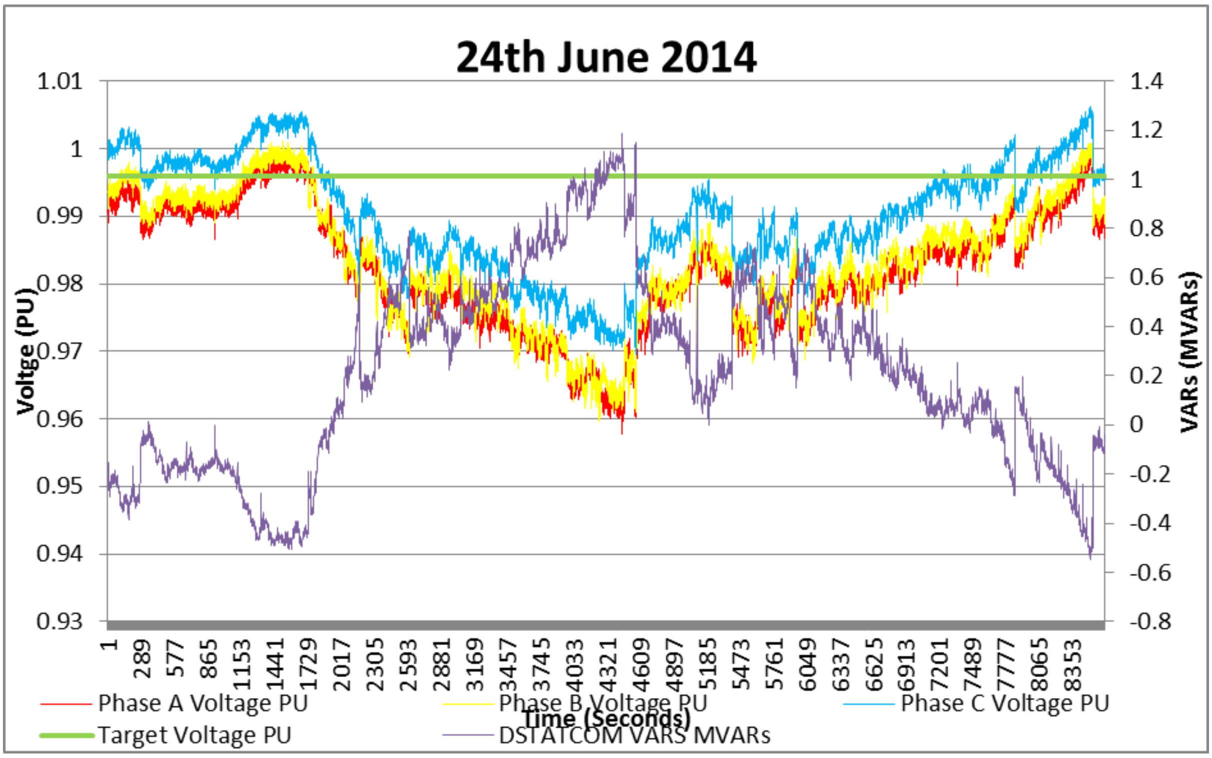
This report has detailed how a DStatcom can be used to improve the voltage performance of a distribution network, boosting the voltage by 3% and dropping the voltage by 5%. It's inclusion on a network could be used to facilitate further demand and generation connection. Further work systems and knowledge may be required before the solution could be replicated in other locations to unlock capacity. The further knowledge gained from this section of the Lincolnshire Low Carbon Hub will be shared in the project close down report.

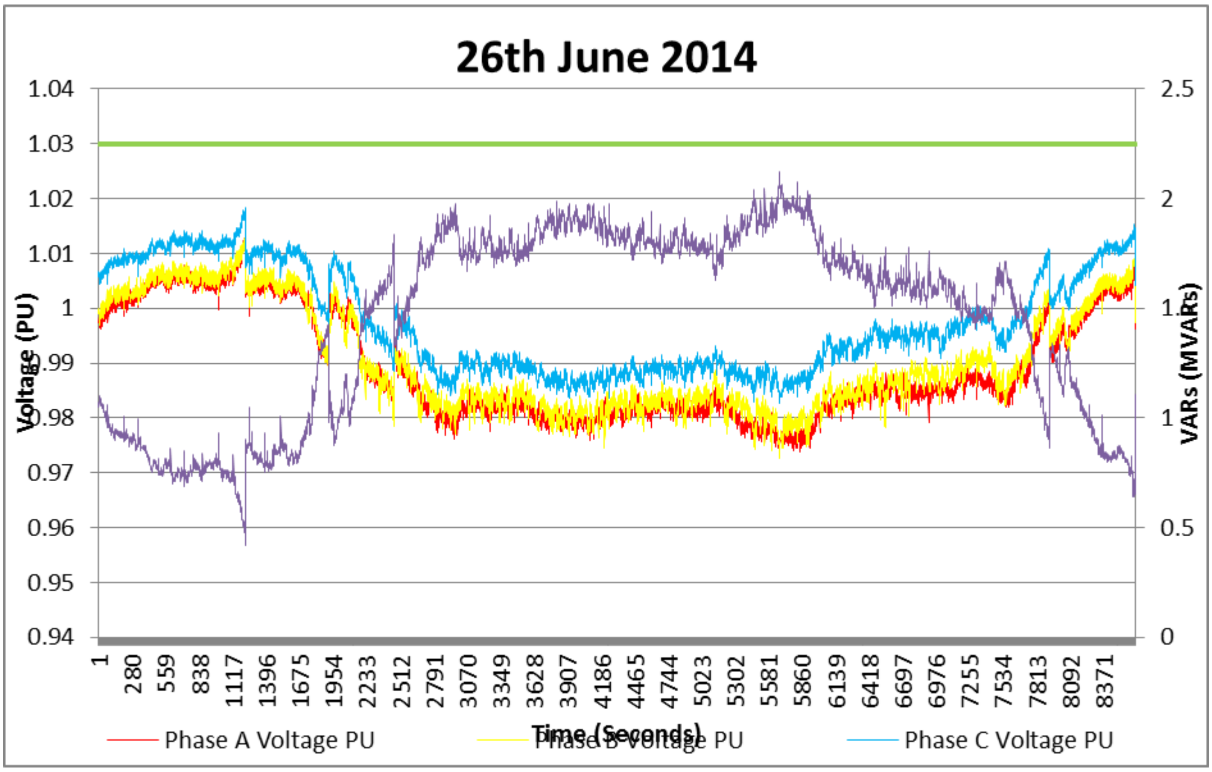
Appendices

Appendix 1 – Single Line Diagram for East Lincolnshire (Excluding Horncastle)



Appendix 2 – DStatcom performance data





Appendix N – Results From Accent Telephone Survey

Appendix N

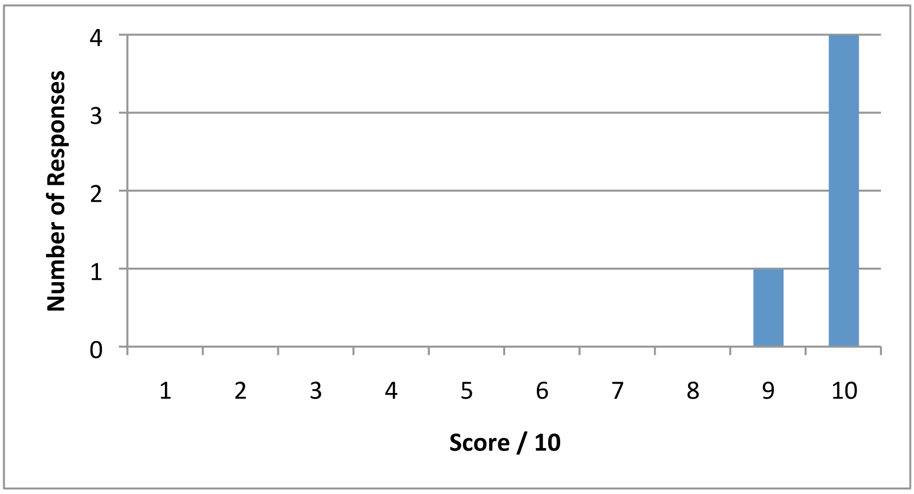
Results from Accent Telephone Survey

Alternative Connections- Feedback from DG Developers

At the time of the survey 12 Distributed Generation (DG) developers had been issued an Alternative Connection. Their contact details were provided to Accent Marketing and Research Ltd. 5 DG developers took part in the telephone survey. The key questions and the answers they provided have been plotted below.

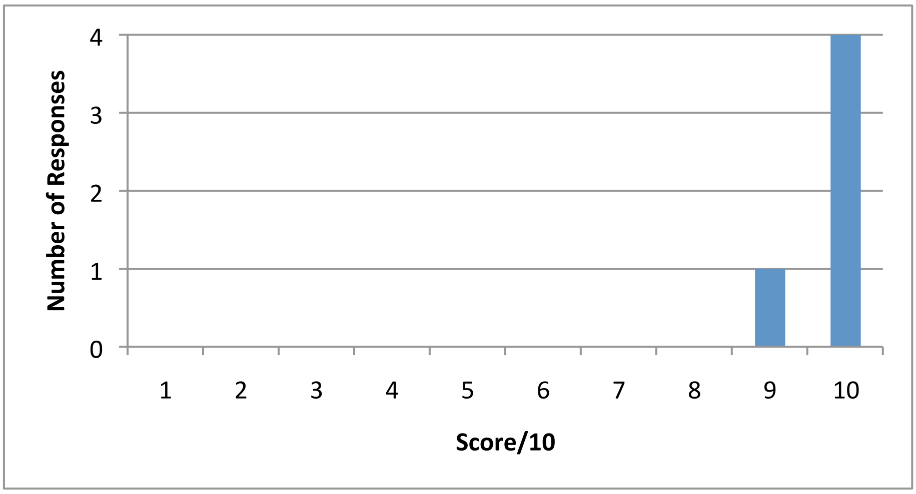
Q2a) Using a scale of 1 to 10, where 1 is very dissatisfied and 10 is very satisfied; can you please tell me how satisfied you were with how easy it was to make initial contact with Western Power Distribution to get a quotation?

5/5 of customers who completed our telephone survey on alternative connections for the Lincolnshire Low Carbon hub were satisfied or very satisfied by how easy it was to make that initial contact with Western Power Distribution.



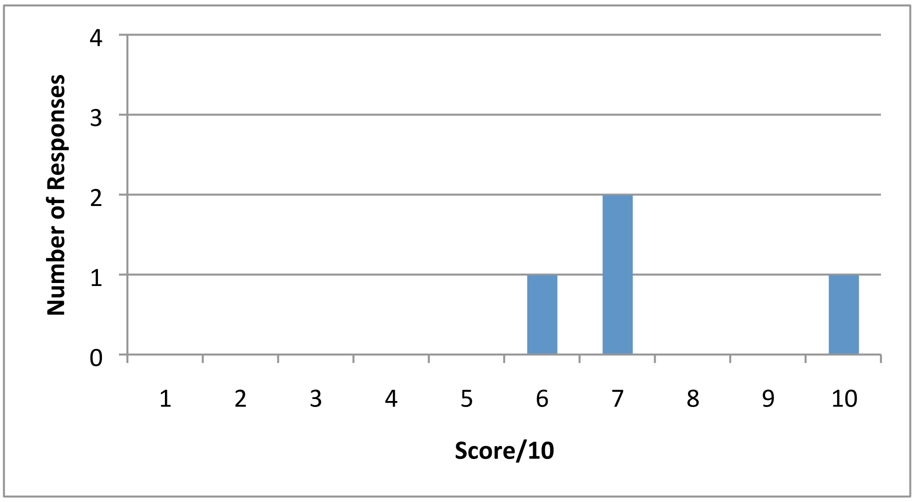
Q2d) Using a scale of 1 to 10, where 1 is very dissatisfied and 10 is very satisfied; - how satisfied were you with the amount of information made available to you by Western Power Distribution before you applied? (e.g. on their website, via leaflets/literature, on the phone etc.)?

4/5 of customers who completed our telephone survey on alternative connections for the Lincolnshire Low Carbon hub were satisfied or very satisfied by with the amount of information made available by Western Power Distribution before they applied for an alternative connection.



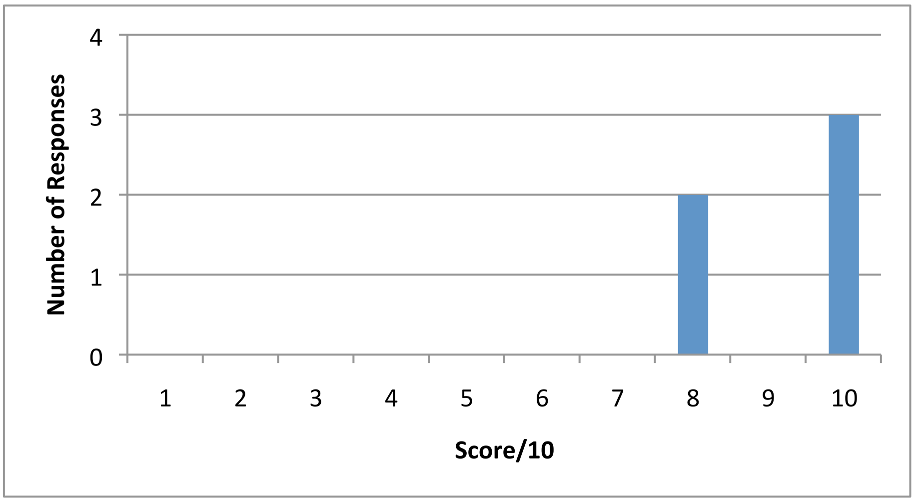
Q3a) Using a scale of 1 to 10, where 1 is very dissatisfied and 10 is very satisfied; how satisfied were you with the time it took them to get you the quotation?

3/5 of customers who completed our telephone survey on alternative connections for the Lincolnshire Low Carbon hub were satisfied or very satisfied with the time it took for them to get receive the quotation. One Customer answered N/A



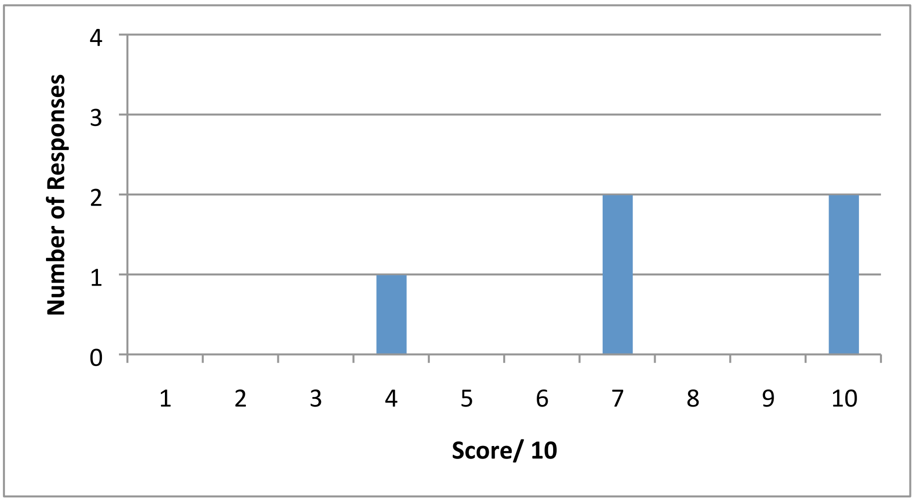
Q4a) How satisfied were you that they had understood your requirements?

Customers were 100% satisfied or very satisfied that we had understood their requirements



Q5a) How satisfied were you with how clearly the connections process was explained within the quotation?

4/5 of customers were satisfied or very satisfied with how clearly the connections process was explained within the quotation. Further works is being undertaken to make the future connections process clearer.

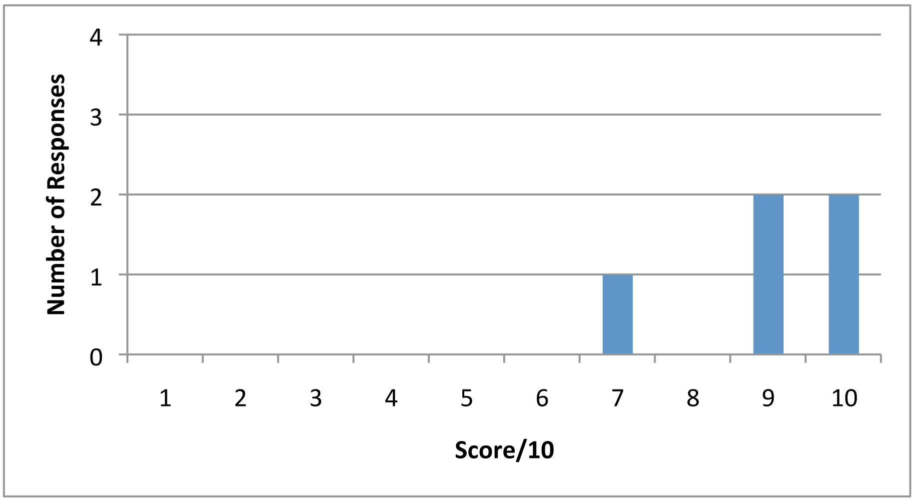


Q5d) Is there a different method of communication or explanation that you would have preferred in this respect?

All participants were happy with the methods of communication for the connections process

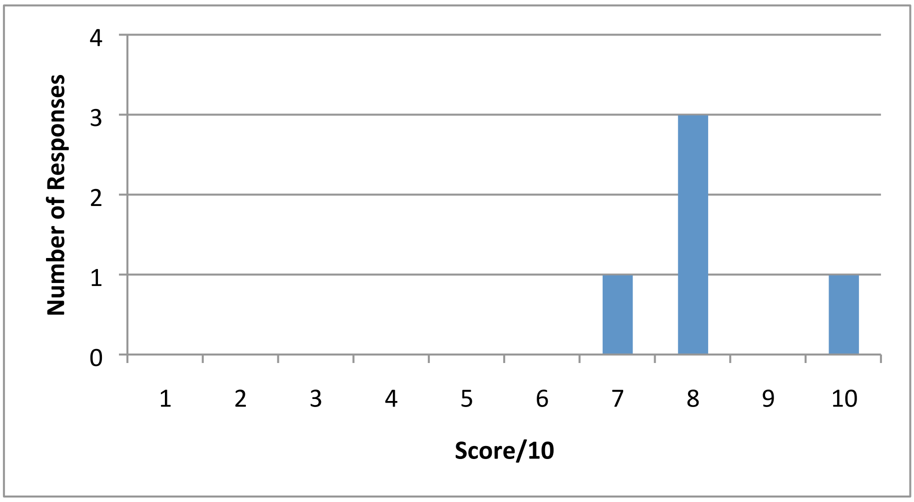
Q6) How satisfied were you with the amount of communication you had with Western Power Distribution during the quotation process?

4/5 of customers were satisfied or very satisfied with the amount of communication you had with Western Power Distribution during the quotation process?



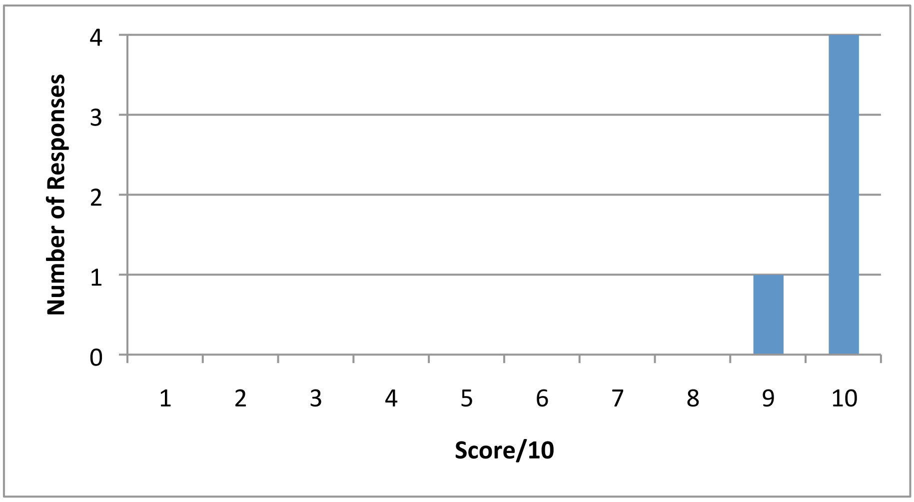
Q6b) Taking all of the above into consideration, and taking only the quotation into consideration, not any work you may subsequently have had done, overall how satisfied were you with the service provided by Western Power Distribution?

Taking the whole quotation process into consideration 4/5 of customers were satisfied and 1/5 very satisfied by the service provided by Western Power Distribution.



Q9a) Again taking all aspects into consideration and using a scale of 1 to 10, where 1 is very unlikely and 10 is very unlikely, how likely are you to apply for another alternative connection?

4/5 of customers surveyed are very likely to apply for another alternative connection based on the experience of applying a connection to the Lincolnshire Low Carbon Hub.

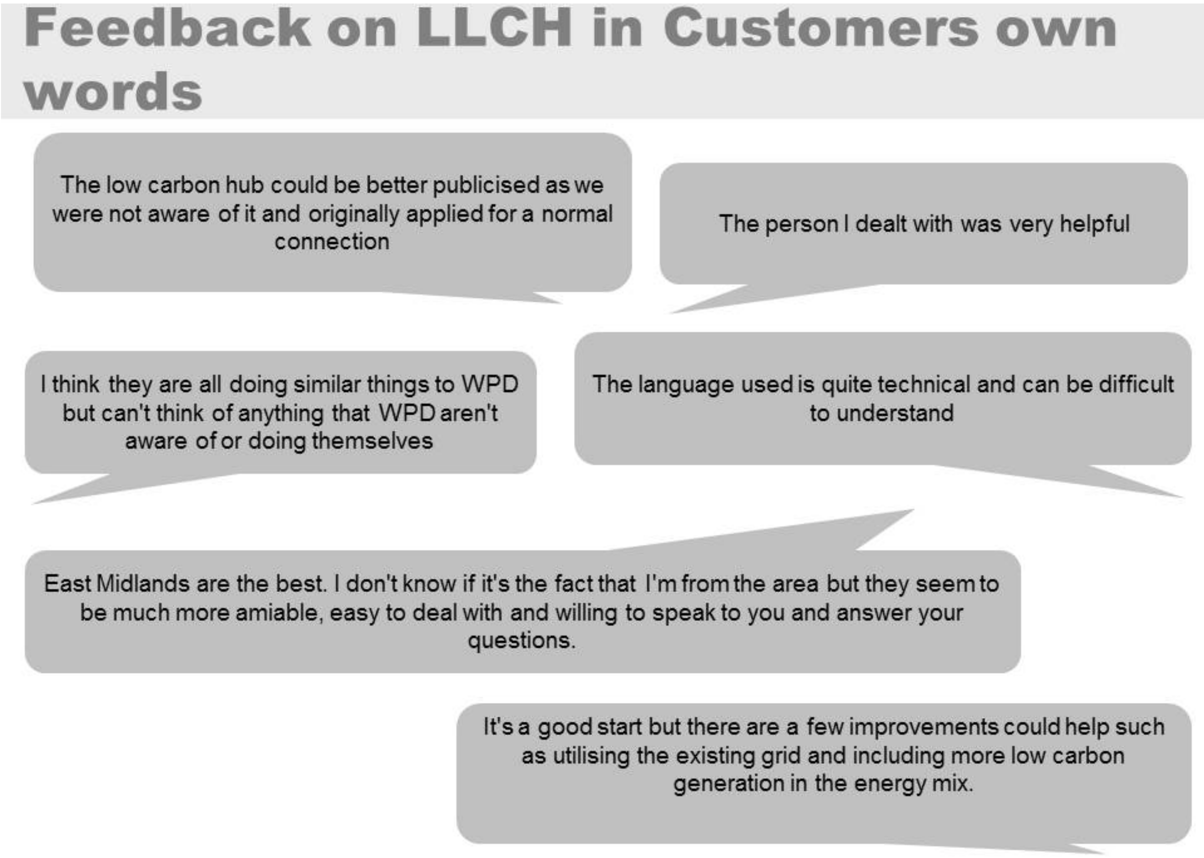

Number of Responses
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
Score/10

Telephone Survey Area's for improvement

1/5 of customers found the explanation of the connection process within the quotation too complicated.

"They need to simplify the language they use as it is quite long winded. This is what I was unable to explain to the client so we had to visit WPD. It was however my first project so I have a much better knowledge of it now."

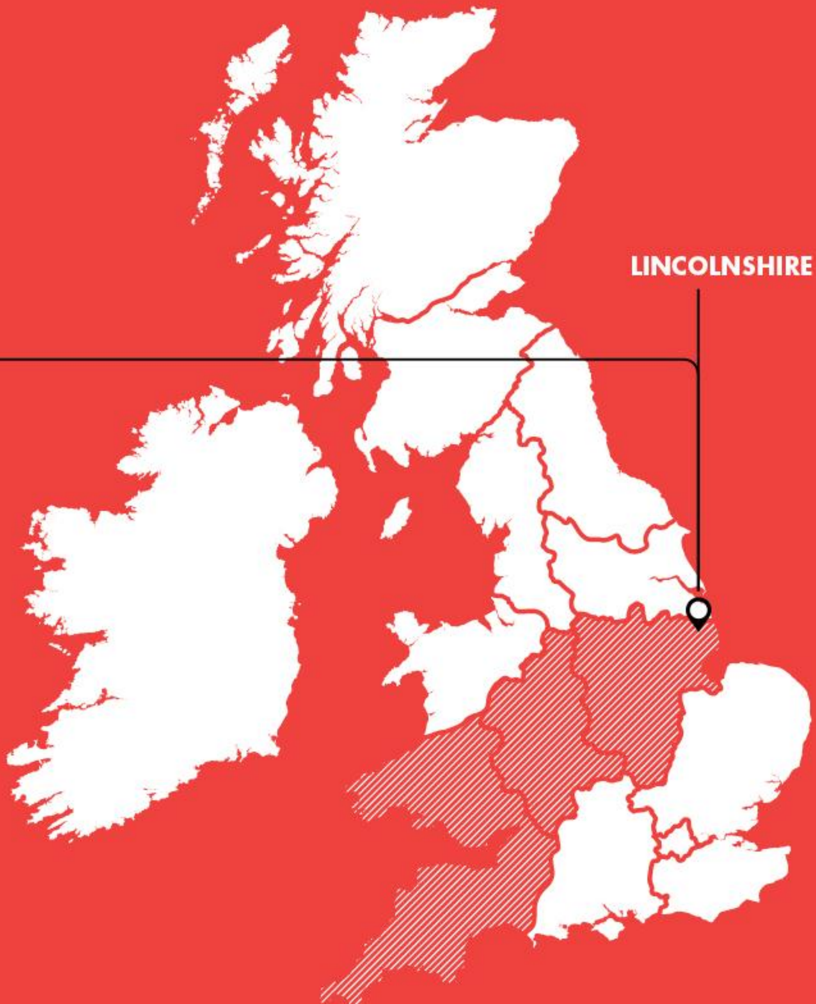
"A lot of the time they use quite technical terminology so it would be good if they provided a separate document with explanations of the terminology used."



Appendix O - Change Request v1

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

CONNECTING RENEWABLE ENERGY IN LINCOLNSHIRE



Change Request v1
16/07/2013

LCN Fund
Low Carbon Networks

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

Content

1. WPD project change mandate
2. WPD design justification report
3. DNV Kema independent audit
4. DNO responses to WPD change request
5. Tracked changes project pro-forma
6. Proposed tracked changes project direction

Appendix

1. LCH resubmission spreadsheet v 1 0

DOCUMENT CONTROL		
Prepared by	Philip Bale	Title / role: Innovation & Low Carbon Engineer
Reviewed by	Roger Hey	Title / role: Future Networks Manager
Approved (WPD)	Roger Hey	Title / role: Future Networks Manager

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Change Request v1

1. WPD project change mandate

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Future Networks Programme Change Mandate

Project Number CNT2002 *Change Number* *01*

Originator: Philip Bale	***Tel:*** 01332 827448	***Date:*** 16/07/13
Project Manager: Philip Bale	***Project:*** Low Carbon Hub	

Change Title:
Low Carbon Hub change request – Creating an active network ring using Ingoldmells primary substation as an alternative to the new 5km interconnector.

Change Type:
- *Resource* ☐
- *Change in Scope* ☒
- *Milestone Change* ☐
- *New Requirement* ☐
- *Budget Change* ☐

Other dependent projects affected: *None*

Proposed change:
The LCH project proforma stated the project would create an active network ring by building a new 5km interconnector. Project progress reports detailed the issues we encountered securing permission for a new 5km interconnector to create the LCH active network ring

The new Low Carbon Hub design includes an additional primary substation in the active ring arrangement (Ingoldmells). This approach has already received all the necessary landowner permissions. The project can also be delivered within the existing project budget. The change request also takes into account the requirements to allocate costs associated with the new network equipment, protection assets and telecommunications equipment as an alternative to the 5km interconnector.

The amended design will fund the enhanced network alterations to 10.5km of OHL instead of 20.1km as identified during the bid. This is due to a circuit no longer being rebuilt in DR5. The original costs £160k (Equipment £60k & Labour £100k) has been replaced with £79.7k (Contractor) costs.

Reason for change:
We have been unable to secure the necessary permissions for the 5km interconnector and thus have been unable to proceed with the active network ring section of the project as detailed in the original bid.

Effect of NOT making change:
Inability to deliver the active ring section of the Low Carbon Hub, a reduction in the learning and effectiveness associated with the active ring and other techniques.

Impacts of Change:
- ***Milestones*** ☒
- ***Resources*** ☒
- ***Costs*** ☒
- ***Project Scope*** ☒
- ***Deliverables*** ☐
- ***Project End Date*** ☐
- ***Benefits*** ☐
- ***Learning Outcomes*** ☐

Describe the impacts on the project for the categories above :
Milestones: The acceptance of the change request will facilitate the project complying with all committed milestones.
Project scope: The project will no longer build a 5km interconnector; instead additional network equipment, protection assets and telecommunications equipment will be installed at Chapel St Leonards and Ingoldmells. This was previously outside of the original scope.
Resources: The amended scope changes the type of work being carried out, this requires a different internal resource.
Costs: The total project costs are reduced as a result of this change, the allocation of costs are now associated with the inclusion of Ingoldmells substation and the associated circuits.
Deliverables: The project deliverables remain the same as identified at the bid stage.
Project End Date: The project end date remains 28/02/2015.
Benefits: The resubmitted project will provide the same level of learning identified at the bid stage; this will be shared with all DNOs.
Learning Outcomes: The LCH is systematically capturing the learning associated with the project, these will be increased by the steps WPD have already taken and will take through the new Active ring network.

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

Cost of making the change (and justification): ***Total Project costs £3,528k*** ***New Total Project Costs £3,417k*** *A reduction of £30.7k due to the amended Active Network Ring design.* *A reduction of £80.3k due to a 9.6km reduction in the number of circuits being rebuilt at 300HDA instead of 150ACSR.*	
Supporting Information: 1. WPD project change mandate, 2. WPD design justification report, 3. DNV Kema independent audit, 4. A copy of DNO responses, 5. A tracked change project pro-forma 6. A proposed tracked change project direction. 7. A amended project spreadsheet.	
Signed: *Project Manager* *Future Networks Manager*	***Date :*** 16/07/13

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Change Request v1

2. WPD design justification report

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

Project

Lincolnshire Low Carbon Hub

Design Justification Report

Version 2.3

28th May 2013

Amendment history

Date	issue	status	author
2013-04-21	1.0	First Version – sent to DNV Kema for review	Philip Bale
2013-05-23	2.1	Second Version – send to DNV Kema	Philip Bale
2013-05-28	2.2	For public release	Philip Bale
2013-06-12	2.3	For public release, with minor amendments	Philip Bale

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

Prepared by	: Philip Bale	Innovation & Low Carbon Networks Engineer Date:21/5/2013
Reviewed by	: Jonathan Berry	Innovation & Low Carbon Networks Engineer Date: 28/05/2013
Checked by	: Karen McCalman	Innovation Support Administrator Date: 24/5/2013
Approved (WPD)	: Jonathan Berry	Innovation & Low Carbon Networks Engineer Date: 28/05/2013

Glossary of Terms

Term	**Definition**
ADSS	All-Dielectric Self Supporting cable
AVC	Automatic Voltage Control
BAU	Business as Usual
CB	Circuit Breaker
CT	Current Transformer
DG	Distributed Generator
DR5	Distribution Review Period 5
EF	Earth Fault
ENA	Energy Networks Association
FACTs	Flexible AC Transmission system
IBGT	Insulated Gate Bipolar Transistors
IDMT	Inverse Definite Minimum Time
LCNF	Low Carbon Networks Fund
LLCH	Lincolnshire Low Carbon Hub
OC	Over Current
OHL	Overhead Line
OPPC	Optical Phase Conductor
OPV	Optimised Protection Variant
POWERON	GE's Network Management Software
RMU	Ring Main Unit
RPZ	Registered Power Zone
SCADA	Supervisory control and data acquisition
Statcom	Static compensator
T1 / T2	Transformer 1 / 2
Tx	Transformer
VT	Voltage Transformer

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

Lincolnshire Low Carbon Hub – Design Justification Report

This document is intended to outline the designs that have been considered as part of the project and record the assessment criteria taken in reaching a final design for construction based on the through life assessment.

Contents

1. Background

The Lincolnshire Low Carbon Hub (LLCH) was awarded £3.063m of Tier 2 Low Carbon Networks Fund (LCNF) funding following the first round of competitive bidding. The project budget is £3.413m and includes a £350k minimum contribution from WPD. The LLCH will investigate how 6 innovative network techniques can be utilised together to reduce the time and cost of generation connections on to a constrained network. These techniques are:

- Ring network configuration
- Dynamic Line Rating
- Active Voltage Control
- Installation of a FACTs device (Statcom)
- Network enhancements (including the addition of optical fibre and microwave comms)
- New commercial agreements

2. Current Network Layout – 2 Radial Feeders

The 33kV distribution network, in rural areas, is largely radial feeders supplying two transformer primary substations. The existing network in the area around the LLCH includes two radial feeders running to normally open points at Trusthorpe, Chapel St Leonards and Ingoldmells primary substations. This radial network configuration is relatively simple to operate and maintain, power can only flow along one path. However radial networks can presents a number of barriers to the connection of additional generation. This is primarily due to voltage rise and thermal constraints on the system. Voltage rise occurs when Distributed Generation (DG) is connected to the network and power flows in the opposite way it is intended. This DG can also exceed the static ratings for an overhead line (OHL) at times of minimum demand; this project will demonstrate how these OHL ratings can be increased.

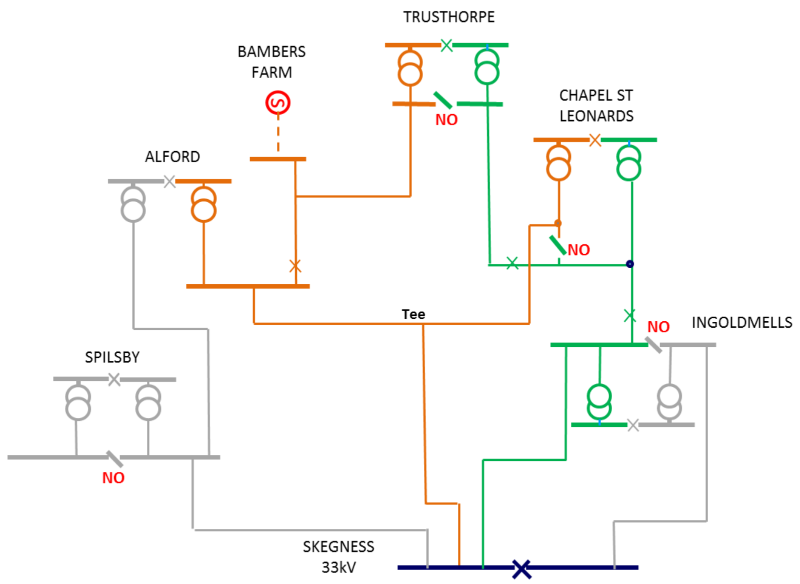


Figure 1 - Current Network Layout – 2 Radial Feeders

3. Lincolnshire Low Carbon Hub – Design submitted during the bid

To create an active ring network the original project design included an additional 4.5 km of new 33kV OHL and the existing normally open point will be closed. This created a network ring. This new OHL in combination with the active ring network will create an increase in the potential capacity to connect generation.

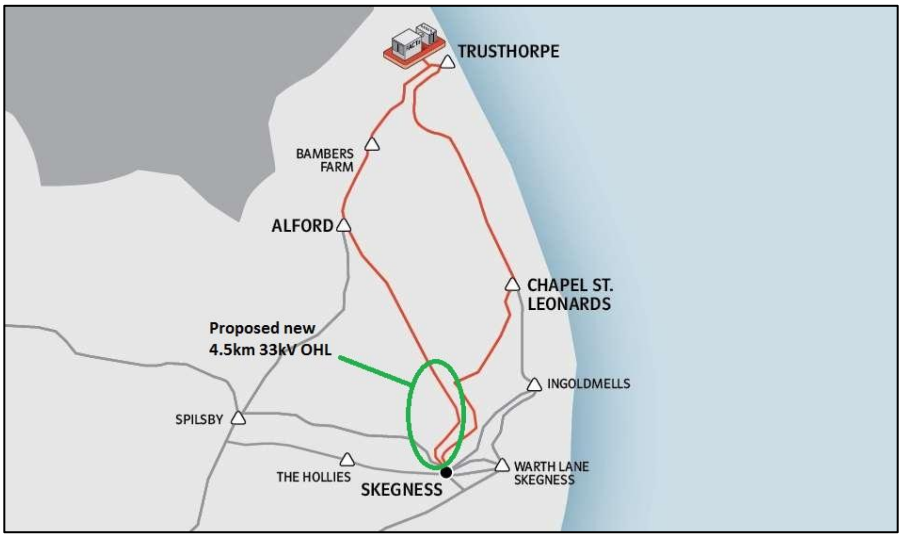


Figure 2 - Original proposed LLCH network layout.

However due to local opposition, largely linked to possible new wind farms, the wayleave process became increasingly difficult. Speaking to local groups it became clear that the proposal to build the new OHL was unfeasible. Although further steps could have been taken to secure permissions (compulsory wayleaves etc.), these where deemed inappropriate for an ahead of need investment or a LCNF demonstration project. Subsequently an alternative network layout has been developed that seeks to maximise the potential operational capacity of the existing assets. While this did not adversely affect the majority of elements of the project, it has had a significant bearing on the design of the active ring network, and resulted in a redesign of the network layout.

Careful consideration was given as to whether WPD should approach any council members in this area to request support for the new OHL. As this is part of strategic ahead of need investment, the project intends to avoid the requirement for either additional OHLs or disruption of public roads from installing 33kV cables. Previous experience gained from working in this region resulted in WPD not approaching any councillors to support this new OHL.

When WPD could not secure permissions for a new OHL, required as part of the active ring network, the option to complete the ring by installing a suitably rated 33kV underground cable was reviewed. This was not selected as the ethos of the project was to make use of the existing network where possible and to install lower cost alternatives to underground cable for generation connections.

4. Lincolnshire Low Carbon Hub – Alternative Network Designs

The LLCH network was re-evaluated, to find an alternative option to operate the network as an active ring sticking to the LLCH aim of making the best use of the existing network assets. A range of network layout options were considered.

It was decided that the most appropriate option to deliver the ring network was to add Ingoldmells 33/11kV primary substation into the LLCH design. This had the added advantage of making the LLCH network larger in an area where further generation connections is likely, increasing the area the innovative network design would serve. However, this created an additional challenge to ensure the network was equally or more operationally robust than the existing network and could be adequately protected electrically.

The largest challenge facing the redesign process was how to deliver the active ring network element of the project whilst providing an operationally robust network that could also be adequately protected. The following protection schemes where considered, with a range of additional network assets included.

- Comprehensive Unit protection scheme
- Distance protection scheme
- Innovative directional overcurrent scheme
- Minimal unit protection scheme

The redesign of the LLCH including Ingoldmells primary substation was firstly supported by TNEI, a specialist energy and environmental consultant, and later by internal WPD Engineering Design resource. Our Engineering Design team are very competent design engineers, however they specialise in delivering standard designs. A current differential scheme is normally associated with 132kV network schemes. During the network and protection design the decisions being made tended to reverted towards the same design principles of a 132kV network design rather than a rural 33kV. This lead to a comprehensive unit protection scheme that added both cost and complexity before more innovative protection schemes and designs were investigated.

During the redesign it was apparent the age and health of the Trusthorpe 33/11kV transformers required them to be replaced. Trusthorpe primary substation is within a flood zone; therefore, in line with WPD’s policy to reduce our most at risk primary substations, it was decided to carry out a DR5 replacement in conjunction with the LCNF works.

The 1 in 200 year flooding risk has led to 33kV assets being elevated by 1m. A rebuild of the site by removing assets and replacing them in the same location, an online build, would have led to unacceptable operational risk. Therefore a 33kV 7 panel board was decided on, providing ultimate flexibility with the FACTS device and further works to change the 33 /11kV transformer. The LLCH requires a ring main unit (three circuit breakers), the DR5 works will fund the additional circuit, transformer circuit breakers and flood prevention work at Trusthorpe primary substation.

4.1. Comprehensive Unit Protection Scheme

The first design considered a comprehensive unit protection scheme, which in turn led to the requirements for additional current transformers and circuit breakers. This led to solutions which required significant reinforcement with new 33kV switch boards at most primary substation sites, and complex site reconfiguration. It was recognised that this provided the lowest operational risk solution, mirroring existing 132kV protection systems already in operation within WPD.

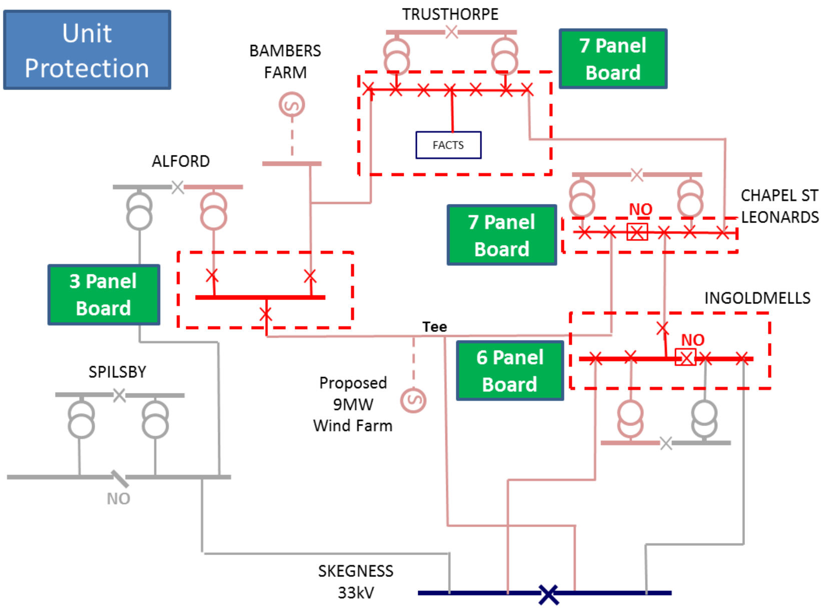


Figure 3 – Comprehensive Unit Protection Scheme

This solution was ultimately rejected due to the additional delivery risk and cost that would have been incurred through the project. The plan was effectively a whole network refurbishment. This also was not considered to deliver the aims of the project of modifying an existing system. It was not fully understood whether this amount of activity could have been concluded within the timescales of the project. Initial estimates also highlighted that the scheme would overrun by £1.5m.

4.2. Distance Protection Scheme

A less asset intensive model was considered, which called for a distance based protection scheme. This required protection to be changed at all sites, within the active ring network, with the need for additional CTs and VTs at Trusthorpe and Skegness primary substations.

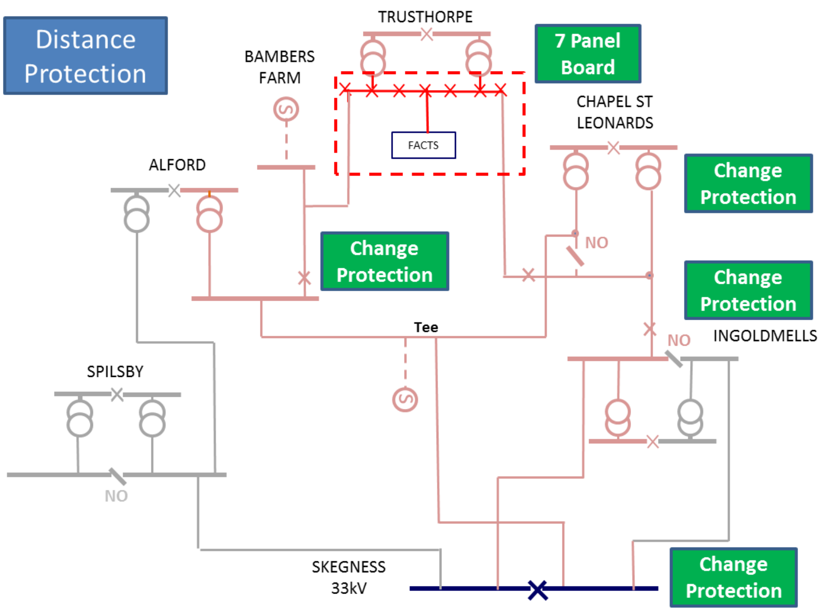


Figure 4 – Distance Based Protection Scheme

There are a number of technical challenges associated with this solution, in particular changing CTs and VTs on the existing switchgear at Skegness primary substation. Detailed analysis of the system however showed that the solution would not work due to some of the distances involved. Protection studies identified that a fault near Trusthorpe may not be detected at Skegness with the ring configuration. This would mean that a potential fault could remain on the system for a prolonged period of time (potentially several seconds) and ultimately outside of the WPD design standards. This solution could have been delivered within the timescales and budget for the scheme, but was ultimately discounted due to the high operational risk.

4.3. Innovative directional overcurrent scheme

One solution that initially seemed possible was a directional overcurrent protection scheme. This would require an upgrade to the protection systems at all sites, but with minimal additional asset replacement on the network. However it was quickly realised that the presence of generators and a FACTS device had the potential to cause instability with the protection settings leading to scenarios whereby the protection would, potentially, fail to operate.

A proposal was produced to look into developing alternative protection settings to be added to existing relays, thereby changing their method of operation. This would have required 3-6 month development work with a relay manufacturer. However it was quickly recognised that this placed an additional delivery risk on the project, which was deemed unacceptable. As this solution had never been trialled, there was the distinct possibility that the protection development timescales would ultimately extend, thereby creating on-going uncertainty around delivery of the LLCH.

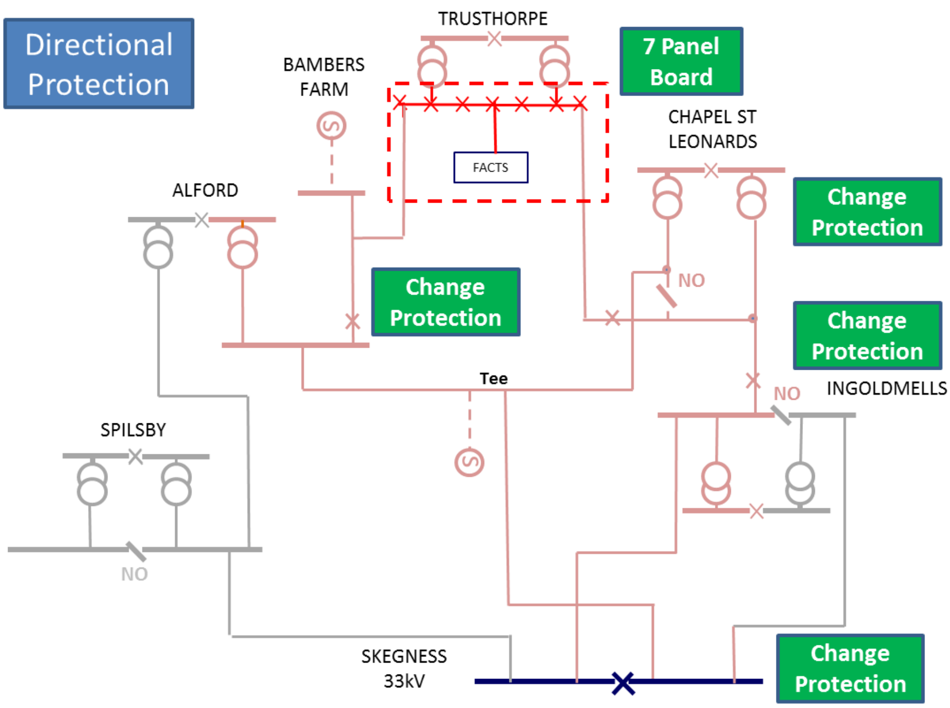


Figure 5 – Innovative Directional Protection Scheme

4.4. Minimal Unit Protection Scheme

The final solution that has now been adopted for the project is that of a minimal design unit protection scheme, using a mixture of outdoor and indoor switchgear. This design was led by the Innovation and Low Carbon Team and supported by the Engineering Design team, Policy team, Primary Planning and the local delivery team, which are all internal to WPD.

This solution requires the replacement and addition of a number of assets to provide additional CTs, disconnectors and circuit breakers for the unit protection scheme. Once costed, this work fell within the project budget, but required some detailed site design work to prove the feasibility. In particular there were a number of iterations considered for how circuit breakers could be added at Ingoldmells primary substation and Chapel St Leonards primary substation within the existing site boundaries.

The Single Line Diagram for the Unit Protection scheme has been included in Appendix A.

4.5. Issues detailed in the last six monthly report

Within the last six monthly report an issue was detailed regarding the network redesign at Ingoldmells primary substation, concerned with maintaining safe equipment spacing between assets. This has meant that some proposed designs could not be realised without significant rebuilding activities. The reason these designs have not progressed is because it would be unacceptable to install equipment that does not comply with WPD's asset clearance distances. However, rebuilding entire primary substations could not be achieved within the project budget, timescales and it is not within the projects aims.

As detailed below in the design justification for each site, the detailed design has led to steps being taken to ensure the whole asset life is considered, included construction, operation and decommissioning. The installation of all equipment will comply with WPDs policies for safe asset spacing.

5. Detailed Design justification for works at each substation location

5.1. Skegness

The work at this site is different to that detailed in the original design submitted during the bid stage. As the LLCH no longer requires the installation of an additional interconnector the existing circuit breakers will be utilised. The works includes:

- The feeders from CB7 & CB8 will be transposed as part of the LLCH
- A three ended current differential protection scheme will be installed on the Alford / Chapel St Leonards circuit with distance protection backup
- A two ended current differential protection scheme will be installed on the Ingoldmells circuit with distance protection backup

Transposing the feeders will ensure that when the network is operated as a ring all the primary substations, in the Skegness group, will be supplied by feeders on alternative sides of the Skegness Bus Bars, reducing the risk of customer interruptions under certain fault conditions. After the completion of the works at Skegness the network will be more operationally secure.

The existing 33kV transformer VTs will be used as part of the LLCH protection scheme. The existing circuit breaker CTs will be operationally tested, including a magnetisation test, before a decision is taken whether to retrofit class PX CTs. WPD has experience of retrofitting CTs to this type of 33kV switchgear for uprated protection schemes.

5.2. Alford

The work at this site is in line with that detailed in the original design submitted during the bid stage. The works includes:

- Replace the existing outdoor 33kV oil circuit breaker at Alford with an outdoor 33kV SF6 circuit breaker
- Replace the two existing line disconnectors, new disconnectors will have with auxiliary contacts fitted
- Post CTs will be installed on T2 to summate the transformer load and the CTs within the CB bushing
- A three ended current differential protection scheme will be installed on the Alford / Chapel St Leonards circuit with distance protection backup
- A three ended current differential protection scheme will be installed on the Trusthorpe / Bambers Farm circuit with distance protection backup
- Three phase VTs will be retrofitted to both line disconnectors for use with distance protection and check synchronisation

Auxiliary contacts will allow the protection scheme to default to stub bus when the line disconnectors are opened, reverting to a simple local protection for the assets within Alford. Retrofitting Auxiliary contacts to the existing line disconnectors was explored and, following consultation with WPD's local operational team, lead to the decision to replace the line disconnectors on the existing civil structures. This is due to operational issues when retrofitting auxiliary contacts. Replacing the disconnectors also ensures further work will not be required at Alford in the near future.

The existing Alford breaker is graded with Skegness OC & EF protection. The breaker does not have the adequately rated matched CTs in both bushings as required for the current differential protection scheme. Replacing the 33kV breaker also ensures further work will not be required at Alford in the near future.

Installing Post CTs on the Transformer allows a three ended protection scheme to be installed instead of a four ended scheme. The existing OC & EF protection scheme protects both the feeder and transformer. The LLCH scheme will install current differential protection on each feeder; the Post CTs will provide protection CTs for transformer protection.

Post CTs have been selected instead of slip over CTs; slip over CTs would reduce the electrical clearance on the 33kV Tx bushings and require additional on-going maintenance to clear material that could collect in between the CT and bushings.

Combined CTs and VTs have been considered and discounted for this project as a suitable unit cannot be incorporated into each location. The ABB PVA123 is 2.7m high, requiring a large support structure to ensure safety clearances are maintained. This would require alterations to the existing bar arrangements, increasing the work required at this site.

The SASA switchgear identified by DNV Kema for possible use in the LLCH as a combined CT and VT, doesn't appear to comply with IEC60044[1] or have ENA approval. This will be reviewed and if this was addressed, it would be considered for future projects. The use of combined CT and VT units provides benefits regarding cost and the number of equipment installed, however can lead to a compromise in the protection scheme as this requires the both transducers to be in the same location.

5.3. Bambers Wind Farm Substation

The work at this site is in line with that detailed in the original design submitted during the bid stage. The works includes:

- Installation of a three ended current differential scheme on the Trusthorpe / Alford circuit with distance protection backup
- Retrofit appropriate CTs to the Bambers Wind Farm Ormazabal 33kV circuit Breaker

The work at this site will allow Bambers Wind Farm to operate as part of the three ended current differential protection scheme.

5.4. Trusthorpe

The work at this site being carried out for the LLCH is in line with that detailed in the original design submitted during the bid stage. This included a ring main unit (three circuit breakers). The DR5 works occurring at the site, at the same time, includes the installation of two cable connected transformers as an offline build. The combined works includes:

- Install a 33kV 7 panel switchboard as part of the Trusthorpe primary substation transformer change and LLCH project. 2 x feeder circuit breakers, 3 x transformer circuit breakers (2 x primary transformers and a FACTs transformer) and 2 x bus sections
- Installation of a three ended current differential scheme on the Trusthorpe / Alford / Bambers Farm circuit with distance protection backup
- Installation of a two ended current differential scheme on the Trusthorpe / Chapel St Leonards circuit with distance protection backup.

The installation of two bus section circuit breakers and the FACTs transformer circuit breaker will allow the network to be operated as a ring, as well as radially, with the FACTs device on either the Alford or Chapel St Leonard's circuit.

[1] IEC60044 – General requirements for instrument transformers

The site will be left with all 33kV assets being protected for a 1 in 200 year flood. The work will be carried out off line due to the duration of the works and level of risk associated with an online build.

The position of the new switch-board building, FACTs, FACTs transformer and Primary transformers are sited in the locations shown in appendix 1, so to allow sufficient room for earthing, fencing and cabling to be installed without any de-rating and the avoidance of land drains.

The position of the FACTs has been configured to the requirements of the FACTs supplier who need a minimum of 3m clearance on all sides. The orientation has been selected on the recommendation of the FACTs supplier to allow future access requirements in the event of a power electronics tray being replaced.

The layout complies with WPD's policies for separation distance between transformers, preventing the layout from being further condensed.

5.5. Chapel St Leonards

The work at this site is further to that detailed in the original design submitted during the bid stage. This is due to the inclusion of Ingoldmells primary substation as part of the network ring. The works includes:

- Installation of a ring main unit (3 x circuit breakers)
- Reinstatement of the T1 line disconnector, cable connecting the Skegness/Alford circuit to T1 Line disconnector
- Removal of over sailing Ingoldmells/Trusthorpe OHL span and line disconnector
- Three phase VTs will be retrofitted to both line disconnectors for both distance protection and check synchronisation
- Cable connect the new ring main unit to both T1 and T2 disconnectors and Trusthorpe OHL.
- A three ended current differential protection scheme will be installed on the Chapel St Leonards / Alford / Bambers Farm circuit with distance protection backup
- A two ended current differential protection scheme will be installed on the Trusthorpe / Chapel St Leonards circuit with distance protection backup to provide adequate protection for this network

Work completed as an online build

The T1 Line disconnector will be reinstated using the existing structures with a new set of cable sealing ends; this will mirror the existing network installed on T2. Site surveys have confirmed the structures are in a good condition and there is adequate room to install a new structure with cable sealing ends whilst still maintaining electrical safety clearances.

Cable sealing ends will be retrofitted to the existing structures, site surveys have confirmed the structures are in a good condition.

The existing protection scheme protects both the feeder and transformer. The LLCH scheme will install current differential protection on each feeder, the Post CTs will provide protection CTs for transformer protection.

Post CTs have been selected instead of slip over CTs; slip over CTs would have reduced the electrical clearance on the primary Tx bushings and require additional on-going maintenance to clear material that could collect in between the CT and bushings.

Auxiliary contacts will allow the protection scheme to default to stub bus when the line disconnectors are opened, reverting to a simple local protection for the assets within Chapel St Leonards. Retrofitting Auxiliary contacts to the existing line disconnectors was explored and, following consultation with WPD's local operational team, lead to the decision to replace the line disconnectors on the existing civil structures, due to operational issues when retrofitting auxiliary contacts. Replacing the disconnectors also ensures further work will not be required at Chapel St Leonards in the near future.

This work as part of an online build can be completed with a sufficiently low level of risk to both people and the network for the entire asset life.

Work completed as an offline build

The installation of a new ring main unit (3 x circuit breakers) will occur outside of the operational compound as part of an offline build. The position of the RMU was selected to make best use of the land conditions, this also allows the RMU to be constructed away from the existing AIS, allows sufficient room for earthing, fencing and cabling to be installed without any de-rating and the avoidance of land drains. The compound and fence will be extended to include the new ring main unit.

The installation of a six panel GIS board was considered as an offline build with the AIS equipment being removed. It was concluded this would not provide a better engineering solution and the costs for this solution was much greater than the hybrid AIS and GIS solution.

5.6. Ingoldmells

The work at this site is further to that that detailed in the original design submitted during the bid stage. This is due to the inclusion of Ingoldmells primary substation as part of the network ring. This work includes:

- Installation of a new bay including terminal structure, Horizon 33kV circuit breaker, disconnector, cable sealing end structure, VT, disconnector and cable sealing structure
- Modification to the existing cross bay, installing a new Horizon 33kV circuit breaker and post insulator
- Three phase VTs will be retrofitted to both line disconnectors for both distance protection and check synchronisation
- The Skegness circuit existing line disconnectors will be replaced with disconnectors including auxiliary contacts
- A two ended current differential protection scheme will be installed on the Chapel St Leonards circuit with distance protection backup
- A two ended current differential protection scheme will be installed on the Skegness circuit with distance protection backup will provide adequate protection for this network

This layout was proposed by operational personnel who believe it is the most appropriate whole life layout. The design has minimal alterations to the existing site with the majority of the construction being completed offline. As detailed in the December 2012 six monthly report a number of online construction layouts have been discounted due to unacceptable construction risk.

The extension of the operational compound was required to allow an offline build of the majority of the equipment at Ingoldmells primary substation. The maintenance requirements and associated risk of maintaining each section of this substation asset has been discussed with the operational team, the design is acceptable to WPD as the best solution for Ingoldmells primary substation.

Auxiliary contacts will allow the protection scheme to default to stub bus when the line disconnectors are opened, reverting to a simple local protection for the assets within Ingoldmells. Retrofitting Auxiliary contacts to the existing line disconnectors was explored and, following consultation with WPD's local operational team, lead to the decision to replace the line disconnectors on the existing civil structures, due to operational issues when retrofitting auxiliary contacts. Replacing the disconnectors also ensures further work will not be required at Ingoldmells in the near future.

The existing protection scheme protects both the feeder and transformer. The LLCH scheme will install current differential protection on each feeder, the Post CTs will provide protection CTs for transformer protection.

Post CTs have been selected instead of slip over CTs; slip over CTs would have reduced the electrical clearance on the primary Tx bushings and require additional on-going maintenance to clear material that could collect in between the CT and bushings.

The installation of a six panel GIS board was considered as an offline build with all AIS equipment being removed. It was concluded this would not provide a better engineering solution and the costs for this solution were much greater than the current design and layout.

6. Telecommunications

Rural primary substations do not routinely have DNO owned and operated telecommunications links for network protection. The protection requirements for the Low Carbon Hub and advanced network operation require a reliable, low latency communications media for protection purposes.

Fitting optical fibre and microwave communication links for primary substation current differential protection schemes is a new area to WPD. There is a low level of risk with any new technology, the decision was made to trial both wired and wireless communications channels as part of the project to further reduce the impact of any one communication technology not operating effectively. A review of the available communication media was conducted by the project team and recommendations were made for the addition of fibre to new overhead lines, existing overhead lines and the most appropriate wireless channels.

The lessons learnt over the last six months, when planning the communications links for the LLCH substation communications, will lead to a revision to the Low Carbon Hub communications design.

The findings have influenced the recommendations made. This review of the LLCH Communication Review document will be completed after the installation of the telecommunication links to capture the installation process.

Optical Fibre Wrap will be installed on the existing overhead lines:

- Optical Phase Conductor (OPPC) requires the re stringing of the centre phase, this is a high cost installation for retrofit. This also requires sufficient spare conductor to be strategically stored for repairs. The use of OPPC could lead to extended periods of time when the optical fibre is not available for protection traffic
- All-Dielectric Self Supporting cable (ADSS) cannot be installed without either reducing the ground clearance, causing an unacceptable risk of clashing, or increasing the height of a number of poles along this circuit. Therefore, especially in locations where there is very large farm machinery, it is not an appropriate choice
- Optical Fibre Wrap will be applied to the centre phase of the existing overhead line. The OHL has been surveyed and the design implications of the wrap have been calculated. Any spans no longer meeting WPD's OHL policy or statutory clearance will be rectified

Optical Fibre Wrap will be installed on the new overhead lines, due to the span length of the new build circuits it is not feasible to design the use of ADSS. The use of OPPC is a lower cost alternative for new build OHLs but still leaves an issue of storing strategic spares and having extended periods of time when the optical fibre communications is not available.

As adding optical fibre will be a new addition to 33kV OHL in the East Midlands WPD area, it will lead to a new Standard Technique policy being written in conjunction with the fibre provider. This will document the installation, on-going maintenance and operational considerations required including the addition of temporary earths when working on the circuit.

Microwave links will be used between Trusthorpe, Chapel St Leonards, Ingoldmells and Skegness primary substations. The microwave towers have been located in positions to allow for line of site paths between all sites. Microwave towers will all be 15metres. Permitted development has being secured for the installation of new towers at, Chapel St Leonards and Ingoldmells primary substations. Permitted development has been secured at Trusthorpe primary substation.

Whilst the use of microwave links for current differential protection has been used by other DNOs within the UK, WPD has limited operational experience of operating microwave links for current differential protection data. Therefore, throughout the project their performance in this area will be closely monitored.

The use of the optimised protection variant (OPV) Mimo Max equipment has been considered for the project, however the bandwith is significantly lower than microwave links, a much higher latency. WPD are conducting a trial testing the operation of the OPV Mimo Max link; the trial is on-going and results have not yet been concluded.

7. Protection

As detailed at the start of this design justification report a number of different network configuration and protection methods have been considered. The decision has been made to select the Areva P543 and P544 relay operating the network as five current differential protection schemes. This will allow the network to operate as a ring configuration with an adequate level of confidence that a fault will be sectionalised with supplies maintained to all primary substations.

HV Transformer protection, three phase high set overcurrent, inverse definite minimum time (IDMT) overcurrent and IDMT earth fault protection will be installed on Transformers supplied by the LLCH ring network.

Bus section protection will be installed to protect against a fault within the bus section, this is in line with WPD's existing standards.

In the event of a communications failure the section of the network will revert to distance protection allowing the ring network operation to be maintained. The distance protection will be graded to clear faults within each zone. This is intended to allow the network to maintain operation as a ring whilst any telecommunication issues are fixed. This still allows the network to be sectionalised and operated as two radial circuits if required due to concerns over protection grading.

Check Synchronisation will be installed, ensuring before a parallel connection is made the network voltage, phase angle and frequency is within the circuit breaker parameters. This has been added due to the inclusion of the FACTs device on the ring network. The Auto reclose functionality will be utilised if available in the main protection relay or an additional auto reclose relay will be installed if required.

Further DG connections into current differential schemes

- If further DG sites connect to a three ended scheme the lowest cost connection would include looping the connection into the three ended scheme, creating a three and a two ended scheme
- If further DG sites connect to a two ended scheme the lowest cost connection would include either replacing the two ended scheme with P454 relays to operate a three ended scheme or looping the connection, creating two, two ended schemes

8. OHL design – new and existing overhead lines

Engagement with arable land owners revealed they were not willing to accept shorter span lengths, i.e. the closer spacing of overhead line poles. The circuits being replaced were constructed in the 1950s, they have a typical span length of 150 – 160m. This feedback from land owners led to a bespoke H pole construction with a 160m span length being designed. The rebuilt overhead line will not obstruct farming practices and the necessary wayleave permissions have been secured.

It has been very difficult to capture the cost implications moving from a standard 300HDA on a single wood pole type of construction to an H pole construction at this stage of the project. It was the view of the wayleaves officer that the original shorter span design would have presented issues securing agreement, delaying the OHL rebuild and potentially increasing the distance and cost of the rebuilds.

The cost implications for constructing a km of the H pole design instead of a km of WPD's standard single wood pole solution is a slight increase in the labour costs associated with the installation of larger poles and longer span lengths. The material cost associated with the delivery is not expected to alter. These OHL rebuilds will be carried out by external resource; the costs associated with the delivery will be captured and compared with standard OHL delivery.

As detailed above, careful consideration was taken over whether WPD should approach any council members in this area to request support for the new OHL. As this is part of strategic investment it could avoid either additional overhead lines or disruption from installing cables in public roads. Previous experiences in this region resulted in WPD not approaching any councillors to support this new overhead line.

Another design option investigated for the new interconnector was looking to rebuild the existing 150ACSR circuit to a portal construction, where two circuits are constructed on a single h pole construction, creating two overhead lines. This was rejected as it would have required securing new wayleaves for the portal construction. Portal construction was no longer a WPD approved construction. Operational restrictions would require both circuits to be de energised when being worked on. This would have led to an unacceptable network operational risk.

9. Dynamic Line Rating

Background

The Skegness Registered Power Zone (RPZ) delivered cheaper connections to offshore wind farms by giving Western Power Distribution a facility to adopt dynamic ratings for overhead lines. This method, which has already been widely disseminated within the industry will be further developed to test new techniques for calculating plant and equipment ratings and the subsequent operating limits based on real time data. A policy has been written to allow the dynamic rating of 132kV lines using a number of weather stations to measure the wind speed and temperature.

The GE dynamic rating "Plug in" has been installed within POWERON to allow assets to be dynamically rated.

Scottish Power has generated a considerable amount of knowledge through the on-going development of dynamic line ratings. The learning generated from their project will be reviewed before Overhead Lines are dynamically rated.

The design for the Dynamic Line rating will take the output from SCADA connected wind generators being used as a proxy for wind speed. The estimated wind speed along with the temperature data from the Skegness weather station will provide a conservative real time rating for the Overhead lines nearest the wind farm. The real time ratings will be reviewed against the static OHL ratings and the real time loads. The analysis from this technique will generate significant learning on whether generation output could be used as a suitable method to dynamically rate local overhead lines, the size of the increase above the static rating and whether it could be used in other areas beyond the Low Carbon Hub.

The use of generator output as a proxy for wind speed will be investigated as a lower capital cost and more reliable alternative to installing weather stations or purchasing weather data from the Met office.

Learning will be generated as to the number and proximity of wind farms providing generation outputs via SCADA before an entire area could be dynamically rated. This will further develop the work being completed under Strategic Technology Platform, analysing the wind speed at weather stations less than 20km form each other.

10. Active Voltage Control

Background

Primary and Grid substations regulate the voltage seen on the secondary winding using on-load tap changers on the primary winding. Pre-determined voltage settings are calculated to ensure the network will operate within statutory limits for normal network operation and changes in load throughout the year. The AVC relay at each primary and grid substation has the parameters installed within the relay.

The most simple scheme used at most primary substations is to control the secondary voltage, to be within pre-defined limits regardless of voltage changes on the primary winding. This pre-defined voltage level is normally set so the voltage will still be within statutory limits during maximum demand periods. This can reduce the available head room for DG to connect and generate during minimum demand.

The control can be further increased by using line drop compensation, allowing the transformer or certain feeders load to be taken into consideration when setting the voltage at the primary or grid substation. This can reduce the set point voltage during periods of minimum demand. This scheme is significantly less effective when DG connects to the network as it can mask the true load on both the network feeder and transformer.

Both methods use the information available at the Grid and Primary substation to estimate the most appropriate voltage. Increasingly networks have either voltage transducers, effective ways to calculate the network voltage, and communications installed. This information could be used in a more intelligent way to calculate centrally the most appropriate voltage set point.

WPD already has both 3% and 6% voltage reduction control if required by the Distribution Code. Modern AVC relays, approved for use by WPD, also have the capability to change or influence the voltage set point in a more granular way using the same SCADA systems.

This technique will allow DNOs to move from calculating the network settings once to a more iterative calculation and the ability to modify the set point based on the iterative calculation.

Design Considerations - Central or Localised control

Centralised control

- ✓ Makes use of the existing communications channels at primary substations to recover information into POWERON and for POWERON to communicate to the Skegness AVC relays
- ✓ Follows WPD's vision of automation and control being within POWERON
- ✓ Can revert to a "Safe" setting if communications are already lost to the AVC relay, pre-set line drop compensation on the most onerous feeder without DG
- ✓ Could be rolled out more successfully with lower costs if used as a BAU technique
- ✓ Requires less hardware to be installed in remote locations that will require on-going maintenance and repairs
- × Requires a back-up incase communications are lost

Localised control

- ✓ Does not require a central link to POWERON and will continue to operate if communications with POWERON is lost
- × Cannot take into account changes to the network operating in the surrounding areas
- × Requires additional communications to be installed to facilitate the technique
- × Would require additional computing to be installed to provide the most appropriate network voltage

Both techniques have been investigated by WPD and Fundamentals Ltd; Fundamentals have provided a quote for both solutions. The centralised control using POWERON with a line drop compensation based on the Horncastle feeder is the most appropriate solution for both the LLCH and other network areas.

How to retrofit voltage transducers at Horncastle

Horncastle is the most onerous network location to regulate the voltage, the two transformer site under normal network operation has a transformer supplied from the Skegness network and a transformer supplied from the Lincoln network. The network can operate with the entire Horncastle load on the Skegness Network leading to a large voltage drop due to the distance and network impedance from Skegness.

Five different methods for recording the voltage at Horncastle have been considered.

- ✓ Installation of an advanced AVC scheme at Horncastle to calculate the 33kV voltage
- ✓ Installation of a 33kV VT on the Skegness feed Transformer
- ✓ Using NVD capacitive cones to derive the 33kV network voltage
- ✓ Retrofitting a resistor chain to the tap indication, recovering the information into POWERON
- ✓ Installation of a self-powered ungrounded voltage transducer

Decision made

- The decision has been made to install the Supertapp N+ relay at Horncastle on both Transformers. This will accurately calculate the 33kV voltage from the known 11kV voltage, transformer characteristics and transformer load. WPD installs advanced AVC schemes at both primary and grid substations as standard. In the future this functionality will be available if required

- The installation of a 33kV VT would have provided an accurate voltage, however WPD do not routinely install 33kV VTs at rural primary substations. The learning generated by this method would be relatively low whereas the costs are relatively high when considering the installation of a civil plinth, structure, VT, multicore and on-going asset maintenance
- The use of NVD capacitor cones to derive network voltage for control was considered. It was decided that further investigative work would be required to ensure this would not have an adverse effect on the network protection. This was discounted for use as part of the LLCH scheme but will continue to be investigated by WPD
- WPD have retrofitted resistor chains to provide tap indications where an advanced AVC relay is not installed. This has been used for indication and is not considered as an on-going reliable solution to calculate the network voltage
- Using a novel ungrounded sensor would provide a low cost installation that could be used for monitoring, however often requires calibration and is not considered an on-going reliable solution to measure the network voltage.

The detailed design for increasing the headroom and the POWERON algorithm for the network control will occur over the next six month period. Network studies conducted suggest the voltage set point during periods of minimum demand with high levels of DG output could allow the voltage could be reduced by 1.5%. This will increase the network headroom and allow the network modelling to allow a 3.5% voltage rise at minimum demand instead of the 2 % currently used. The upper voltage threshold would be reduced from 104% to 102.5% during periods of minimum demand.

Learning will be generated as to the ability to operate the network with a dynamic voltage control based on the network parameters calculated within POWERON. How often the network target voltage could and should be changed. The amount of generation capacity this technique could unlock and the reliability of both the primary and back up voltage control.

11. FACTs device (stat-com)

As detailed in the LLCH bid a Statcom would be trialled at Trusthorpe primary substation to regulate the voltage through the both importing and exporting reactive power. The studies by TNEI suggested a 3MVAr unit should be installed at Trusthorpe primary substation.

11.1. FACTs overview

Often very rural distribution networks are classified as being electrically “weak”; this is because it will have relatively high network impedance from long overhead lines with a relatively small cross sectional area. This means connecting DG to the network will have a big influence on the network voltage. This can act as a limiting factor for further DG connections in rural locations.

A Statcom is one of the devices in the FACTs family and contains inverter blocks containing Insulated Gate Bipolar Transistors (IBGT); these will influence the network voltage by generating and absorbing reactive power. Injecting or absorbing reactive power (VARs) on relatively “weak” distribution networks has a significant effect on the network voltage and could be used as a technique to connect more distributed generation whilst keeping the voltage within statutory limits.

A Statcom has a very quick network response, is very responsive and the device can be used to reduce network losses when not required to keep the voltage within statutory limits by improving the network power factor.

Tendering

After a competitive tender process the contract for providing the FACTs device was awarded to S&C Electric. Due to installing modular units, S&C will install 3 x 1.25 MVAr units providing 3.75MVAr of reactive power capability at Trusthorpe primary substation with a maximum output of 9.9MVAr for short term overloads. The DStatcom is being installed as per the recommendations from S&C.

The installation of a Statcom as a technique to allow the connection of increased levels of DG will increase the network OPEX costs. The manufacturer recommends an annual inspection and maintenance taking approximately 1 day. This will be reviewed and disseminated at the end of the project.

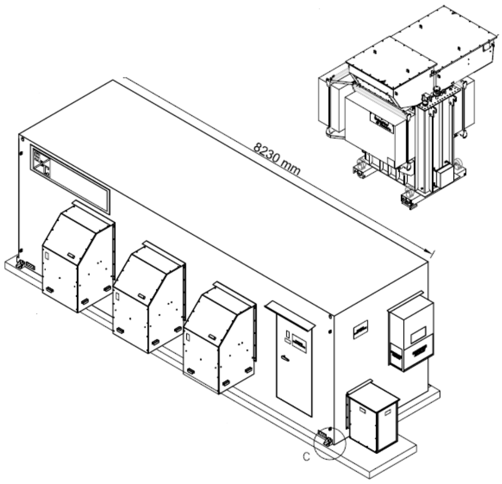


Figure 6 - 3.75MVAr DStatcom within an 8.23m shipping container with a 5MVA step up Transformer

Design Considerations – FACTs vs Generators operating in VAR support

FACTs

- ✓ Can be located in the most optimum network location
- ✓ Can be used to reduce system losses as well as control system volts
- ✓ Has a guaranteed output regardless of network conditions – DG can have a limited ability to offer VAR support at lower power outputs
- ✓ Can be used for system stability, responding to network dips
- ✓ Can be used to boost system voltage as well as reduce system voltage.
- × High Capital Cost
- × Requires on-going maintenance.

Generator in Voltage control

- ✓ Less capital cost then the installation of a Statcom
- ✓ Could be provided as a free service as an alternative to conventional network reinforcement.
- × Often can only provide generation support when the generators is operating – this could not be relied upon to boost network voltage
- × A DG's location will not always make this a viable option
- × Historic generators with unconstrained connections may not consider the solutions
- × Would require every new generator to opt into innovative voltage control modes.

Learning will be generated as to the ability of the FACTs device to influence the network voltage and the surrounding area. Whether a 3.75 MVA is the optimal sized Statcom for this location and the reliability of the unit. What are the benefits of a Statcom over a generator operating in VAR support mode. WPD will also learn how a FACTs device could be used in conjunction with the dynamic AVC scheme at Skegness.

12. New commercial agreements - Generator Connections

The majority of the generation connection offers made are non-firm (teed connections) that operate with a fixed power factor. These typically have very little communications between the DNO and the generation customer, the only communications with the generator is the recovery of high level generation outputs through SCADA.

Generation connections made under a fit and forget arrangement must be modelled for the most onerous credible scenarios that can occur on the network. This connection philosophy will ensure under normal operating conditions the generation will be unconstrained. This can lead to significant amounts of spare capacity in the system not being utilised for periods where the worst possible scenarios do not occur.

"Fit and forget" networks are modelled for the worst probable scenarios:

- Connected DG are all simultaneously operating at their full outputs
- Whilst the distribution network is at minimum demand
- Whilst the distribution network is operating the upper voltage bandwidth

Currently, if a generation connection study shows the network will operate outside of its design parameters or breach statutory voltage limits traditional network reinforcement is offered to provide the lowest cost connection. This often includes installing underground cable as installing overhead lines require planning permission from the Local Authority and has little certainty for delivery dates.

New innovative commercial arrangements involving both reactive power control and Active power constraints are being developed as part of the LLCH and are to be offered as an alternative to conventional network reinforcement.

The commercial agreements being developed as part of the LLCH will be included into WPD's standard DG connection agreement by WPDs legal team and Osbourne Clarke. During this stage the agreements will be reviewed to ensure they are sufficiently robust and fit for purpose. The learning can be used as an alternative to conventional network reinforcement.

13. Overall project benefits

The LLCH will provide the ability to trial each technique on a real distribution network, whilst analysing the networks increased ability to connect generation and the interoperability of an existing network.

Through this project each of the techniques will be designed, installed and operated with lessons being learnt and disseminated on the entire project. This will allow WPD and other DNOs to assess the use of each technique, where it will provide the greatest benefit and where this is a credible alternative to conventional network reinforcement.

Elements of the LLCH techniques could be applied to a wide range of distribution networks operating at different voltage levels. When used together techniques will be optimised for rural "weaker" distribution networks where the level of generation is currently triggering conventional network reinforcement.

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Change Request v1

3. DNV Kema independent audit

Report

16010975

Low Carbon Hub - Optimising Renewable Energy Resources in Lincolnshire - General Review

London, 10 June 2013

DNV KEMA Energy & Sustainability

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CONTENTS

1 INTRODUCTION

WPD has requested that DNV KEMA provide an independent overview for the task listed below. This includes reviewing the designs and producing a commentary on how well the now planned Method delivers the original Solution, and how rollout benefits compare to those originally identified.

1. WPD will produce a full narrative of the learning encountered during the design phase of the project. It will include the issues discovered, the options we analysed, why we picked the ones we did, any cultural barriers, political resistance, technical considerations, etc. The consultant will provide a commentary on how well the now planned Method delivers the original Solution, and how rollout benefits compare to those originally identified (i.e.: replica-ability).

DNV KEMA's understanding of the requirements is that WPD are looking for an independent assessment of the proposed Method to which this project is to be carried out.

The rest of the report is DNV KEMA’s commentary on their findings from all of the documentation provided by WPD to date. This document has been revised following additional information received from WPD on the 21st and 22nd May 2013, which has addressed a number of the concerns raised during the first audit which was carried out on the 15th May 2013.

Additional information was provided by WPD on the 7th June 2013 which closed out some comments made on the drawings produced for this project and the commercial agreement development.

2 REVIEW OF DOCUMENTATION

DNV KEMA has carried out an extensive review of all of the documentation that was made available for the Low Carbon Hub project by WPD.

A good design justification report is fundamental for a project of this type. This requirement has now been fulfilled and is deemed to be of a sufficient quality.

2.1 LCH Re – Submission

DNV KEMA has no comment on the LCH resubmission (version 2), other than it is recommended that reference to the design justification, risk register and the learning outcomes schedules be referenced within the appendices (Section D).

2.2 LCH Communications Review

General comment: For the different technologies, it would have been of interest if the outage requirements were indicated within the report.

Page 22: It should have been stated if any of these options require a form of planning permission. From a meeting held with WPD on 07/05/2013 it was indicated to DNV KEMA that the requirement for antennas would not require planning permission, since these can be installed as part of a permitted development.

Page 22: It should have been stated here that a decision was made to have a mixture of microwave links and fibre optic links as stated to DNV KEMA during the meeting held on the 07/05/2013 with WPD. Normally it would be expected that all of the communication links would have been the same for each leg, but it is not unheard of that there is at times a mix of technologies.

2.3 Carbon Hub Landowner Traffic Light Plan

No comment. This has been superseded since there is no longer a requirement to construct a new 4.5km section of overhead line.

2.4 LCH Design Options

On all of the drawings, there should be a Northing included so that the reader can easily orientate the drawing. Also to make it easier for the reader, the scale and orientation should be the same for both the existing and proposed layouts. This has now been addressed with the latest revisions of the drawings.

There could be a possibility to use a combined CT/VT instead of installing separate CTs and VTs, which would provide space saving and will simplify the installation. This would require the combined CT/VT to be type tested for use on the WPD distribution network.

Below are a number of manufacturers of combined CT/VTs;

SASA Switchgear: Details provided below;

General Particulars	**33 KV**

Highest System Voltage	36 KV (r.m.s.)
Power frequency dry/ wet with-stand voltage on primary wind-ing for one minute	70 KV (r.m.s.)
Lightning Impulse withstand Voltage (1.2 x 50 ?s)	170 KV (r.m.s.)
System Particulars	
3 Phase 4 Wire with Isolated / Floating neutral as well as solid-ly earthed.	3 Nos. CTs & 1 No. 3 - Phase PT 3 Nos. CTs & 3 Nos. 1 - Phase PT
3 Phase 4 Wire with Isolated / Floating neutral as well as solid-ly earthed.	2 Nos. CTs & 1 No. 3 - Phase PT 2 Nos. CTs & 3 Nos. 1 - Phase PT
Specific Particulars	
Short Time Thermal Current (Ith)	As per customer requirement. In general CT is to be specified with STF of 100 for 1 Sec. or STC (Ith) equal to the system fault level whichever is lower. KA (r.m.s.)
Output	10 VA to 100 VA for VT 5 VA to 30 VA for CT
Accuracy Class	0.2S, 0.2, 0.5S, 0.5, 1.0 for CT. 0.2, 0.5 & 1.0 for VT
Secondary Current (CT)	1 Amp or 5 Amp
Primary Current (CT)	As per customer requirement.
Primary Voltage (VT)	11KV, 22KV, 33KV for 3-Phase VT 11/v3, 22/v3, 33/v3 for 1-Phase VT

ABB: Details provided below; Note that you can specify the primary voltage level

Type	**PVA 123**
Compliance with standards	IEC 60044-3; PN-EN 60044-3
Rated primary voltage	110: √3 kV
Highest system voltage	123 kV
Rated power – frequency withstand voltage	230 kV

Rated lightning – impulse withstand voltage 1,2/50 µs	550 kV
Minimum creepage distance	3625; 3800* mm
Rated frequency	50 Hz
Total weight	650; 580* kg
Insulating oil weight [free]	140 kg
	*with composite insulator

Current module

Rated current [A]	50 - 3000
Rated 1s thermal current [kA]	10 - 63
Rated dynamic current	25 - 157
• reconnectable 1:2 or 1:2:4	
Rated secondary current	1 A; 5 A
Rated continuous thermal current	120 %;150 %;200 %
Number of cores	1 - 6
Measuring cores parameters	
– total rated output	2,5 - 90 VA
– accuracy classes	from 0,2 S
Protection cores parameters	
– total rated output	2,5 - 90 VA
– accuracy classes	5 P; 10 P

Voltage module

Voltage factor and time		1,5/30 s; 1,9/8 h	
Number of windings:		1 - 5	
Measuring/protection windings:			
– rated secondary voltage		100: 3 V; 110: 3 V	
– total rated output	up to 75 VA	up to 150 VA	up to 400 VA
– accuracy classes	0,1; 0,1/3P	0,2; 0,2/3P	0,5; 0,5/3P
Residual winding:			
– rated secondary voltage		100:3 V; 110:3 V	
– rated output		25 VA; 50 VA	
– accuracy classes		3P; 6P	

The above combined CT/VT's could also be used for all of the sites.

Subsequent to the initial review of the documentation, WPD have looked at the possibility of using combined CT/VT's but they have been discounted due to the height requirements for the units which will complicate the busbar arrangement for Alford. This has been stated within the design justification report. Following additional information on the 7th June 2013, WPD have stated that they will consider these for future projects and will also start the process of "type testing" of the combined CT/VT units.

2.4.1 **Trusthorpe layout drawings (15th May 2013)**

From a first glance, with drawing LN52_1104 rev 1.2, it would appear that with some changes the amount of cable used could be reduced for both the transformers and for the FACTS device. This should be looked at for any further development of the layout. In the Design Justification Report, the logic was presented on why the plant was placed where it is, which appears to be reasonable.

On drawings LN52_1201 and LN52_1202 it would make it easier for the reader if the heights of the building and equipment were included.

2.4.2 **Alford layout drawings (15th May 2013)**

Drawing LN00_1001 rev 0.1 does not include the same amount of information that is shown on the existing site layout drawing and therefore provides the reader with an element of confusion. This has been remedied and all of the drawings are now to the same scale.

2.4.3 **Chapel St Leonards layout drawings (15th May 2013)**

From a first glance, with drawing LN07_1101 rev 0.1, it would appear that with some changes, the amount of cable used could be reduced by moving the RMU closer to the AIS switchgear. The design Justification Report states the logic in why the plant has been placed where it is. This logic appears to be reasonable.

2.4.4 **Ingoldmells layout drawings (15th May 2013)**

On drawing LN21_1101 rev 1.3 the proposed layout, at first glance appears to be a very complex solution to achieve the goals of what is required, as defined in the system single line diagram.

As mentioned during the meeting held with WPD on the 07/05/2013, the current design has been approved by Operations within WPD.

While the design does appear to be complex, it is however compliant with WPD's design standards and procedures and it has also been assessed for its Health and Safety by WPD's own Health and Safety team.

2.5 LCH Commercial Agreements

During DNV KEMA's meeting with WPD on the 07/05/13, it was stated that the development of the commercial agreement has been awarded to a sub-contractor. DNV KEMA recommends that the agreement which is developed is tested by legal experts before issuing it to the other stakeholders for this project. From additional information proved by WPD on the 7th June 2013, the agreement will be tested by WPD's own in house legal team.

Also during the same meeting it was raised how WPD would be able to claim back the investment made, should this project become successful, for other parts of the network where it is deemed that a FACTS, DVC and DLR are suitable.

On the 7th June 2013, DNV KEMA received the scoping document for the commercial agreement for WPD's LCH project. DNV KEMA are in agreement with the approach adopted to develop the commercial agreement, but would recommend that the agreement is tested by an external legal team since WPD's own legal advisors will be working on the agreement. To test it properly, it needs a third party review done before submitting it to Ofgem.

2.6 LCH Single Line Diagrams

There were a number of drawings which are no longer valid and hence it was confusing to follow. The drawing showing the protection zones was incorrect and needed to be revised. This has now been completed.

WPD has stated that they are currently in the process of revising the single line diagrams to show the current state of the design for the network. The revised drawings have been submitted to DNV KEMA to review on the 21st May 2013 and on the 7th June 2013. The review of the new drawings has been included later on within this report.

The production of a network tripping logic would be useful, especially for when the network is re-configured e.g. to restore supplies following a fault occurrence. This will help to ensure that the protection systems are designed to be able to protect the whole of the network no matter how the network is configured.

2.7 TNEI Reports

DNV KEMA reviewed the various reports which have been produced by TNEI. On a high level it was found that the reports are rather “woolly” and do not provide good guidance to WPD and the results are deemed to be rather confusing to the reader. Also, the network which has been modelled is incorrect to the current design for the Skegness network and some of the models will need to be re-run taking into consideration the changes to the design. With that said, in DNV KEMA’s opinion, the change in the network design will not overly affect the results currently provided by TNEI.

TNEI should also have looked at the studies with not just wind generation but also with solar, since solar provides the distribution network with additional challenges.

Following is a summary of the review carried out on the different reports.

2.7.1 Protection Review

Page 10 – Proposed Layout Option A – The network model does not match the proposed layout for the LCH.

Page 9 – Protection Options – As stated in the report, the use of unit protection will cause problems should additional generation require to be added into the network. TNEI should have provided guidance on possible solutions that could be applied to connect in new generation.

Page 11 – Conclusion – Extremely vague and does not provide sufficient guidance to WPD. TNEI should have stated what the cost impacts for the different options are in real terms rather than just stating it within the conclusion.

Note: In DNV KEMA’s opinion, a unit protection scheme is the best, if not ideal solution for the LCH. Back-up protection requirements should also have been included. During the meeting held with WPD on the 07/05/13, it was stated by WPD that the proposed method for back up protection will be distance protection. This will need to be carefully applied and the settings will be critical to help to restrict the possible issue of mal-operation in the event of a fault (e.g. the wrong section of network trips out). In DNV KEMA’s opinion a basic High Set Back-up Overcurrent and Earth Fault protection scheme should be considered as a possible alternative solution for the back-up scheme.

2.7.2 Phase 1 Network Studies

Without modelling the network, the results would appear to be a fair reflection on what would happen to the network parameters when a FACTS device is added to the network. The network diagrams within the report are very difficult to read. The rating of FACTS device stated within the report is incorrect, where the actual rating will be +/-3.75MVAr. However, in DNV KEMA's opinion, this slight increase will only have a marginal impact in the results provided.

This study should be revisited once the overall design has been finalised.

2.7.3 Phase 1 Additional Network Studies

DNV KEMA has found it hard to understand why TNEI modelled the FACTS device when the generation is at unity power factor, since WPD do not operate their network at unity. A more realistic figure should have been used.

The conclusions provided are vague and rather confusing. A more concise conclusion would have been appropriate, however the results provided would appear to be reasonable and within DNV KEMA's expectations. This study will not need to be run again in the future.

2.7.4 Transient Recovery Voltage Studies

DNV KEMA has no comment on the report, other that the conclusions provided are again vague. In addition to this, DNV KEMA has struggled to understand why such a study needed to be carried out. During the meeting held with WPD on 07/05/13, it was stated by WPD that the TRV study was performed as WPD did not know if it would be an issue or not.

This study does not need to be carried out again for this project.

2.7.5 Technical Note – Phase 3 Study Results

Page 3 – Low Carbon Hub Network – The network model does not match the proposed layout for the LCH.

Page 13 – Conclusions – It states that DLR does not make a significant difference to the amount of generation that can be connected to the network. DNV KEMA is in agreement of this assessment for the DLR.

2.7.6 Harmonic Studies

General note: This study should have included the impact of Photovoltaic generation as well as wind generation.

Page 13 – Incremental Harmonic Voltage – What are the circumstances where a 5^{th} harmonic filter is required at Skegness? The report has not stated what type or types of wind turbine were modelled. This is fundamental, since different turbines will have a different impact on harmonics in a distribution network.

2.8 Dynamic Voltage Control

Sufficient information has been provided to be able to make a high level assessment. The only part that DNV KEMA is struggling to understand is the reasoning behind the inclusion of Horn Castle into the overall Skegness scheme. This project calls for a new SuperTAPP n+ to be installed at Horncastle. WPD have provided justification on why they are installing a SuperTAPP n+ at Horncastle within their Design Justification Report in that this installation will provide WPD with additional learning on how accurate the calculated 33kV voltage level is against standard practise.

2.9 Six Monthly Reports

The monthly reports will form the backbone of the design justification report. It is important to note that the quality of the information provided within the reports has improved with time and therefore it raised additional questions and comments by DNV KEMA. This should not be deemed as a negative outcome; rather it should be a more positive outcome for WPD.

2.9.1 Project Progress Report – June 2011

Page 7 – Commercial Aspects – Will the commercial agreement be tested by legal experts before issue? This in DNV KEMA's opinion is critical to ensure that the developed agreement will be able to survive a legal challenge by the other party.

Page 16 – Risk 3 – Planning delays – From the meeting held with WPD on the 07/05/2013 it is understood that no politician other than the local council were informed about this project. In DNV KEMA's opinion, the planning permissions associated with the new overhead line, which was part of the original solution, could have been helped with by getting local politicians involved at an early stage. The main selling point would be the reduction in the amount of additional new overhead lines that would be required for future generation connections plus the other benefits. If this occurred then in DNV KEMA's opinion there would, from experience, be an improvement in a more positive outcome in respect to the planning permission.

2.9.2 Project Progress Report – December 2011

No comment

2.9.3 Project Progress Report – June 2012

Page 5 – Project Redesign – Information should have been included here on why at the end of the day this has become the preferred solution and also to provide a little more detail on why consents was not forthcoming for the new 4.5km overhead line.

Page 8 – Business case update – Are the direct benefits forecast a true reflection on the change to the network due to the required redesign of the overall solution. In DNV KEMA's opinion, the rest of the network should be included to provide an overall benefit analysis.

2.9.4 Project Progress Report – December 2012

Page 9 – Project Redesign – Issues associated with Ingoldmells substation will need to be included within the design justification report.

Page 10 – Wayleaves and legal – The issues associated with the initial need for the poles to be put closer together for the original type of overhead line conductor. A solution has been gained and agreement with land owners gained through the construction of an H pole construction. This has now been covered within the Design Justification Report.

Page 10 – Network construction – The existing assets which are being replaced at the same time as this project should all be itemised to make it clear to the reader what assets are being installed as part of the LCH project and what is being replaced as part of the normal management of the distribution system.

Page 11 – Dynamic line rating – More information needs to be provided on this as currently DNV KEMA are struggling to understand what additional benefits this will provide in addition to what the FACTS device provides. During the meeting held with WPD on the 07/05/2013, WPD stated that this is a further development of a current project which is to be trialled with this project to see if it actually does provide additional benefits to the network operator. It will also provide the DNO with additional data which they will be able to analise. This is a fair argument, but to be able to agree with this statement, further information needs to be provided to DNV KEMA.

Page 17 – Applying dynamic line rating to GE PowerOn Fusion – From DNV KEMA's experience, integrating any new technology into an existing system can cause problems. WPD should provide details on how they propose to ensure that the marriage of the two systems can be achieved, especially now that there are delays with the delivery of the GE standard module. This should and has been included within the risk assessment.

Page 18 – Substation design and construction – Maintaining safe equipment spacing between assets. It has been stated that there are issues associated with achieving this, what are WPD doing about this? What needs to be done to ensure that this can be achieved and what budget would be needed to achieve this? WPD have now addressed these points within the Design Justification Report

Page 20 – Risk 2 – Significant additional network expenditure is required due to unforeseen network scenarios. It has been stated that due to the design iterations that the majority of unforeseen network scenarios have been captured and therefore the risk has been reduced. These have now been captured within the overall project risk register and will be tracked throughout the life of the project.

3 DOCUMENTS RECEVIED IN LATE MAY

3.1 Design Justification Report

The first version of this document was received by DNV KEMA on the 21st May 2013 and it has subsequently been revised in line with initial comments made by DNV KEMA.

This document as at the point of writing this report has been found to be sufficient and captures the essence of what has happened in the project and also it has identified the way forward for the project.

The only outstanding comment is that the individual sites single line diagrams, layout drawings and main connections protection drawings should be referenced and included within an appendix.

3.2 LCH Risk Register

The risk register demonstrates that a number of the key risks associated with a project of this type have been identified and mitigation been put into place to help to reduce the risk. The next state will be for some construction, commissioning and decommissioning risks to be identified and added to the risk schedule. This schedule must remain up to date to remain beneficial to the project.

A revised risk register was issued to DNV KEMA on the 7th June 2013 and it was found that additions and changes have been made, which strengthens the position that WPD are using the register actively to help to deliver the project in a managed risk way.

3.3 LCH Benefits and Outcomes

This document does now start to capture the learning outcomes for the project which was a shortcoming of the initial documentation that DNV KEMA were requested to review. This schedule must remain updated to remain beneficial to the project.

3.4 New Issue of Drawings – 21st May 2013 and 7th June 2013

During the meeting which was held with WPD on the 23rd May 2013, it was recommended that a front sheet be produced to show the different symbols used by WPD, since not all DNO's in the UK use the same.

As mentioned during the meeting held with WPD on the 23rd May 2013, it was recommended that for the title block, the use of MCP should be ex-tended to its full name of Main Connections Protection diagram, just so that it is clear. This is to be done to the SLD drawings too. This has now been done on the revised drawings which were issued to DNV KEMA on the 7th June 2013

3.4.1 Alford Drawings

3.4.1.1 Alford Existing Layout Drawing

Why has the existing bays been shown in green, while for the other sites the bays have been shown in black. DNV KEMA suggests that this drawing be revised to show the existing bays to be in black. No other comment.

3.4.1.2 Alford Proposed Layout Drawing

No further comment. The drawing produced is clearer than the first issue and is deemed to be acceptable.

3.4.1.3 Alford Proposed SLD

No comment on the drawing.

3.4.1.4 Alford Proposed MCP

No comment on the drawing, however DNV KEMA would have preferred to have seen on the drawing the tripping logic e.g. which relay trips which circuit breaker, which would add value to this drawing, but it is not essential.

3.4.2 **Chapel St Leonards Drawings**

3.4.2.1 Chapel St Leonards Existing Layout Drawing

No comment.

3.4.2.2 Chapel St Leonards Proposed Layout Drawing

No further comment. The drawing produced is clearer than the first issue and is deemed to be acceptable.

3.4.2.3 Chapel St Leonards Proposed SLD

No comment on the drawing.

3.4.2.4 Chapel St Leonards Proposed MCP

No comment on the drawing, however DNV KEMA would have preferred to have seen on the drawing the tripping logic e.g. which relay trips which circuit breaker, which would add value to this drawing, but it is not essential.

3.4.3 **Ingoldmells Drawings**

3.4.3.1 Ingoldmells Existing Layout Drawing

No comment.

3.4.3.2 Ingoldmells Proposed Layout Drawing

No comment. The drawing produced is clearer than the first issue and is deemed to be acceptable.

As mentioned during the meeting held with WPD on the 07/05/2013, the current design has been approved by Operations within WPD. WPD have provided DNV KEMA with supporting information on how they have got to the current new arrangement, which was found to be acceptable

After some initial investigations on how to change the layout to suit a more standard arrangement, it was found that the design presented by WPD is the best solution with the minimal amount of expense to achieve the required arrangement.

3.4.3.3 Ingoldmells Proposed SLD

No comment on the drawing.

3.4.3.4 Ingoldmells Proposed MCP

No comment on the drawing, however DNV KEMA would have preferred to have seen on the drawing the tripping logic e.g. which relay trips which circuit breaker, which would add value to this drawing, but is not essential.

3.4.4 **Skegness Drawings**

3.4.4.1 Skegness Proposed SLD

No comment on the drawing.

3.4.4.2 Skegness Proposed MCP

No comment on the drawing.

3.4.5 Trusthorpe Drawings

3.4.5.1 Trusthorpe Existing Layout Drawing

Why has the existing bays been shown in green, while for the other sites the bays have been shown in black. DNV KEMA suggests that this drawing be revised to show the existing bays to be in black. No other comment.

3.4.5.2 Trusthorpe Proposed Layout Drawing

Cable routing has not been shown on this drawing between the switchgear, transformers and the FACTS device. This needs to be included.

3.4.5.3 Trusthorpe Proposed SLD

No comment on the drawing. During the meeting which was held with WPD on the 23rd May 2013, it was recommended that a front sheet be produced to show the different symbols used by WPD, since not all DNO's in the UK use the same.

3.4.5.4 Trusthorpe Proposed MCP

The protection requirements for the FACTS circuit are unclear and have not been defined. WPD need to review this and to correctly assign the protection. This should link into the S&C Electric Protection Diagram for the FACTS device. All of the other circuits are OK.

DNV KEMA would have preferred to have seen on the drawing the tripping logic e.g. which relay trips which circuit breaker, which would add value to this drawing, but is not essential.

3.4.6 Bambers Drawings

3.4.6.1 Bambers Proposed SLD

No comment on the drawing.

3.4.6.2 Bambers Proposed MCP

No comment on the drawing. Has the backup protection been agreed yet?

3.4.7 **Network Drawings**

3.4.7.1 Existing Network SLD Drawing

No comment on the drawing.

3.4.7.2 New Whole System SLD Drawing

No comment on the drawing. It has now been made clear where the changes are going to happen on the network. This is a very good piece of information.

3.4.7.3 New Whole System MCP

No comment on the drawing. Has the backup protection been agreed yet at Bambers Bridge?

3.4.7.4 Trusthorpe FACTS Protection Diagram

No comment on the drawing. While DNV KEMA know that S&C Electric are using ANSI designations for the type of protection used, it would have been better if this was included as a key within the drawing, e.g. 51N – Earth Fault Protection.

3.5 **WPD LCH Slide Presentation by TNEI**

No comment, other than WPD has confirmed that this is no longer valid.

4 EXISTING PROJECTS

Country	**Location**	**Type**	**Q [Mvar]**	**U [kV]**	**Date of commissioning**	**manufacturer**
Germany - Arcelor Mittal	Bremen	STATCOM	-32…48	30	2011	ABB
France- SNCF	Mesnay	STATCOM	-15 … 15	63	2007	ABB

The above projects are associated with supporting steeling make processes and the rail electrification systems, rather than supporting a DNO network. There are many projects like this that use either STATCOM or SVC technology which are used for industrial uses

Below has been attached a number of projects to which the FACTS STATCOM technology suitable for application on the distribution network;

3BHS393734D01_RevB_Fullabrook_web.p A02-0200 E LR.pdf A02-0204 E LR.pdf CIREDWS2012_0211_final.pdf Siemens project.docx

5 RECOMMENDATIONS

DNV KEMA have found from this audit of all of the project documentation, that there is now sufficient information that has now been captured in the form of the design justification report, risk assessment and learning points' schedule. The documentation now shows the current status of the project and should be updated if any changes are required during the life of the project.

Some very minor changes need to be made to some of the diagrams and all of the diagrams and supporting documentation should now all be referenced within the design justification report.

6 CONCLUSION

In DNV KEMA's opinion, all of the components for an innovation project of this type are now in place

DNV KEMA are of the view that the proposed DLR (Dynamic Line Rating) benefits for the Skegness network should be investigated further, but the argument that this system will provide WPD with valuable information on how the network performs is correct and would help with the further developments of the DLR system.

DNV KEMA are confident that the LCH project will provide the stated benefits to the WPD distribution network and will facilitate the connecting up of additional generation onto the distribution network with a minimal amount of reinforcement and new assets in comparison to a classical solution of connecting to the nearest network node.

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Change Request v1

4. DNO responses to WPD change request

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

DNO Responses to the Western Power Distribution Change Request

Chris Goodhand, Northern Powergrid

“Having thoroughly reviewed this we certainly have no objections.

It looks to be a pragmatic approach to tackling an emergent issue that wasn’t clear at project inception – just the sort of thing that we often have to do on this type of activity.”

Steve Cox, Electricity North West

“We would be happy to endorse this change request”

Stewart A Reid, Scottish & Southern Energy Power Distribution

"Having read your revised submission we can see that this project still has the potential to provide valuable learning, in fact Dynamic line rating is a key part of our own portfolio and as such we would anticipate a strong synergy between the learning that you are obtaining and work we are doing ourselves.

The reality is that all these solutions will need to be able to cope with real life limitations like consents and as such your project by the nature of the change is demonstrating the practicality of real life implementation.

I am happy to state that we believe this continues to be a valuable project in the UK's portfolio."

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

SP ENERGY NETWORKS

Philip Bale
Innovation and Low Carbon Networks Engineer
Western Power Distribution
Herald Way
Pegasus Business Park
Castle Donington
DE74 2TU

Our Ref: ac/WPD_LLCH/001
Your ref:
Date: 4th July 2013

Dear Philip,

Scottish Power Comments on WPD Change Request (Lincolnshire Low Carbon Hub)

Thank-you for the opportunity to comment on your proposed change request in relation to the above LCNF Tier 2 project. Generally, we are supportive of your change request. We recognise the challenges involved in any innovative trial project and recognise the need to be flexible in responding to some of the unexpected challenges that these types of projects can create. It should also be recognised that it is often the "problem areas" that have the potential to generate the most valuable learning and there is always the potential to generate unexpected additional learning points in projects of this nature, which, whilst not intentional, can still provide real value. Therefore, "problems" are not as unwelcome in a trial project as they might be in a regular project. In other words, "problem solving" is a key element in any trial project.

Our more detailed comments are outlined below, making reference to the change request document as appropriate:

i) Reinforcement "ahead of need"

The question related to re-enforcement "ahead of need" is not unique to this project. Indeed it applies to any project whose justification is required to be supported by a formal "need case". It is normal practice, particularly for new wind farm connections, to base such a need case on accepted connection offers - but this is not an essential requirement. In our view, we consider that whilst the need case for the reinforcement in this project was not based on accepted connection offers, the reinforcement was not necessarily "ahead of need". For example, there were known wind farm development opportunities within the area. If concerns about "ahead of need" reinforcement existed, we believe that they could have been allayed by making any consent for the reinforcement subject to appropriate conditions – such as connection offers being accepted within a given time frame. In any case, a DNO would not wish to construct such a reinforcement without formal agreements being in place with any new developer, so there would be no real risk of the overhead line actually being built unnecessarily.

ii) Applying Smart Grid design philosophies to avoid conventional reinforcement

Notwithstanding our previous comments, we consider that the re-design of the scheme to avoid the requirement to build an additional 33kV overhead line (or 33kV cable) actually strengthens the project.

iii) Project Review Process

The project review process applied to this project appears to have been robust, with good use of both independent external consultancies (i.e. KEMA and TNEI) and internal technical expertise. The experiences of the trial to date illustrate very well that field trials have to take place within a very complex environment, taking place alongside "normal" business activities - such as flood risk assessments, overhead line clearance assessments and on-going asset replacement and refurbishment programmes. This re-emphasises the requirement for a degree of flexibility during the project review process to accommodate the practicalities and variabilities within the real-world environment and we believe that a degree of pragmatic flexibility (i.e. retrofit vs replacement, space availability, cost vs network performance, etc.) is correctly reflected in the outcomes of the review processes that have taken place so far as part of this project.

iv) Dynamic Overhead Line Ratings

We are particularly pleased to note that WPD are making use of the considerable knowledge generated by SPEN's dynamic overhead line rating projects. Further results from our dynamic ratings project will be published shortly in the soon-to-be issued project close-down report. We also note the additional novel dynamic rating aspects that WPD are looking to introduce as part of this project (such as using the local wind farm outputs as a proxy for local wind speed) and we are certainly interested in the outcome of this particular element.

In conclusion, we consider that the proposed changes to the project scope are appropriate, given the external influences which were beyond WPD's control. Indeed, some aspects of the project have been enhanced (i.e. examining different 33kV protection strategies), whilst still retaining the original project objectives (i.e. advanced voltage control strategies, protection and control communication strategies and dynamic system control and operation using POWERON).

We look forward to the dissemination of the results from this project.

Yours sincerely,

Dr Alan Collinson
Technical Specialist
SP Energy Networks

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Change Request v1

5. Tracked changes project pro-forma

Project Summary

Box 1: Please provide details of the Project, the Method and Solution

~~Central Networks~~Western Power Distribution Low Carbon Hub - Optimising renewable energy resources in Lincolnshire

THE PROBLEM
Traditionally the distribution networks have been designed to operate passively. This means that the network is designed with a tapering capacity on the assumption that electricity generation is large scale and centralised, and power flow will be unidirectional from the higher voltage transmission system to the lower voltages of the distribution network. The capacity of network circuits and components is dictated by the maximum demand, the fault level rating and the need to maintain voltages within defined ranges. When a generator is connected to the distribution network power flow often becomes bidirectional, fault level is increased and voltage control becomes more complex. Conventional design solutions to the resulting changes in fault level, voltage control and capacity are often substantial cost. This can mean that in areas which have abundant renewable energy resources the connection of distributed generation is uneconomical. Lincolnshire is one such area. It has a rich wind resource which may be underutilised for distributed generation due in part to electricity distribution network connection costs.

THE SOLUTION
Creating an active smarter design and operation of the network will allow generation to be connected to the distribution network more economically. This will allow the most suitable generation sites to connect to the network.
The Low Carbon Hub solution will develop a distribution network optimised for demand and generation whilst demonstrating solutions to some of the network limitations.

THE METHODS
The Low Carbon Hub has six project components and these will be trialled together as outlined below:
1. Network enhancements – Sections of existing overhead lines will be upgraded within the demonstration area with higher rated conductors to increase the network's capacity to connect DG. This work is in addition to investment already funded through the DPCR5 settlement.
2. New commercial agreements – Innovative agreements will be negotiated with DG customers to optimise their output and mitigate network issues (e.g. To deliver reactive power service) using real time network measurements. Potential limitations of the current regulatory framework will be identified.
3. Dynamic voltage control – Building on the principles of an existing Innovation Funding Incentive (IFI) project, the 33kV target voltage will be actively varied. This will be done dynamically based on real time measurements of demand and generation. Dynamic voltage control should increase network utilisation whilst maintaining the system voltage within the statutory limits.
4. 33kV active network ring – The active ring allows increased control of the 33kV system and network reconfiguration based on real time power flows. Construction of the ring will involve the installation of an additional circuit breakers, disconnectors ~~a new interconnector~~ and smart grid protection and control.
5. Flexible AC Transmission System (FACT) Device –A Flexible AC Transmission system device will enable us to control both network voltage and system harmonics of the active ring. This equipment is not normally deployed on Distribution networks for this purpose. Shunt compensation will be used to generate or absorb reactive power. These highly technical solutions will be designed to increase the amount of distributed generation that can be connected.

6. Dynamic system ratings – The Skegness Registered Power Zone delivered innovative connections to offshore wind farms based on dynamic rating of overhead lines. This component will further develop the solution and test new techniques to calculate the network capacity and operating limits based on real time asset data.

THE PROJECT

The demonstration project will be undertaken on an area of primary network where there has been a history of connection enquiries that our customers tell us haven't proceeded due to high network reinforcement costs. East Lincolnshire has attracted a large number of connection requests but due to a relatively weak network there have only been two connections.
The innovative techniques detailed above will be used together to demonstrate how the network can connect significantly more generation with greatly reduced network reinforcement costs.

Box 2: Please provide a description of the Project

Low Carbon Hub description

The Low Carbon Hub is based around the existing 33kV wood pole overhead lines in East Lincolnshire. This network supplies electricity to homes and business in the areas surrounding Skegness, Alford, Mablethorpe, Ingoldmells and Chapel St Leonards. Appendix B shows that the grid substation at Skegness supplies nine different primary substations through seven circuits. The Low Carbon Hub will involve five~~our~~ of the primary substations and alter the design or operation of five circuits. The alterations can be viewed through the direct comparison between the Single Line Diagram before and after the network changes. These network alterations along with the operational and commercial aspects of the project will create the opportunity for distributed generators connecting to the network.
The project will directly engage with a number of distributed generators. Project partners will come forward following a workshop explaining the Low Carbon Hub to be hosted by Western Power Distribution. The workshop will invite all distributed generator developers to participate in the Low Carbon Hub with developments of between 3 MW and 30 MW. Nine of the existing distributed generators who have already applied for network connections have been contacted as part of the project development. All nine are interested in attending the workshop to learn about the opportunities created by the Low Carbon Hub. The Low Carbon Hub could connect up to ~~110~~42 MW of additional distributed generation.
To ensure the process is fair we will not form any contractual relationships with customers until after the generator workshop. One of the main project aspects is to create a new set of commercial agreements that will provide benefits to generators and network operators. The commercial arrangements will be created in conjunction with all interested customers.

What we have already done... (Planning, design and studies)

Western Power Distribution has recognised that some areas of our network receive more connection enquiries for distributed generation than others, based on the availability of natural resources. The East Lincolnshire region of our distribution network has received a high number of enquiries, mainly from onshore wind developers due to the high average wind speed. Many of the connections create network issues, as the infrastructure was designed for passive electricity flows. Using conventional network reinforcement techniques to reduce the generator effects is inherently costly and our customers inform us this is a factor for not connecting a generator.
Western Power Distribution believes that connecting distributed generation will play a key part in the UK reaching its 2020 targets for generating electricity from renewable sources, and started to look for a new method to connect generation to the network that is more economical by departing from conventional design. The design is a combination of new technologies, new operating procedures and commercial contracts.

The network studies have showed that the amount of generation that can connect to a network is increased if a systematic plan was formed taking into account all the activities in the area.

Box 3: Please outline the changes which you have made to the Project since the Initial Screening Process

The fundamental aspects of the Low Carbon Hub are the same as detailed in the screening submission. However there have been a number of changes since the Initial Screening Process:
1. Following a more detailed planning exercise, the total project costs have increased from £3m to £3.5m.
2. In the main, the increased project costs are due to greater knowledge management and dissemination aspects within the project.
3. Consequently the LCNF funding request has also increased slightly from £2.7m to £2.8m, the level of cost increases have been offset by the increasing benefits.
4. An external collaborator will be selected for the FACTs device. The collaborator will be determined after a European procurement process.

Project Costs

These should be the same amounts as detailed in the Full Submission Spread sheet tab entitled 'Second Tier Funding Request' included as Appendix A

Total Project Cost	~~£ 3,527,503~~ £ 3,416,983
External Funding	~~£30,000 from external an external collaborator~~
DNO Extra Contribution	~~£0~~ £30,000
DNO Compulsory Contribution	£349,829
Second Tier Funding Request	~~£2,837,629~~ £2,767,140
Project Completion date	02/2015

Derogations or exemptions

If awarded funding, will you require a derogation, licence consent or exemption, or any change to the regulatory arrangements in order to undertake the Project or cater for contingencies? No

Box 4: If Yes, DNOs must provide a summary of the details of the derogation, licence consent or exemption, or change to the regulatory arrangements required

Western Power Distribution will not seek any derogations or exceptions for the Low Carbon Hub as we are able to carry out all activities within the existing frameworks.

Section B: Project Management

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Box 5: Please provide details of your Project plan
DNOs should outline up to ten key milestones associated with their Project.

Date	Milestone
02/2011	Host a workshop with distributed generators interested in connecting to the Low Carbon Hub
06/2011	Dissemination to other GB DNOs and IDNOs of design recommendations for connecting optical fibres and wireless links to new and existing wood pole overhead power lines
07/2013	Dissemination of a new set of commercial arrangements jointly created between generators and the DNO.
08/2013	Completion and demonstration of the dynamic voltage control capability implemented within GE POWERON ~~PowerOn~~ ~~Fusion~~ (Network control system widely used by UK DNOs)
06/2013	Completion and demonstration of the dynamic system ratings capability implemented within GE POWERON (Network control system widely used by UK DNOs)
04/2014	Completion of the nominated 10~~20~~.5~~1~~km of Overhead Lines that have already been included in the DPCR5 submission to the new Low Carbon Hub standard. (See diagram in Appendix B)
01/2014	Installation and commissioning of the Flexible Alternating Current Transmission system (FACTs) device.
08/2014	Operation of the 33kV active network ring connecting Alford, Trusthorpe, Chapel St Leonards and Skegness. Creating a network suitable for demonstrating the high penetration of DG.
12/2014	Completion of the Low Carbon Hub, demonstrating the knowledge from the six project areas
02/2015	Dissemination of knowledge to other DNOs, IDNOs and distributed generators.

Project Budget

DNOs must complete the Full Submission Spreadsheet tab entitled 'Second Tier Funding Request' and include it within Appendix A

Box 6: Please provide a breakdown of your total employment costs for the total Project which you are project managing and highlight where these are funded by, or provided by others

Total employment costs should include all the costs used for labour, including pensions but excluding Contractors (whose costs are detailed separately). Personnel with the same role can be grouped together

Staff type	Total Costs	Person days	Funding
~~Dedicated Project Manager for the Low Carbon Hub activities~~	~~£240,640~~	~~1080~~	~~Funded as part of the DNO Compulsory contribution~~
~~Trade Staff including Linesperson, Fitters, Jointers~~	~~£79,545~~	~~357~~	~~LCNF~~
~~Construction Project Management~~	~~£65,730~~	~~295~~	~~LCNF~~
~~Protection and Commissioning~~	~~£30,080~~	~~135~~	~~LCNF~~
~~System Design & Commercials~~	~~£27,406~~	~~123~~	~~LCNF~~
~~Communications Engineers~~	~~£2,897~~	~~13~~	~~LCNF~~
WPD Project Management	£234,954	979	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Skegness	£16,792	81	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Alford	£35,930	173	Funded through LCNF and DNO compulsory contribution

Create a 33Kv active network ring – Ingoldmells	£82,878	398	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Chapel St Leonards	£91,215	439	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Trusthorpe	£81,753	393	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Bambers	£5,070	24	Funded through LCNF and DNO compulsory contribution

Box 7: Please outline the main Equipment costs required for the total Project which you are project managing

Item description & No. of units	Function in Project	Cost per unit	Total Cost	Funding	Direct Benefit
~~FACTS Units~~	~~The FACTs device will control voltage variations caused by intermittent generation and varying demand. The reactive power generation will aid the reduction in losses~~	~~£500,000~~	~~£500,000~~	~~LCNF~~	~~By demonstrating enhanced voltage control, significantly more distributed generation can be connected to the distribution network.~~
~~2x 33kv Ring Main Unit~~	~~The plant is required to allow increased control of the network during fault conditions.~~	~~£140,000~~	~~£280,000~~	~~LCNF~~	~~Installation to facilitate the FACTs device and the new interconnecter. Both reduce losses and increases connection of generation~~
~~4.5 km circuit Overhead line & 0.5 km Underground cable~~	~~The network interconnector is required to split the Skegness Alford Chapel St Leonards teed circuit.~~	~~£164,425~~	~~£164,425~~	~~LCNF~~	~~Creates greater thermal capacity allowing greater generation connection, improved network availability for generators.~~
~~75 x Unit protection schemes~~	~~The network will have five current differential protected zones. Operating the network as a ring will require the protection to have an increased level of~~	~~£30,000~~	~~£21150,000~~	~~LCNF~~	~~Ability to operate the network as a ring, more connected DG with increased network availability, whilst maintaining safe network operations.~~

	~~discrimination to ensure a high level of network reliability and safe operation.~~				
Dynamic Voltage Control - Development + Maintain of ENMAC and SCADA systems, Voltage control algorithm including Training and site AVC modifications		£42,000	£42,000	Funded through LCNF and DNO compulsory contribution	
Flexible Alternating Current Transmission system (FACTs) - procurement of Devices		£575,000	£575,000	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Skegness includes: new CT's, Protection, 33kV cable and small wiring		N/A	£47,792	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Alford includes: new CT's, protection, 1250A busbar, voltage transformer, 36kV Breaker, 33kV cable & small wiring		N/A	£102,262	Funded through LCNF and DNO compulsory contribution	

Create a 33kV active network ring - Ingoldmells includes: new CT's, protection, Voltage Transformer, earth electrode, 36kV Breaker, 1250a busbar, 3ph insulators, 33kV cable & small wiring		N/A	£235,885	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Chapel St Leonards includes: new CT's, protection, Voltage Transformer, RMU, 1250a busbar, 33kV cable & small wiring		N/A	£259,611	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Trusthorpe includes: new CT's, protection, Incoming Transformer, 3/7 new switchboard, earth electrode, 33kV cable & small wiring		N/A	£232,682	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Bambers includes: new CT's, protection & small wiring		N/A	£14,430	Funded through LCNF and DNO compulsory contribution	

Box 8: Please outline the Contractor costs required for the total Project which you are project managing

Contractor	Role in Project	Funding	Expected length of contract	Total Cost
~~FACTs provider~~	~~Combine the FACTs device with the On Load Tap Changer to deliver the best voltage control for the Low Carbon Hub.~~	~~Provided by FACTs provider~~	~~2 Months~~	~~£30,000~~
~~Communications network (Fibre and Microwave)~~	~~Create a communications network design to allow protection and SCADA data.~~	~~LCNF~~	~~3 Months~~	~~£60,000~~
~~Communications network (Fibre and Microwave)~~	~~Install the necessary fibre and microwave networks.~~	~~LCNF~~	~~8 Months~~	~~£150,000~~
~~Legal~~	~~Assist in creating a new commercial contract between generators and land owners for communication permissions.~~	~~LCNF~~	~~3 Months~~	~~£80,000~~

Engineering Design & Surveys		Funded through LCNF and DNO compulsory contribution	24 months	£106,254
Enhancing planned network alterations - 33kV OHL asset rebuilds as 300HDA instead of 150 ASCR		Funded through LCNF and DNO compulsory contribution	10 months	£79,725
Innovative Commercial Arrangements - Workshop, Lawyers, data flows, network		Funded through LCNF and DNO compulsory	36 months	£70,000

configuring with generators		contribution		
Development + Maintain of ENMAC and SCADA systems, Voltage control algorithm including Training and site AVC modifications		Funded through LCNF and DNO compulsory contribution	5 months	£21,000
Dynamic Systems Ratings - Future Design standard 1) fibre over exisiting lines		Funded through LCNF and DNO compulsory contribution	2 months	£10,000
Dynamic Systems Ratings - Future Design standard 2) fibre over new lines		Funded through LCNF and DNO compulsory contribution	2 months	£10,000
Dynamic Ststems Ratings - Future Design standard 3) Radio or Microwave links		Funded through LCNF and DNO compulsory contribution	2 months	£10,000
Flexible Alternating Current Transmission system (FACTs) - Provision of Foundations		Funded through LCNF and DNO compulsory contribution	3 months	£50,000

Box 9: Payments to users or Customers
Please outline the details of any payments you wish to make to users or Customers as part of the Project.

Type of user or Customer	Payment per User	Total Payment	Funding
Customer payments are not a feature of the Low Carbon Hub.			

Box 10: Other costs for the total Project which you are project managing. This should be categorised into the following categories: IT costs, Contingency costs, IPR costs, decommissioning costs, abnormal travel costs and costs associated with public engagement and dissemination of learning

Cost Category	Cost Item	Cost
~~IT Costs~~	~~Software Development~~	~~£238,000~~
~~Contingency~~	~~Contingency across the project~~	~~£209,062~~
~~Decommissioning~~	~~Removal of network structures~~	~~£28,992~~
~~Abnormal travel costs~~	~~Site accommodation / office~~	~~£36,000~~
~~Professional Services~~	~~Professional Services~~	~~£103,416~~
IT Costs	Telecommunications	£872,270
Contingency	Contingency across the project	£129,478

Cost over-runs & Unrealised benefit

Box 11: Please detail any cost over-run you anticipate requiring for the Project and express this as a percentage of the funding you are requesting

The Low Carbon Hub includes significant network alterations, the majority of these are to the primary network. The Low Carbon Hub detailed budget includes contingency averaging 6.3% across the project aspects; this is to allow for sensible cost variations from the initial desktop design to full project implementation. Western Power Distribution are therefore comfortable with the default level of cost over run protection. 5%

Box 12: Please detail the level of protection required against Direct Benefits in excess of the DNO Compulsory Contribution

Western Power Distribution seeks the default level of protection against direct benefits. 50%

Successful Delivery Reward Criteria

Box 13: Please set out your proposed Successful Delivery Reward Criteria

Table 3. Successful Delivery Reward Criteria Successful Delivery Reward criterion	Evidence
Host a successful workshop with Distributed Generation developers and feed learnings into the project plan.	Holding an interactive workshop by the end of 02/2011, collating feedback from attendees during the workshop sessions. A satisfaction survey will be carried out within 30 days of the event to gauge the value of the workshop to participants and identify any further follow up actions.
Development of a UK technical recommendations for: 1. Installing optical fibre on existing wood pole overhead lines; 2. Installing optical fibre on new wood pole overhead lines 3. Installing microwave or radio antennas and associated equipment within the proximity of distribution assets including the configuration of equipment for effective system protection.	A set of three comprehensive documents sent to all UK DNOs and IDNOs before 31/05/2011. These documents could form the basis of future ENA Engineering Recommendations. The technical recommendations will provide costs and designs for generic overhead line construction. ~~Central Networks~~Western Power Distribution will also present lessons learnt from project management and engineering experiences associated with delivery of the three aspects. This will be carried out on a minimum of an annual basis. A final report will be included in the project closure documentation in 02/2015.
Completion of the first application of dynamic system control and operation using GE POWERON	Evidenced through the handover of the capability to the Network Control centre. In accordance with our normal IT business processes the handover will have a documented Operational Acceptance certificate approved by the project board during the 08/2012 meeting.
Determining the degree to which voltage can be controlled by installing and operating a FACTs device. In particular, ascertain whether the device improves quality of supply to demand customers and/or improves generator network availability.	Install a FACTs device, and connect to our network by 01/2014. We will operate the FACTs device under a variety of network conditions and demonstrate how generation could be used to support the system under abnormal operating conditions. The knowledge learnt from this element of the project will be disseminated through a technical paper. The dissemination will be supported by a site visit for interested parties to the FACTs device location. The paper and the visit will be completed by 07/2014. A final report will be included in the project closure documentation in 02/2015.

Development of a stronger relationship with distributed generation developers directly impacted by the Low Carbon Hub.	A telephone survey will be conducted by an external agency before and after the project (12/2010 and 02/2015 respectively). During the project we will continuously collect and review feedback, which will be formally reviewed at the four lessons learned sessions detailed in the project plan.
The capture of sufficient information to determine the business case for operating active 33kV ring networks using innovative solutions.	Project closure documentation (02/2015) will include a cost benefit analysis for each of the techniques deployed and the combination of all aspects.
Disseminate knowledge and evaluate the potential for similar projects throughout the UK.	The project closure documentation will detail the knowledge generated from the design, construction operation and commercial aspects from the Low Carbon Hub before 02/02/2015. The final project report will be shared with DNOs and IDNOs and interested parties along with: An internet presence ENA workshops Publications Appropriate industry conferences Etc.

Section C – Evaluation Criteria
Accelerates the development of a low carbon energy sector
Box 14: Outline how the Solution accelerates the development of a low carbon energy sector

The Low Carbon Hub will demonstrate how substantial levels of renewable generation can be connected to a primary distribution network. This contributes to the UK Low Carbon Transition Plan target of 30% of electricity being generated from renewable sources by 2020. The Lincolnshire area is rich in renewable resources and has had a high volume of connection enquiries with limited network infrastructure. This makes it an ideal location for an LCNF demonstration, as we understand from customers that network connection is sometimes a preventative factor to distributed generation being installed. As the UK approaches 2020 and other distributed generation technology matures, conventional electricity networks will increasingly prevent suitable sites being developed.
The solution we are trialling delivers the following carbon benefits:

Accelerates the connection of renewable DG – Novel approaches will enable renewable DG to connect more quickly and at a lower cost than with conventional solutions. This zero carbon generation will reduce the carbon content of the local grid. Generation and demand will be balanced at a local level in real time, minimising the need for imports from the national grid, and occasionally allowing low carbon exports.

Reduces emitted carbon from technical network losses - By installing the smart grid components visibility of the network will be greatly improved, leading to an increased capability to manage voltage and power factor to reduce losses.

Reduces the carbon footprint associated with construction activities – A single strategic investment as proposed will eliminate the need for multiple infrastructure projects.

Our prediction for the NPV of deploying the Low Carbon Hub solution across the UK is £2.2bn. This is based on two sites being developed within each distribution licence area; it will be possible to connect up to 1,400 MW of installed distributed generation before 2020 using techniques demonstrated by the Low Carbon Hub. These sites, like the East Lincolnshire area, are otherwise unlikely to be developed due to the cost of conventional network reinforcement.

Has the potential to deliver net benefits to existing and/or future customers

DNOs must complete the spreadsheet tab 'Net benefits' within the Full Submission spreadsheet and include as Appendix A.

Box 15: Please provide a qualitative account of the net benefits which the Solution has the potential to deliver if rolled out across GB.

The Low Carbon Hub could be repeated regardless of geographic locations, voltage levels or project scale. This will allow DG customers to cost effectively connect to distribution networks in any part of the UK that would have otherwise required extensive conventional network reinforcement.

Cost

It has been assumed the future nationwide solution could be delivered for an average cost of £2.4 million per project and that two future projects would be installed per licence area, each connecting an additional 50 MW of generation that couldn't have been previously connected before 2020. The duration and proportionate cost profile applied for each replica is the same as for the trial. The East Lincolnshire Low Carbon Hub will develop the key principles, and include one off expenses not needed to be replicated for future projects.

Carbon Benefits

The principal carbon benefit is the displacement of centralised fossil fuelled generation by local renewable DG. The carbon benefit calculation assumes a 33% load factor and a lifetime of 25 years for onshore wind generators. Each hub is assumed to have 50MW generation capacity and an output of 147587 MWh. The carbon saved takes the Defra conversion factor for rolling average grid electricity in 2008, converted to currency by the DECC non traded carbon price.

Other Benefits

~~The other benefits section assumes that each low carbon hub reduces losses (as described in the 'Direct Benefits' tab) and receives the DPCR5 losses mechanism treatment (£60/MWh).~~ The DPCR5 DG incentive is assumed to continue at the assumed 50MW of generation per hub. Further it is assumed that the generators and FACTS device have a life of 25 years.

The scale of the first low carbon hub is defined by the existing network in the East Lincolnshire area, the level of generation that has requested connection and the network constraints. Creating a network ring at 33kV will combine two existing network circuits. The knowledge generated from the low carbon hub will help to determine the scale of future projects. Connecting a large amount of generation onto the low carbon hub will fully test the principles the low carbon hub.

There are financial benefits that will accrue to Distributed Generators but have not been included in Appendix A, for example the reduced sole use connection costs.

Direct Impact on the operation of the Distribution System

Box 16: Explain the way in which the Project/Solution has a Direct Impact on the Distribution System

This project is focused exclusively around the operation of the distribution network. New operating procedures will be developed and refined. The network will dynamically distribute locally generated power providing key learning on how to operate smart grids with high DG penetrations in real time.
The solutions we are trialling will directly impact the operation of the network through a range of technical, commercial and operational approaches including:

Increased visibility and control of the 33kV system (e.g. power factor, voltage management and power flows)

Demonstration of previously unproven high voltage network assets

Real time management of connected DG and relationship with DG customers

Operational interface with GBSO

Generates new knowledge that can be shared amongst all DNOs

Answers to this section should be detailed in boxes 17 to 19

Box 17: Explain the new learning which will result from a successful Project

The Low Carbon Hub will be constructed within a typical rural distribution network. Consequently the hub could be replicated at a large number of locations across the UK. In addition some aspects of the hub, such as the technical standard for installation of communication links on wood pole overhead lines, could be widely used as standalone applications. The project will bring incremental learning in four key areas.
The hub network design is intended to offer more flexible operation that will allow more generator capacity to connect to a section of network at a lower cost of reinforcement. The project will test the network design in terms of dynamic voltage control, network availability and level of losses. The results will influence network design into the future.
The use of a FACTS device in a distribution network will provide important learning in terms of both operational procedures and effectiveness. Network monitoring will demonstrate the extent to which a FACTS device can moderate the step changes in voltage associated with intermittent generation, improve voltage regulation in coordination with on line tap changers and influence network losses.
Western Power Distribution in conjunction with the generators that connect to the hub will develop commercial agreements that will be different to those traditionally held between DNOs and generators. The agreements will seek to optimise generator export in a way that will minimise network issues, for example by delivering reactive power services. The resultant forms of agreement will provide useful templates for generator connections UK wide.
The project will deploy dynamic voltage control schemes and communications links to support network control and protection. The design of the voltage control schemes and the deployment of optic fibre and wireless communication links on wood pole overhead power lines will both require the development of technical specifications. It is likely that these specifications will form the basis of technical standards which can be adopted across the industry.
The project will incorporate several methods of learning capture. The overall performance of the hub will be assessed by analysis of network data gathered by network transducers. An enhanced level of transducer coverage will give greater visibility of network performance, allowing comparison with modelled forecasts of network behaviour. This will allow robust conclusions on the effectiveness of control schemes and network devices. Learning about the installation of equipment will be captured in method statements, specifications and technical standards. Commercial arrangements will be trialled and best practice will be proposed in agreement templates.

Box 18: Outline the arrangements for disseminating learning from the Project

The learning from this project will be disseminated through a combination of transparency during implementation and formal records such as papers and technical standards.
The project's progress will be captured and displayed on our external web site both through a project gantt chart and photographs displaying physical progress. At regular intervals invitations will be extended to DG customers, Ofgem, other DNOs and other relevant stakeholders to visit and observe the project. It is widely recognised that first hand experience often provides the most powerful learning, and this high level of transparency offers the opportunity to an industry audience to follow the project closely.
Learning from all aspects of the project will be captured systematically. This will include the design, installation and operational stages of the project. This learning will be shared with DNOs and IDNOs through papers, workshops and conference presentations.
A number of technical specifications will be developed to implement the project, in particular relating to the installation of optic fibre and wireless communication links on wood pole overhead power lines and the design of voltage control systems. These specifications will be shared, and are likely to form the basis of technical standards.
The data from enhanced network monitoring will populate a data base with wind speed, generator output and corresponding network conditions. The new software tool will use this data to evaluate network performance against original planning standards. The results of the analysis will be shared with all DNOs, and the software tool will be made available to DNOs to enable them to repeat the analysis for their own networks.
The new features of the contracts with generators taking part in the trial, and their performance in practice, will be shared with other generators, subject to commercial confidentiality.
An assessment will be made of how the hub principle could be implemented without support from the Low Carbon Network Fund. This will be shared with all DNOs. Western Power Distribution expect the results of this assessment to influence our ED1~~DPCR6~~ business plan.

Box 19: Outline the arrangements for Intellectual Property Rights (IPR)

Does the Project conform to the default arrangements for IPR? Yes
No agreements on IPR have been signed at this stage of the project development. Western Power Distribution will seek to enter into agreements which are in keeping with the IP principles set out by Ofgem on 15 April 2010. Early discussions with our bid partners have highlighted some areas which they would wish to discuss in more detail including the definitions of foreground and background IPR, the scope of license grants and warranties.

Involvement of External Collaborators and external funding

Does the Project involve External Collaborators and/or external funding?

Yes

Box 20: If you have been unsuccessful in attracting External Collaborators and/or external funding to the Project, please detail your endeavours to do so

Western Power Distribution has approached two market leaders with the capability of providing a FACTs solution. Significant interest has been shown as they also believe the principles being demonstrated could help stimulate market opportunities. An open market tender is required for the FACTs device procurement to comply with European procurement laws. The connection of generation to the Low Carbon Hub must be a fair process between new and existing market players. We will hold the generation workshop within 60 days of winning the LCNF funding; this will ensure we capture all interested participants as well as the nine existing market players that have already shown an interest. Holding the generator workshop within the first ten weeks of winning the LCNF funding will ensure generation can be involved in the project at the earliest opportunity.

Box 21: Where funding is provided by a third party that is not an External Collaborator, DNOs should provide details of the funder. If there is more than one External Funder, details of others can be included as an appendix:

Organisation name	No funding is being provided by a third party
Type of organisation	
Amount of funding	
Funding arrangements	
When funds will be provided	
Conditions of funding	
Risks/uncertainties	
Details of contract or agreement	

Box 22: Details of External Collaborators

DNOs should provide details of the 6 main parties who are collaborating with them on a Project. Details of any further External Collaborators should be included as an appendix.

Organisation name	**S&C~~FACTs Provider~~**
Relationship to DNO (if any)	There is no relationship between the external collaborator and Western Power Distribution
Type of Organisation	~~The external collaborator~~S&C is an experienced FACTs provider already supplying solutions on UK distribution or transmission networks to allow asynchronous generators to comply with the grid code.
Role in Project	The company will: 1. Supply the FACTs device and network filters 2. Implement the device into the distribution network as part of the dynamic voltage control, allowing the FACTs target voltage to be varied dependent on the network conditions. 3. Provide commissioning, operation and maintenance guidance of the device.
Prior experience brought to Project	Facts devices are unusual for the distribution network and still at the trialling stage. The supplier will have operated in the UK market to allow asynchronous generators to comply with the grid code. This will allow them to adapt the device to control the network voltage to allow an increased level of generation connected to the network and increase the strength of the distribution network.
Funding	The Facts provider will develop the operational capabilities for the FACTs dynamic voltage control and then implement into the GE POWERON network control software.~~, calculated at £30,000.~~
Contractual relationship	Due to European procurement laws, we will conduct a full market evaluation post award.
External Collaborator benefits from the Project	The FACTs provider will develop the capability to strengthen the distribution network to facilitate distributed generation. The FACTs provider can develop and demonstrate their control capabilities to be suitable for distribution network control. Facts providers feel this will help stimulate a new market for them, demonstrating this capability of combining a FACTs unit and the existing

	OLTC through the LCNF.

Box 23: Other partners

Distributed Generators Nine renewable energy developers who have already applied for generation points of connection in the Lincolnshire area have been approached to determine the extent of their interest in the principles being demonstrated by the Low Carbon Hub and they are all interested in knowing more. These generators will be invited to the generator workshop along with all other interested parties. **Local Authority** Western Power Distribution has worked with East Lindsey District Council to ensure the project helps facilitate the delivery of their renewable generation targets. Western Power Distribution has also worked with East Midlands Development Agency (EMDA) to coordinate their regional targets for generating more energy from renewable sources with the Low Carbon Hub. We will continue to work with EMDA and its successor organisation during the delivery phase. **Technical Partners** We have worked with Fundamentals Ltd to develop the Automatic Voltage Control at Skegness under an OFGEM Innovative Funding Incentive project. Fundamentals share our view that an ability to vary the network voltage based on real network conditions is the next transition for smarter networks with increased levels of distributed generation. Please see appendix 2 for a letter of support from Fundamentals Ltd

Relevance & Timing of Project

Box 24: Please outline why the learning from the Project is relevant to Network Operators

2020 targets for renewable energy imply that the level of generation connected to networks before the end of ED1 will have to increase significantly. Any constraints on distribution networks which might restrict generator connections could prevent the UK from reaching its targets. The cost of generator connections is based on the point of connection and the amount of upstream reinforcement required. If successful, the techniques used in the demonstration project could be applied to any DNO's network. They will be used to provide a point of connection closer to the generator and require less upstream reinforcement. Reducing the cost of generator connections will reduce barriers to achieving renewable energy targets and aid the move to a low carbon economy. If the methods used in the trial are successful then, in general terms, a higher level of generation will be able to connect to a given piece of network at lower cost than if conventional network designs were used. The knowledge gained by operating the network will include better understanding of generator availability and load factor. This knowledge can be used to review security of supply standards and in particular the contribution that can be made by intermittent generation, in terms of voltage control and load growth. The successful trial would open the possibility to future collaboration between generators and network operators, helping to develop suitable network locations to provide value for money and facilitate more generation connections, of mutual benefit. Both of these factors would be reflected in business plans for future price controls. Plans for network reinforcement are in part driven by the security of supply standard, and recognition of an increased contribution by generation may reduce the need for network reinforcement. Collaboration with generators to develop suitable locations may give rise to some investment ahead of need, or at any rate projects with a different business case to those put forward in DPCR5, and these would be reflected in ED1 business plans.

Demonstration of a robust methodology and that the Project is ready to implement (answers should be detailed in boxes 25 to 27)

Box 25: Please demonstrate that the Project has a robust methodology and can start in a timely manner

Western Power Distribution has received a number of enquiries from generator developers for connections in the East Lincolnshire area in recent years. The Low Carbon Hub concept has been developed over a similar timespan. The project was first scoped in 2009 and has evolved further over the last twelve months. A significant amount of design work has been carried out based on generator locations as per the previous enquiries. Consequently the network design and protection requirements are well developed and ready for the trial.
Rebuilding the ~~20.1~~10.5km of overhead lines to a conventional design is already included in the Western Power Distribution DPCR5 business plan and work programme. The implementation of the modified overhead line design for the trial can be readily accommodated without disrupting the work programme.
The project plan takes into account the aspects of the trial with long lead times to which we cannot formally commit until the project has been awarded. We are ready to commence immediately other aspects with shorter lead times.
Stakeholders including generator developers and the local authority have been consulted and are aware of the scope of the trial. They are ready for further engagement as the trial progresses to implementation.
The costs for the trial have been estimated using two approaches. For those elements of the project that relate to conventional network activities the same unit costs have been used as those allowed by Ofgem in DPCR5 Final Proposals. For products and services that are not standard to Western Power Distribution' normal operations budget quotes have been obtained from contractors and suppliers. In combination the two approaches represent a robust cost estimate. The submitted costs cover the network alterations shown on the single line diagram and protection document. Post award, the network alterations will be reviewed to identify any further efficiencies.
The benefits that Western Power Distribution derives from the project are in the form of reduced losses and revenue from the DG Incentive.
The reduction in losses has been calculated by modelling actual hourly load data from May 2009 to May 2010 against the existing network and proposed network and taking the difference between the two. The losses reduction from the installation of a ~~20.1~~10.5km of lower impedance conductor ~~and a new 5.1km interconnector~~ can be modelled with a high level of confidence. The losses reduction as a result of using the FACTS device and the generator output can be modelled with a lower degree of confidence as a number of assumptions are required. The FACTS device will reduce losses by exporting the reactive power requirements of the hub; it has been assumed the device will operate on average exporting 1MVAr over the lifetime of the unit, but will vary between ±4MVAr. The generator load factor is based on experience of offshore wind generators but applies a 3% reduction to reflect onshore performance.

Box 26: Please provide details of the risks associated with the Project
Western Power Distribution has identified a several risks during the project development stage. Consideration has been given to how these risks could be reduced or mitigated. The project costs have contingency applied averaging 6.3% across all activities to take into account these project risks. The key risks identified are listed below, along with the steps proposed to manage them.
1) The project cannot be delivered for the amount of funding requested
The design of the project has been sufficiently detailed to ensure that the amount requested is sufficient to deliver the Low Carbon Hub; contingency built in where appropriate has created the confidence to request the default arrangements for cost overrun protection.
2) Significant additional network expenditure is required due to unforeseen network scenarios
The processes for obtaining wayleaves and gaining planning consent are naturally uncertain in terms of duration and outcome. Both could result in increased expenditure if the proposed design, routes or locations are not permitted. The overall project design of the Low Carbon Hub is such that it could still demonstrate the majority of the project aims if the required planning consents or wayleaves were not granted in the way anticipated. This would however change the scale of the project; we are working closely with ELDC to mitigate this risk.
3) There are extensive planning delays involved for either Low Carbon Hub activities or Generators construction
We are working with DG customers and ELDC to coordinate planning requests.
4) Experimental aspects of the trial do not fully realise the planned benefits
The experimental sections of the Low Carbon Hub have been demonstrated at a lower Technology Readiness Level (TRL) and through the IFI mechanism. This has given Western Power Distribution the confidence to develop the functions implementing them together in the Low Carbon Hub. Western Power Distribution will be partnering with experts in these sections to reduce the risk. The safe operation of the distribution network will not depend on any of the experimental features.
5) Generators choose not to connect to the network as they are targeting other locations
One of the reasons the location of the Low Carbon Hub will be in Lincolnshire is due to the high number of connection enquiries and the high cost of connection preventing generators connecting. Nine of the distributed generators that have made connection enquiries have been contacted; all are interested in the project and would like to know more about costs, areas and network constraint. The workshop for generator developers will publicise the potential of the hub to a wider audience to increase the likelihood of connection applications.
6) Generators choose to generate in new locations within East Lincolnshire and request different points of connections. The design has been carried out with likely generator locations based on previous enquiries. However the design concept is flexible and some degree of generator location shifting can be readily accommodated

Box 27: Please provide details of the risk monitoring procedures you will put in place for the Project
Western Power Distribution will proactively manage the risks associated with the Low Carbon Hub using existing procedures within the business. The risk management processes, based on project management industry standards, consists of six sequenced stages. 1. Risk Management Planning 2. Risk Identification 3. Qualitative Risk Analysis 4. Risk Response Planning 5. Risk Monitoring and Control 6. Project Closure The risk process will be continually reviewed by a project board consisting of senior managers, to ensure risks are correctly categorised and the adequate mitigations have been put in place to reduce the risks where possible. This continual improvement should ensure any risks can be reacted to before they become an issue. The risk will be recorded using the standard documentation. Risk Register Outage Risk Calculations Risk Management Plan Risk Management File Issues Log Project Health Check Risk Management Close out Report Risk watch reports Buddy Reports These risk management techniques will ensure the Low Carbon Hub can be delivered to time, quality and cost whilst maintaining our high standard of Safety, Health and Environmental management.

Section D: Appendices

Please list all the appendices you have attached to this pro-forma and outline the information which they provide. Where these appendices support any information provided in the pro-forma, that information should be adequately referenced

Appendix A	**Full Submission Spreadsheet**
Appendix B	**Maps and network diagrams**
Appendix C	**Organogram**
Appendix D	**Project plan**
Appendix E	**Information sources referenced in Box 14**
Summary	The Western Power Distribution Low Carbon Hub submission includes two numbered appendices. Appendix 1 is our document to describe our vision for the Low Carbon Hub, and will be distributed to customers and other interested parties who wish to know more about the project. It describes the work that will be carried out by the project. Appendix 2 is a letter of support from Fundamentals Ltd, a technical partner in our bid.
Appendix 1	Low Carbon Hub vision
Appendix 2	Letter of support

Project Summary

Box 1: Please provide details of the Project, the Method and Solution

Western Power Distribution Low Carbon Hub - Optimising renewable energy resources in Lincolnshire

THE PROBLEM
Traditionally the distribution networks have been designed to operate passively. This means that the network is designed with a tapering capacity on the assumption that electricity generation is large scale and centralised, and power flow will be unidirectional from the higher voltage transmission system to the lower voltages of the distribution network. The capacity of network circuits and components is dictated by the maximum demand, the fault level rating and the need to maintain voltages within defined ranges. When a generator is connected to the distribution network power flow often becomes bidirectional, fault level is increased and voltage control becomes more complex. Conventional design solutions to the resulting changes in fault level, voltage control and capacity are often substantial cost. This can mean that in areas which have abundant renewable energy resources the connection of distributed generation is uneconomical. Lincolnshire is one such area. It has a rich wind resource which may be underutilised for distributed generation due in part to electricity distribution network connection costs.

THE SOLUTION
Creating an active smarter design and operation of the network will allow generation to be connected to the distribution network more economically. This will allow the most suitable generation sites to connect to the network.
The Low Carbon Hub solution will develop a distribution network optimised for demand and generation whilst demonstrating solutions to some of the network limitations.

THE METHODS
The Low Carbon Hub has six project components and these will be trialled together as outlined below:
1. Network enhancements – Sections of existing overhead lines will be upgraded within the demonstration area with higher rated conductors to increase the network's capacity to connect DG. This work is in addition to investment already funded through the DPCR5 settlement.
2. New commercial agreements – Innovative agreements will be negotiated with DG customers to optimise their output and mitigate network issues (e.g. To deliver reactive power service) using real time network measurements. Potential limitations of the current regulatory framework will be identified.
3. Dynamic voltage control – Building on the principles of an existing Innovation Funding Incentive (IFI) project, the 33kV target voltage will be actively varied. This will be done dynamically based on real time measurements of demand and generation. Dynamic voltage control should increase network utilisation whilst maintaining the system voltage within the statutory limits.
4. 33kV active network ring – The active ring allows increased control of the 33kV system and network reconfiguration based on real time power flows. Construction of the ring will involve the installation of an additional circuit breakers, disconnectors and smart grid protection and control.
5. Flexible AC Transmission System (FACT) Device –A Flexible AC Transmission system device will enable us to control both network voltage and system harmonics of the active ring. This equipment is not normally deployed on Distribution networks for this purpose. Shunt compensation will be used to generate or absorb reactive power. These highly technical solutions will be designed to increase the amount of distributed generation that can be connected**.**

6. Dynamic system ratings – The Skegness Registered Power Zone delivered innovative connections to offshore wind farms based on dynamic rating of overhead lines. This component will further develop the solution and test new techniques to calculate the network capacity and operating limits based on real time asset data.

THE PROJECT

The demonstration project will be undertaken on an area of primary network where there has been a history of connection enquiries that our customers tell us haven't proceeded due to high network reinforcement costs. East Lincolnshire has attracted a large number of connection requests but due to a relatively weak network there have only been two connections.

The innovative techniques detailed above will be used together to demonstrate how the network can connect significantly more generation with greatly reduced network reinforcement costs.

Box 2: Please provide a description of the Project

Low Carbon Hub description

The Low Carbon Hub is based around the existing 33kV wood pole overhead lines in East Lincolnshire. This network supplies electricity to homes and business in the areas surrounding Skegness, Alford, Mablethorpe, Ingoldmells and Chapel St Leonards. Appendix B shows that the grid substation at Skegness supplies nine different primary substations through seven circuits. The Low Carbon Hub will involve five of the primary substations and alter the design or operation of five circuits. The alterations can be viewed through the direct comparison between the Single Line Diagram before and after the network changes. These network alterations along with the operational and commercial aspects of the project will create the opportunity for distributed generators connecting to the network.

The project will directly engage with a number of distributed generators. Project partners will come forward following a workshop explaining the Low Carbon Hub to be hosted by Western Power Distribution. The workshop will invite all distributed generator developers to participate in the Low Carbon Hub with developments of between 3 MW and 30 MW. Nine of the existing distributed generators who have already applied for network connections have been contacted as part of the project development. All nine are interested in attending the workshop to learn about the opportunities created by the Low Carbon Hub. The Low Carbon Hub could connect up to 42 MW of additional distributed generation.

To ensure the process is fair we will not form any contractual relationships with customers until after the generator workshop. One of the main project aspects is to create a new set of commercial agreements that will provide benefits to generators and network operators. The commercial arrangements will be created in conjunction with all interested customers.

What we have already done… (Planning, design and studies)

Western Power Distribution has recognised that some areas of our network receive more connection enquiries for distributed generation than others, based on the availability of natural resources. The East Lincolnshire region of our distribution network has received a high number of enquiries, mainly from onshore wind developers due to the high average wind speed. Many of the connections create network issues, as the infrastructure was designed for passive electricity flows. Using conventional network reinforcement techniques to reduce the generator effects is inherently costly and our customers inform us this is a factor for not connecting a generator.

Western Power Distribution believes that connecting distributed generation will play a key part in the UK reaching its 2020 targets for generating electricity from renewable sources, and started to look for a new method to connect generation to the network that is more economical by departing from conventional design. The design is a combination of new technologies, new operating procedures and commercial contracts.

The network studies have showed that the amount of generation that can connect to a network is increased if a systematic plan was formed taking into account all the activities in the area.

Box 3: Please outline the changes which you have made to the Project since the Initial Screening Process

The fundamental aspects of the Low Carbon Hub are the same as detailed in the screening submission. However there have been a number of changes since the Initial Screening Process:

1. Following a more detailed planning exercise, the total project costs have increased from £3m to £3.5m.
2. In the main, the increased project costs are due to greater knowledge management and dissemination aspects within the project.
3. Consequently the LCNF funding request has also increased slightly from £2.7m to £2.8m, the level of cost increases have been offset by the increasing benefits.
4. An external collaborator will be selected for the FACTs device. The collaborator will be determined after a European procurement process.

Project Costs

These should be the same amounts as detailed in the Full Submission Spread sheet tab entitled 'Second Tier Funding Request' included as Appendix A

Total Project Cost	£ 3,416,983
External Funding	
DNO Extra Contribution	£30,000
DNO Compulsory Contribution	£349,829
Second Tier Funding Request	£2,767,140
Project Completion date	02/2015

Derogations or exemptions

If awarded funding, will you require a derogation, licence consent or exemption, or any change to the regulatory arrangements in order to undertake the Project or cater for contingencies? No

Box 4: If Yes, DNOs must provide a summary of the details of the derogation, licence consent or exemption, or change to the regulatory arrangements required

Western Power Distribution will not seek any derogations or exceptions for the Low Carbon Hub as we are able to carry out all activities within the existing frameworks.

Section B: Project Management

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Box 5: Please provide details of your Project plan
DNOs should outline up to ten key milestones associated with their Project.

Date	Milestone
02/2011	Host a workshop with distributed generators interested in connecting to the Low Carbon Hub
06/2011	Dissemination to other GB DNOs and IDNOs of design recommendations for connecting optical fibres and wireless links to new and existing wood pole overhead power lines
07/2013	Dissemination of a new set of commercial arrangements jointly created between generators and the DNO.
08/2013	Completion and demonstration of the dynamic voltage control capability implemented within GE POWERON(Network control system widely used by UK DNOs)
06/2013	Completion and demonstration of the dynamic system ratings capability implemented within GE POWERON (Network control system widely used by UK DNOs)
04/2014	Completion of the nominated 10.5km of Overhead Lines that have already been included in the DPCR5 submission to the new Low Carbon Hub standard. (See diagram in Appendix B)
01/2014	Installation and commissioning of the Flexible Alternating Current Transmission system (FACTs) device.
08/2014	Operation of the 33kV active network ring connecting Alford, Trusthorpe, Chapel St Leonards and Skegness. Creating a network suitable for demonstrating the high penetration of DG.
12/2014	Completion of the Low Carbon Hub, demonstrating the knowledge from the six project areas
02/2015	Dissemination of knowledge to other DNOs, IDNOs and distributed generators.

Project Budget

DNOs must complete the Full Submission Spreadsheet tab entitled 'Second Tier Funding Request' and include it within Appendix A

Box 6: Please provide a breakdown of your total employment costs for the total Project which you are project managing and highlight where these are funded by, or provided by others

Total employment costs should include all the costs used for labour, including pensions but excluding Contractors (whose costs are detailed separately). Personnel with the same role can be grouped together

Staff type	Total Costs	Person days	Funding
WPD Project Management	£234,954	979	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Skegness	£16,792	81	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Alford	£35,930	173	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Ingoldmells	£82,878	398	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Chapel St Leonards	£91,215	439	Funded through LCNF and DNO compulsory contribution
Create a 33Kv active network ring – Trusthorpe	£81,753	393	Funded through LCNF and DNO compulsory contribution

Create a 33Kv active network ring – Bambers	£5,070	24	Funded through LCNF and DNO compulsory contribution

Box 7: Please outline the main Equipment costs required for the total Project which you are project managing

Item description & No. of units	Function in Project	Cost per unit	Total Cost	Funding	Direct Benefit
Dynamic Voltage Control - Development + Maintain of ENMAC and SCADA systems, Voltage control algorithm including Training and site AVC modifications		£42,000	£42,000	Funded through LCNF and DNO compulsory contribution	
Flexible Alternating Current Transmission system (FACTs) - procurement of Devices		£575,000	£575,000	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Skegness includes: new CT's, Protection, 33kV cable and small wiring		N/A	£47,792	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Alford includes: new CT's, protection, 1250A busbar, voltage transformer, 36kV Breaker, 33kV cable & small wiring		N/A	£102,262	Funded through LCNF and DNO compulsory contribution	

Create a 33kV active network ring - Ingoldmells includes: new CT's, protection, Voltage Transformer, earth electrode, 36kV Breaker, 1250a busbar, 3ph insulators, 33kV cable & small wiring		N/A	£235,885	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Chapel St Leonards includes: new CT's, protection, Voltage Transformer, RMU, 1250a busbar, 33kV cable & small wiring		N/A	£259,611	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Trusthorpe includes: new CT's, protection, Incoming Transformer, 3/7 new switchboard, earth electrode, 33kV cable & small wiring		N/A	£232,682	Funded through LCNF and DNO compulsory contribution	
Create a 33kV active network ring - Bambers includes: new CT's, protection & small wiring		N/A	£14,430	Funded through LCNF and DNO compulsory contribution	

Box 8: Please outline the Contractor costs required for the total Project which you are project managing

Contractor	Role in Project	Funding	Expected length of contract	Total Cost
Engineering Design & Surveys		Funded through LCNF and DNO compulsory contribution	24 months	£106,254
Enhancing planned network alterations - 33kV OHL asset rebuilds as 300HDA instead of 150 ASCR		Funded through LCNF and DNO compulsory contribution	10 months	£79,725
Innovative Commercial Arrangements - Workshop, Lawyers, data flows, network configuring with generators		Funded through LCNF and DNO compulsory contribution	36 months	£70,000
Development + Maintain of ENMAC and SCADA systems, Voltage control algorithm including Training and site AVC modifications		Funded through LCNF and DNO compulsory contribution	5 months	£21,000
Dynamic Systems Ratings - Future Design standard 1) fibre over exisiting lines		Funded through LCNF and DNO compulsory contribution	2 months	£10,000
Dynamic Systems Ratings - Future Design standard 2) fibre over new lines		Funded through LCNF and DNO compulsory contribution	2 months	£10,000

Dynamic Ststems Ratings - Future Design standard 3) Radio or Microwave links		Funded through LCNF and DNO compulsory contribution	2 months	£10,000
Flexible Alternating Current Transmission system (FACTs) - Provision of Foundations		Funded through LCNF and DNO compulsory contribution	3 months	£50,000

Box 9: Payments to users or Customers
Please outline the details of any payments you wish to make to users or Customers as part of the Project.

Type of user or Customer	Payment per User	Total Payment	Funding
Customer payments are not a feature of the Low Carbon Hub.			

Box 10: Other costs for the total Project which you are project managing. This should be categorised into the following categories: IT costs, Contingency costs, IPR costs, decommissioning costs, abnormal travel costs and costs associated with public engagement and dissemination of learning

Cost Category	Cost Item	Cost
IT Costs	Telecommunications	£872,270
Contingency	Contingency across the project	£129,478

Cost over-runs & Unrealised benefit

Box 11: Please detail any cost over-run you anticipate requiring for the Project and express this as a percentage of the funding you are requesting

The Low Carbon Hub includes significant network alterations, the majority of these are to the primary network. The Low Carbon Hub detailed budget includes contingency averaging 6.3% across the project aspects; this is to allow for sensible cost variations from the initial desktop design to full project implementation. Western Power Distribution are therefore comfortable with the default level of cost over run protection.

5%

Box 12: Please detail the level of protection required against Direct Benefits in excess of the DNO Compulsory Contribution

Western Power Distribution seeks the default level of protection against direct benefits.

50%

Successful Delivery Reward Criteria

Box 13: Please set out your proposed Successful Delivery Reward Criteria

Table 3. Successful Delivery Reward Criteria Successful Delivery Reward criterion	Evidence
Host a successful workshop with Distributed Generation developers and feed learnings into the project plan.	Holding an interactive workshop by the end of 02/2011, collating feedback from attendees during the workshop sessions. A satisfaction survey will be carried out within 30 days of the event to gauge the value of the workshop to participants and identify any further follow up actions.
Development of a UK technical recommendations for: 1. Installing optical fibre on existing wood pole overhead lines; 2. Installing optical fibre on new wood pole overhead lines 3. Installing microwave or radio antennas and associated equipment within the proximity of distribution assets including the configuration of equipment for effective system protection.	A set of three comprehensive documents sent to all UK DNOs and IDNOs before 31/05/2011. These documents could form the basis of future ENA Engineering Recommendations. The technical recommendations will provide costs and designs for generic overhead line construction. Western Power Distribution will also present lessons learnt from project management and engineering experiences associated with delivery of the three aspects. This will be carried out on a minimum of an annual basis. A final report will be included in the project closure documentation in 02/2015.
Completion of the first application of dynamic system control and operation using GE POWERON	Evidenced through the handover of the capability to the Network Control centre. In accordance with our normal IT business processes the handover will have a documented Operational Acceptance certificate approved by the project board during the 08/2012 meeting.
Determining the degree to which voltage can be controlled by installing and operating a FACTs device. In particular, ascertain whether the device improves quality of supply to demand customers and/or improves generator network availability.	Install a FACTs device, and connect to our network by 01/2014. We will operate the FACTs device under a variety of network conditions and demonstrate how generation could be used to support the system under abnormal operating conditions. The knowledge learnt from this element of the project will be disseminated through a technical paper. The dissemination will be supported by a site visit for interested parties to the FACTs device location. The paper and the visit will be completed by 07/2014. A final report will be included in the project closure documentation in 02/2015.
Development of a stronger relationship with distributed generation developers directly impacted by the Low Carbon Hub.	A telephone survey will be conducted by an external agency before and after the project (12/2010 and 02/2015 respectively). During the project we will continuously collect and review feedback, which will be formally reviewed at the four lessons learned

	sessions detailed in the project plan.
The capture of sufficient information to determine the business case for operating active 33kV ring networks using innovative solutions.	Project closure documentation (02/2015) will include a cost benefit analysis for each of the techniques deployed and the combination of all aspects.
Disseminate knowledge and evaluate the potential for similar projects throughout the UK.	The project closure documentation will detail the knowledge generated from the design, construction operation and commercial aspects from the Low Carbon Hub before 02/02/2015. The final project report will be shared with DNOs and IDNOs and interested parties along with: An internet presence ENA workshops Publications Appropriate industry conferences Etc.

Section C – Evaluation Criteria

Accelerates the development of a low carbon energy sector

Box 14: Outline how the Solution accelerates the development of a low carbon energy sector

The Low Carbon Hub will demonstrate how substantial levels of renewable generation can be connected to a primary distribution network. This contributes to the UK Low Carbon Transition Plan target of 30% of electricity being generated from renewable sources by 2020. The Lincolnshire area is rich in renewable resources and has had a high volume of connection enquiries with limited network infrastructure. This makes it an ideal location for an LCNF demonstration, as we understand from customers that network connection is sometimes a preventative factor to distributed generation being installed. As the UK approaches 2020 and other distributed generation technology matures, conventional electricity networks will increasingly prevent suitable sites being developed.
The solution we are trialling delivers the following carbon benefits:

Accelerates the connection of renewable DG – Novel approaches will enable renewable DG to connect more quickly and at a lower cost than with conventional solutions. This zero carbon generation will reduce the carbon content of the local grid. Generation and demand will be balanced at a local level in real time, minimising the need for imports from the national grid, and occasionally allowing low carbon exports.

Reduces emitted carbon from technical network losses - By installing the smart grid components visibility of the network will be greatly improved, leading to an increased capability to manage voltage and power factor to reduce losses.

Reduces the carbon footprint associated with construction activities – A single strategic investment as proposed will eliminate the need for multiple infrastructure projects.

Our prediction for the NPV of deploying the Low Carbon Hub solution across the UK is £2.2bn. This is based on two sites being developed within each distribution licence area; it will be possible to connect up to 1,400 MW of installed distributed generation before 2020 using techniques demonstrated by the Low Carbon Hub. These sites, like the East Lincolnshire area, are otherwise unlikely to be developed due to the cost of conventional network reinforcement.

Has the potential to deliver net benefits to existing and/or future customers

DNOs must complete the spreadsheet tab 'Net benefits' within the Full Submission spreadsheet and include as Appendix A.

Box 15: Please provide a qualitative account of the net benefits which the Solution has the potential to deliver if rolled out across GB.

The Low Carbon Hub could be repeated regardless of geographic locations, voltage levels or project scale. This will allow DG customers to cost effectively connect to distribution networks in any part of the UK that would have otherwise required extensive conventional network reinforcement.

Cost

It has been assumed the future nationwide solution could be delivered for an average cost of £2.4 million per project and that two future projects would be installed per licence area, each connecting an additional 50 MW of generation that couldn't have been previously connected before 2020. The duration and proportionate cost profile applied for each replica is the same as for the trial. The East Lincolnshire Low Carbon Hub will develop the key principles, and include one off expenses not needed to be replicated for future projects.

Carbon Benefits

The principal carbon benefit is the displacement of centralised fossil fuelled generation by local renewable DG. The carbon benefit calculation assumes a 33% load factor and a lifetime of 25 years for onshore wind generators. Each hub is assumed to have 50MW generation capacity and an output of 147587 MWh. The carbon saved takes the Defra conversion factor for rolling average grid electricity in 2008, converted to currency by the DECC non traded carbon price.

Other Benefits

The DPCR5 DG incentive is assumed to continue at the assumed 50MW of generation per hub. Further it is assumed that the generators and FACTS device have a life of 25 years.

The scale of the first low carbon hub is defined by the existing network in the East Lincolnshire area, the level of generation that has requested connection and the network constraints. Creating a network ring at 33kV will combine two existing network circuits. The knowledge generated from the low carbon hub will help to determine the scale of future projects. Connecting a large amount of generation onto the low carbon hub will fully test the principles the low carbon hub.

There are financial benefits that will accrue to Distributed Generators but have not been included in Appendix A, for example the reduced sole use connection costs.

Direct Impact on the operation of the Distribution System

Box 16: Explain the way in which the Project/Solution has a Direct Impact on the Distribution System

This project is focused exclusively around the operation of the distribution network. New operating procedures will be developed and refined. The network will dynamically distribute locally generated power providing key learning on how to operate smart grids with high DG penetrations in real time.
The solutions we are trialling will directly impact the operation of the network through a range of technical, commercial and operational approaches including:

Increased visibility and control of the 33kV system (e.g. power factor, voltage management and power flows)

Demonstration of previously unproven high voltage network assets

Real time management of connected DG and relationship with DG customers

Operational interface with GBSO

Generates new knowledge that can be shared amongst all DNOs

Answers to this section should be detailed in boxes 17 to 19

Box 17: Explain the new learning which will result from a successful Project

The Low Carbon Hub will be constructed within a typical rural distribution network. Consequently the hub could be replicated at a large number of locations across the UK. In addition some aspects of the hub, such as the technical standard for installation of communication links on wood pole overhead lines, could be widely used as standalone applications. The project will bring incremental learning in four key areas.

The hub network design is intended to offer more flexible operation that will allow more generator capacity to connect to a section of network at a lower cost of reinforcement. The project will test the network design in terms of dynamic voltage control, network availability and level of losses. The results will influence network design into the future.

The use of a FACTS device in a distribution network will provide important learning in terms of both operational procedures and effectiveness. Network monitoring will demonstrate the extent to which a FACTS device can moderate the step changes in voltage associated with intermittent generation, improve voltage regulation in coordination with on line tap changers and influence network losses.

Western Power Distribution in conjunction with the generators that connect to the hub will develop commercial agreements that will be different to those traditionally held between DNOs and generators. The agreements will seek to optimise generator export in a way that will minimise network issues, for example by delivering reactive power services. The resultant forms of agreement will provide useful templates for generator connections UK wide.

The project will deploy dynamic voltage control schemes and communications links to support network control and protection. The design of the voltage control schemes and the deployment of optic fibre and wireless communication links on wood pole overhead power lines will both require the development of technical specifications. It is likely that these specifications will form the basis of technical standards which can be adopted across the industry.

The project will incorporate several methods of learning capture. The overall performance of the hub will be assessed by analysis of network data gathered by network transducers. An enhanced level of transducer coverage will give greater visibility of network performance, allowing comparison with modelled forecasts of network behaviour. This will allow robust conclusions on the effectiveness of control schemes and network devices. Learning about the installation of equipment will be captured in method statements, specifications and technical standards. Commercial arrangements will be trialled and best practice will be proposed in agreement templates.

Box 18: Outline the arrangements for disseminating learning from the Project

The learning from this project will be disseminated through a combination of transparency during implementation and formal records such as papers and technical standards.
The project's progress will be captured and displayed on our external web site both through a project gantt chart and photographs displaying physical progress. At regular intervals invitations will be extended to DG customers, Ofgem, other DNOs and other relevant stakeholders to visit and observe the project. It is widely recognised that first hand experience often provides the most powerful learning, and this high level of transparency offers the opportunity to an industry audience to follow the project closely.
Learning from all aspects of the project will be captured systematically. This will include the design, installation and operational stages of the project. This learning will be shared with DNOs and IDNOs through papers, workshops and conference presentations.
A number of technical specifications will be developed to implement the project, in particular relating to the installation of optic fibre and wireless communication links on wood pole overhead power lines and the design of voltage control systems. These specifications will be shared, and are likely to form the basis of technical standards.
The data from enhanced network monitoring will populate a data base with wind speed, generator output and corresponding network conditions. The new software tool will use this data to evaluate network performance against original planning standards. The results of the analysis will be shared with all DNOs, and the software tool will be made available to DNOs to enable them to repeat the analysis for their own networks.
The new features of the contracts with generators taking part in the trial, and their performance in practice, will be shared with other generators, subject to commercial confidentiality.
An assessment will be made of how the hub principle could be implemented without support from the Low Carbon Network Fund. This will be shared with all DNOs.
Western Power Distribution expect the results of this assessment to influence our ED1 business plan.

Box 19: Outline the arrangements for Intellectual Property Rights (IPR)

Does the Project conform to the default arrangements for IPR? Yes
No agreements on IPR have been signed at this stage of the project development.
Western Power Distribution will seek to enter into agreements which are in keeping with the IP principles set out by Ofgem on 15 April 2010. Early discussions with our bid partners have highlighted some areas which they would wish to discuss in more detail including the definitions of foreground and background IPR, the scope of license grants and warranties.

Involvement of External Collaborators and external funding

Does the Project involve External Collaborators and/or external funding?

Yes

Box 20: If you have been unsuccessful in attracting External Collaborators and/or external funding to the Project, please detail your endeavours to do so

Western Power Distribution has approached two market leaders with the capability of providing a FACTs solution. Significant interest has been shown as they also believe the principles being demonstrated could help stimulate market opportunities. An open market tender is required for the FACTs device procurement to comply with European procurement laws. The connection of generation to the Low Carbon Hub must be a fair process between new and existing market players. We will hold the generation workshop within 60 days of winning the LCNF funding; this will ensure we capture all interested participants as well as the nine existing market players that have already shown an interest. Holding the generator workshop within the first ten weeks of winning the LCNF funding will ensure generation can be involved in the project at the earliest opportunity.

Box 21: Where funding is provided by a third party that is not an External Collaborator, DNOs should provide details of the funder. If there is more than one External Funder, details of others can be included as an appendix:

Organisation name	No funding is being provided by a third party
Type of organisation	
Amount of funding	
Funding arrangements	
When funds will be provided	
Conditions of funding	
Risks/uncertainties	
Details of contract or agreement	

Box 22: Details of External Collaborators

DNOs should provide details of the 6 main parties who are collaborating with them on a Project. Details of any further External Collaborators should be included as an appendix.

Organisation name	**S&C**
Relationship to DNO (if any)	There is no relationship between the external collaborator and Western Power Distribution
Type of Organisation	S&C is an experienced FACTs provider already supplying solutions on UK distribution or transmission networks to allow asynchronous generators to comply with the grid code.
Role in Project	The company will: 1. Supply the FACTs device and network filters 2. Implement the device into the distribution network as part of the dynamic voltage control, allowing the FACTs target voltage to be varied dependent on the network conditions. 3. Provide commissioning, operation and maintenance guidance of the device.
Prior experience brought to Project	Facts devices are unusual for the distribution network and still at the trialling stage. The supplier will have operated in the UK market to allow asynchronous generators to comply with the grid code. This will allow them to adapt the device to control the network voltage to allow an increased level of generation connected to the network and increase the strength of the distribution network.
Funding	The Facts provider will develop the operational capabilities for the FACTs dynamic voltage control and then implement into the GE POWERON network control software.
Contractual relationship	Due to European procurement laws, we will conduct a full market evaluation post award.
External Collaborator benefits from the Project	The FACTs provider will develop the capability to strengthen the distribution network to facilitate distributed generation. The FACTs provider can develop and demonstrate their control capabilities to be suitable for distribution network control. Facts providers feel this will help stimulate a new market for them, demonstrating this capability of combining a FACTs unit and the existing OLTC through the LCNF.

Box 23: Other partners

Distributed Generators
Nine renewable energy developers who have already applied for generation points of connection in the Lincolnshire area have been approached to determine the extent of their interest in the principles being demonstrated by the Low Carbon Hub and they are all interested in knowing more. These generators will be invited to the generator workshop along with all other interested parties.

Local Authority
Western Power Distribution has worked with East Lindsey District Council to ensure the project helps facilitate the delivery of their renewable generation targets. Western Power Distribution has also worked with East Midlands Development Agency (EMDA) to coordinate their regional targets for generating more energy from renewable sources with the Low Carbon Hub. We will continue to work with EMDA and its successor organisation during the delivery phase.

Technical Partners
We have worked with Fundamentals Ltd to develop the Automatic Voltage Control at Skegness under an OFGEM Innovative Funding Incentive project. Fundamentals share our view that an ability to vary the network voltage based on real network conditions is the next transition for smarter networks with increased levels of distributed generation. Please see appendix 2 for a letter of support from Fundamentals Ltd

Relevance & Timing of Project

Box 24: Please outline why the learning from the Project is relevant to Network Operators

2020 targets for renewable energy imply that the level of generation connected to networks before the end of ED1 will have to increase significantly. Any constraints on distribution networks which might restrict generator connections could prevent the UK from reaching its targets. The cost of generator connections is based on the point of connection and the amount of upstream reinforcement required. If successful, the techniques used in the demonstration project could be applied to any DNO's network. They will be used to provide a point of connection closer to the generator and require less upstream reinforcement. Reducing the cost of generator connections will reduce barriers to achieving renewable energy targets and aid the move to a low carbon economy. If the methods used in the trial are successful then, in general terms, a higher level of generation will be able to connect to a given piece of network at lower cost than if conventional network designs were used. The knowledge gained by operating the network will include better understanding of generator availability and load factor. This knowledge can be used to review security of supply standards and in particular the contribution that can be made by intermittent generation, in terms of voltage control and load growth. The successful trial would open the possibility to future collaboration between generators and network operators, helping to develop suitable network locations to provide value for money and facilitate more generation connections, of mutual benefit. Both of these factors would be reflected in business plans for future price controls. Plans for network reinforcement are in part driven by the security of supply standard, and recognition of an increased contribution by generation may reduce the need for network reinforcement. Collaboration with generators to develop suitable locations may give rise to some investment ahead of need, or at any rate projects with a different business case to those put forward in DPCR5, and these would be reflected in ED1 business plans.

Demonstration of a robust methodology and that the Project is ready to implement (answers should be detailed in boxes 25 to 27)

Box 25: Please demonstrate that the Project has a robust methodology and can start in a timely manner

Western Power Distribution has received a number of enquiries from generator developers for connections in the East Lincolnshire area in recent years. The Low Carbon Hub concept has been developed over a similar timespan. The project was first scoped in 2009 and has evolved further over the last twelve months. A significant amount of design work has been carried out based on generator locations as per the previous enquiries. Consequently the network design and protection requirements are well developed and ready for the trial.

Rebuilding the 10.5km of overhead lines to a conventional design is already included in the Western Power Distribution DPCR5 business plan and work programme. The implementation of the modified overhead line design for the trial can be readily accommodated without disrupting the work programme.

The project plan takes into account the aspects of the trial with long lead times to which we cannot formally commit until the project has been awarded. We are ready to commence immediately other aspects with shorter lead times.

Stakeholders including generator developers and the local authority have been consulted and are aware of the scope of the trial. They are ready for further engagement as the trial progresses to implementation.

The costs for the trial have been estimated using two approaches. For those elements of the project that relate to conventional network activities the same unit costs have been used as those allowed by Ofgem in DPCR5 Final Proposals. For products and services that are not standard to Western Power Distribution' normal operations budget quotes have been obtained from contractors and suppliers. In combination the two approaches represent a robust cost estimate. The submitted costs cover the network alterations shown on the single line diagram and protection document. Post award, the network alterations will be reviewed to identify any further efficiencies.

The benefits that Western Power Distribution derives from the project are in the form of reduced losses and revenue from the DG Incentive.

The reduction in losses has been calculated by modelling actual hourly load data from May 2009 to May 2010 against the existing network and proposed network and taking the difference between the two. The losses reduction from the installation of a 10.5km of lower impedance conductor can be modelled with a high level of confidence. The losses reduction as a result of using the FACTS device and the generator output can be modelled with a lower degree of confidence as a number of assumptions are required. The FACTS device will reduce losses by exporting the reactive power requirements of the hub; it has been assumed the device will operate on average exporting 1MVAr over the lifetime of the unit, but will vary between ±4MVAr. The generator load factor is based on experience of offshore wind generators but applies a 3% reduction to reflect onshore performance.

Box 26: Please provide details of the risks associated with the Project
Western Power Distribution has identified a several risks during the project development stage. Consideration has been given to how these risks could be reduced or mitigated. The project costs have contingency applied averaging 6.3% across all activities to take into account these project risks. The key risks identified are listed below, along with the steps proposed to manage them.
1) The project cannot be delivered for the amount of funding requested
The design of the project has been sufficiently detailed to ensure that the amount requested is sufficient to deliver the Low Carbon Hub; contingency built in where appropriate has created the confidence to request the default arrangements for cost overrun protection.
2) Significant additional network expenditure is required due to unforeseen network scenarios
The processes for obtaining wayleaves and gaining planning consent are naturally uncertain in terms of duration and outcome. Both could result in increased expenditure if the proposed design, routes or locations are not permitted. The overall project design of the Low Carbon Hub is such that it could still demonstrate the majority of the project aims if the required planning consents or wayleaves were not granted in the way anticipated. This would however change the scale of the project; we are working closely with ELDC to mitigate this risk.
3) There are extensive planning delays involved for either Low Carbon Hub activities or Generators construction
We are working with DG customers and ELDC to coordinate planning requests.
4) Experimental aspects of the trial do not fully realise the planned benefits
The experimental sections of the Low Carbon Hub have been demonstrated at a lower Technology Readiness Level (TRL) and through the IFI mechanism. This has given Western Power Distribution the confidence to develop the functions implementing them together in the Low Carbon Hub. Western Power Distribution will be partnering with experts in these sections to reduce the risk. The safe operation of the distribution network will not depend on any of the experimental features.
5) Generators choose not to connect to the network as they are targeting other locations
One of the reasons the location of the Low Carbon Hub will be in Lincolnshire is due to the high number of connection enquiries and the high cost of connection preventing generators connecting. Nine of the distributed generators that have made connection enquiries have been contacted; all are interested in the project and would like to know more about costs, areas and network constraint. The workshop for generator developers will publicise the potential of the hub to a wider audience to increase the likelihood of connection applications.
6) Generators choose to generate in new locations within East Lincolnshire and request different points of connections. The design has been carried out with likely generator locations based on previous enquiries. However the design concept is flexible and some degree of generator location shifting can be readily accommodated

Box 27: Please provide details of the risk monitoring procedures you will put in place for the Project

Western Power Distribution will proactively manage the risks associated with the Low Carbon Hub using existing procedures within the business. The risk management processes, based on project management industry standards, consists of six sequenced stages.

1. Risk Management Planning
2. Risk Identification
3. Qualitative Risk Analysis
4. Risk Response Planning
5. Risk Monitoring and Control
6. Project Closure

The risk process will be continually reviewed by a project board consisting of senior managers, to ensure risks are correctly categorised and the adequate mitigations have been put in place to reduce the risks where possible. This continual improvement should ensure any risks can be reacted to before they become an issue.
The risk will be recorded using the standard documentation.

Risk Register

Outage Risk Calculations

Risk Management Plan

Risk Management File

Issues Log

Project Health Check

Risk Management Close out Report

Risk watch reports

Buddy Reports

These risk management techniques will ensure the Low Carbon Hub can be delivered to time, quality and cost whilst maintaining our high standard of Safety, Health and Environmental management.

Section D: Appendices

Please list all the appendices you have attached to this pro-forma and outline the information which they provide. Where these appendices support any information provided in the pro-forma, that information should be adequately referenced

Appendix A	**Full Submission Spreadsheet**
Appendix B	**Maps and network diagrams**
Appendix C	**Organogram**
Appendix D	**Project plan**
Appendix E	**Information sources referenced in Box 14**
Summary	The Western Power Distribution Low Carbon Hub submission includes two numbered appendices. Appendix 1 is our document to describe our vision for the Low Carbon Hub, and will be distributed to customers and other interested parties who wish to know more about the project. It describes the work that will be carried out by the project. Appendix 2 is a letter of support from Fundamentals Ltd, a technical partner in our bid.
Appendix 1	Low Carbon Hub vision
Appendix 2	Letter of support

WESTERN POWER DISTRIBUTION
LOW CARBON HUB

WPD Change Request v1

6. Proposed tracked changes project direction

Company Secretary
Central Networks (East) Plc
Company number: 2366923
Westwood Way
Westwood Business Park
Coventry
CV4 8LG

Promoting choice and value for all gas and electricity customers

Direct Dial: 020 7901 7194
Email: rachel.fletcher@ofgem.gov.uk

Date: 17 December 2010

Dear Company Secretary,

Project Direction ref: CN(East)/Low Carbon Hub/17-12-10

Project Direction issued to Central Networks (East) Plc ("CN East") pursuant to the LCN Fund Governance Document issued[1] pursuant to Part E of Charge Restriction Condition 13 (Low Carbon Networks Fund) ("CRC13") of the Electricity Distribution Licence setting out the terms to be followed in relation to the Low Carbon Hub project (the "Project") as a condition of it being funded under the Second Tier and Discretionary Funding Mechanism[2].

CRC13 establishes the arrangements, known as the Low Carbon Networks Fund ("LCN Fund"), for the purposes of incentivising the development of low carbon networks.

Part E of CRC13 requires the Gas and Electricity Markets Authority (the "Authority") to issue the LCN Fund Governance Document for the purposes of regulating, governing and administering the LCN Fund.

Part G of CRC13 defines a Project Direction as a direction issued by the Authority pursuant to the LCN Fund Governance Document setting out the terms to be followed in relation to the Eligible LCN Fund Project[3] as a condition of its being funded pursuant to the Second Tier and Discretionary Funding Mechanism. A Project Direction must, by virtue of paragraph 3.64 of Section Two of the LCN Fund Governance Document:

- set out the Project-specific conditions that a distribution network operator ("DNO") is committing to in accepting Second Tier Funding[4];
- require the DNO to undertake the Project in accordance with the commitments it has made in the Full Submission[5]. Where appropriate the Project Direction may therefore include extracts from the Full Submission; and
- set out the Approved Amount for the Project, as defined in CRC13.28, that will form part of the calculation contained in the direction issued by the Authority under CRC13.16 (the Funding Direction).

[1] http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/Documents1/LCN_Fund_Governance_doc_v.3_Final_published.pdf
[2] Second Tier and Discretionary Funding Mechanism has the meaning given in CRC 13.3(b).
[3] Eligible LCN Fund Project has the meaning given in Part G of CRC 13.
[4] Second Tier Funding has the meaning given in CRC13.11.
[5] Unless otherwise specified, defined terms (terms in capitals) in this Project Direction are defined in Section seven of the LCN Fund Governance Document.

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CN East submitted the Project for funding under the LCN Fund on 3 September 2010 and the Authority decided to award the funding to CN East in a decision dated 29 November 2010 (the "Decision Document")[6] subject to CN East complying with CRC 13, the LCN Fund Governance Document (as may be modified from time to time in accordance with CRC 13 and as modified and/or augmented in respect of this Project by this Project Direction) and this Project Direction. In accordance with the LCN Governance Document the Authority hereby requires CN East to comply with the conditions set out in the Schedule to this Project Direction.

The Approved Amount set out in section 5 of the Schedule is different to the amount set out in the Decision Document. This is because, following the decision, it was discovered that the spreadsheet included as part of the submission pro-forma overstated the DNOs" earnings from bank interest on the amount requested from the LCN Fund. This resulted in the funding request amounts for all projects being understated. In addition CN East had made a revision to their submission spreadsheet prior to the Authority"s decision which was not reflected in the Decision Document. This also resulted in the requested amount for the Project being understated. The revised amounts do not affect the Authority"s decision on who should be awarded funding.

This Project Direction is issued by the Authority, and provided CN East complies with the LCN Fund Governance Document and this Project Direction, the Project is deemed to be an Eligible LCN Fund Project, as defined in CRC13.

This Project Direction constitutes notice pursuant to section 49A (Reasons for decisions) of the Electricity Act 1989.

Rachel Fletcher
Partner, Distribution
Signed on behalf of the Authority and authorised for that purpose by the Authority
17 December 2010

[6] http://www.ofgem.gov.uk/networks/elecdist/lcnf/Documents1/LCNFunddecision_Final.pdf

Tracked Changes PROJECT DIRECTION

Schedule to Project Direction

1. TITLE

Project Direction ref: CN (East)/Low Carbon Hub/17-12-10

2. PREAMBLE

This Project Direction issued by the Gas and Electricity Markets Authority (the "Authority") to Central Networks (East) Plc (the "Implementing DNO") pursuant to the LCN Fund Governance Document issued pursuant to Part E of Charge Restriction Condition 13 (Low Carbon Networks Fund) ("CRC 13") of the Electricity Distribution Licence (the "Licence") sets out the terms to be followed in relation to the Low Carbon Hub (the "Project") as a condition of it being funded under the Second Tier and Discretionary Funding Mechanism[7].

Unless otherwise specified, defined terms in this Project Direction are defined in section 7 of the LCN Fund Governance Document.

References to specific sections of the Implementing DNO"s Full Submission in this Project Direction are, for ease of reference, made by referring to the box number in the Implementing DNO"s Full Submission pro-forma.

3. COMPLIANCE

The Implementing DNO must comply with CRC13 and the LCN Fund Governance Document (as may be modified from time to time in accordance with CRC13 and as modified and/or augmented in respect of the Project by this Project Direction) and the Project Direction.

Any part of the Approved Amount that the Authority determines not to have been spent in accordance with this Project Direction (or the LCN Fund Governance Document) is deemed to be Disallowed Expenditure.

Pursuant to CRC 13.14 Disallowed Expenditure is revenue received (whether by the Implementing DNO or another DSP) under the Second Tier and Discretionary Funding Mechanism that the Authority determines not to have been spent in accordance with the provisions of the LCN Fund Governance Document or those of the relevant Project Direction.

Pursuant to paragraph 3.93 of Section Two of the LCN Fund Governance Document, Disallowed Expenditure includes any funds that must be returned if the Project is halted without Ofgem's[8] permission, any funds that have not been spent in line with the approved Project Budget contained within the Project Direction, and any unspent funds on the completion of the Project.

4. APPROVED AMOUNT FOR THE PROJECT

The Approved Amount is ~~£3,063k~~£2,767k.

5. PROJECT BUDGET

The Project Budget is set out in Table 2. The Implementing DNO must not spend more than 110% of any category total (e.g. Box 6 Employment costs) without the Authority"s prior consent (such consent is not to be unreasonably withheld).

[7] Second Tier and Discretionary Funding Mechanism has the meaning given in CRC 13.3(b).
[8] Ofgem is the offices of the Gas and Electricity Markets Authority. The terms "Ofgem" and "Authority" are used interchangeably in this Project Direction.

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Tracked Changes PROJECT DIRECTION

The Implementing DNO will report on expenditure against each line in the Project Budget, and explain any projected variance against each line total in excess of 5%, as part of its detailed report which will be provided at least every six months, in accordance with paragraph 3.68 of Section Two of the LCN Fund Governance Document. Ofgem will use the reported expenditure and explanation to assess whether the funding has been spent in accordance with the LCN Fund Governance Document or with this Project Direction.

For the avoidance of doubt this reporting requirement does not change or remove any obligations on the Implementing DNO with respect to reporting that are set out in the LCN Fund Governance Document.

Table 2. Project Budget

~~**Box 6 (Employment costs)**~~	
~~Project Manager~~	~~£241k~~
~~Trade Staff~~	~~£80k~~
~~Construction Project Management~~	~~£66k~~
~~Protection and Commissioning~~	~~£30k~~
~~System Design & Commercials~~	~~£27k~~
~~Communications Engineers~~	~~£3k~~
~~**Box 7 (Equipment costs)**~~	
~~FACTS Units~~	~~£500k~~
~~2 x 33kV Ring Main Unit~~	~~£280k~~
~~4.5 km circuit overhead line & 0.5 km underground cable~~	~~£164k~~
~~5 x unit protection schemes~~	~~£150k~~
~~Filters~~	~~£76k~~
~~Overhead line rebuilds~~	~~£75k~~
~~Optical fibres~~	~~£76k~~
~~1 x circuit breaker~~	~~£47k~~
~~**Box 8 (Contractor costs)**~~	
~~FACTS provider~~	~~£30k~~
~~Communications (fibre & microwave)~~	~~£210k~~
~~Legal~~	~~£80k~~
~~**Box 9 (Customer and user payments)**~~	
~~**Box 10 (Other costs)**~~	
~~IT costs – software development~~	~~£238k~~
~~Contingency~~	~~£209k~~
~~Decommissioning~~	~~£29k~~
~~Abnormal travel~~	~~£36k~~
~~Professional services~~	~~£103k~~

Box 6 (Employment costs)	
WPD Project Management	£235k
Create a 33Kv active network ring – Skegness	£17k
Create a 33Kv active network ring – Alford	£36k
Create a 33Kv active network ring – Ingoldmells	£83k
Create a 33Kv active network ring – Chapel St Leonards	£91k

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Create a 33Kv active network ring – Trusthorpe	£82k
Create a 33Kv active network ring – Bambers	£5k
Box 7 (Equipment costs)	
Dynamic Voltage Control - Development + Maintain of ENMAC and SCADA systems, Voltage control algorithm including Training and site AVC modifications	£42k
Flexible Alternating Current Transmission system (FACTs) - procurement of Devices	£575k
Create a 33kV active network ring – Skegness includes: new CT's, Protection, 33kV cable and small wiring	£48k
Create a 33kV active network ring – Alford includes: new CT's, protection, 1250A busbar, voltage transformer, 36kV Breaker, 33kV cable & small wiring	£102k
Create a 33kV active network ring – Ingoldmells includes: new CT's, protection, Voltage Transformer, earth electrode, 36kV Breaker, 1250a busbar, 3ph insulators, 33kV cable & small wiring	£236k
Create a 33kV active network ring - Chapel St Leonards includes: new CT's, protection, Voltage Transformer, RMU, 1250a busbar, 33kV cable & small wiring	£260k
Create a 33kV active network ring – Trusthorpe includes: new CT's, protection, Incoming Transformer, 3/7 new switchboard, earth electrode, 33kV cable & small wiring	£233k
Create a 33kV active network ring – Bambers includes: new CT's, protection & small wiring	£14k
Box 8 (Contractor costs)	
Engineering Design & Surveys	£106k
Enhancing planned network alterations - 33kV OHL asset rebuilds as 300HDA instead of 150 ASCR	£80k
Innovative Commercial Arrangements - Workshop, Lawyers, data flows, network configuring with generators	£70k
Development + Maintain of ENMAC and SCADA systems, Voltage control algorithm including Training and site AVC modifications	£21k
Dynamic Systems Ratings - Future Design standard 1) fibre over exisiting lines	£10k
Dynamic Systems Ratings - Future Design standard 2) fibre over new lines	£10k
Dynamic Ststems Ratings - Future Design standard 3) Radio or Microwave links	£10k
Flexible Alternating Current Transmission system (FACTs) - Provision of Foundations	£50k
Box 9 (Customer and user payments)	
Box 10 (Other costs)	
IT costs – including telecommunications	£872k
Contingency	£129k

6. PROJECT IMPLEMENTATION

The Implementing DNO must undertake the Project in accordance with the commitments it has made in the Full Submission approved by the Authority pursuant to the LCN Fund Governance Document and the terms of this Project Direction. These include (but are not limited to) the following:

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(i) undertake the Project in accordance with the description set out in Box 1 (Project, Method and Solution) and Box 2 (Project description);

(ii) provide a DNO Compulsory Contribution of £350k;

(iii) complete the Project on or before the Project completion date of 28 February 2015; and

(iv) disseminate the learning from the Project at least to the level described in Box 18 (Arrangements for disseminating learning).

7. REPORTING

The Implementing DNO must submit to the Authority, within two months of the date of this Project Direction, how it proposes to comply with paragraph 3.68 of Section Two of the LCN Fund Governance Document, including how it will assure us that the information in the report is accurate.

Ofgem may produce further guidance about the structure and content of the reports required by paragraph 3.68 of Section Two of the LCN Fund Governance Document.

8. COST OVERUNS

The maximum amount of Discretionary Funding that the Implementing DNO can request as additional funding for cost overruns on the Project is 5%.[9]

9. INTELLECTUAL PROPERTY RIGHTS (IPR)

In Box 19 (Arrangements for Intellectual Property Rights) the Implementing DNO has stated that the Project does conform to the default IPR arrangements set out in Chapter 2 of Section Five of the LCN Fund Governance Document and must therefore undertake the Project in accordance with the default IPR arrangements.

10. SUCCESSFUL DELIVERY REWARD CRITERIA

The Project will be judged by the Authority for the purposes of the Second Tier Successful Delivery Reward against the Successful Delivery Reward Criteria set out in Table 3[10] below (that comply with paragraphs 3.17 and 3.18 of Section Two of the LCN Fund Governance Document):

Table 3. Successful Delivery Reward Criteria

Successful Delivery Reward criterion	Evidence
Host a successful workshop with Distributed Generation developers and feed learnings into the project plan.	Holding an interactive workshop by the end of 02/2011, collating feedback from attendees during the workshop sessions. A satisfaction survey will be carried out within 30 days of the event to gauge the value of the workshop to participants and identify any further follow up actions.
Development of a UK technical recommendations for: 1. Installing optical fibre on existing wood pole overhead lines;	A set of three comprehensive documents sent to all UK DNOs and IDNOs before 31/05/2011. These documents could form the basis of future ENA Engineering Recommendations. The technical

[9] This is the amount requested by the Implementing DNO in its Full Submission.
[10] These are the Successful Delivery Reward Criteria set out in the Implementing DNOs Full Submission

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Tracked Changes PROJECT DIRECTION

2. Installing optical fibre on new wood pole overhead lines 3. Installing microwave or radio antennas and associated equipment within the proximity of distribution assets including the configuration of equipment for effective system protection.	recommendations will provide costs and designs for generic overhead line construction. Central Networks will also present lessons learnt from project management and engineering experiences associated with delivery of the three aspects. This will be carried out on a minimum of an annual basis. A final report will be included in the project closure documentation in 02/2015.
Completion of the first application of dynamic system control and operation using GE PowerOn Fusion	Evidenced through the handover of the capability to the Network Control centre. In accordance with our normal IT business processes the handover will have a documented Operational Acceptance certificate approved by the project board during the 08/2012 meeting.
Determining the degree to which voltage can be controlled by installing and operating a FACTs device. In particular, ascertain whether the device improves quality of supply to demand customers and/or improves generator network availability.	Install a FACTs device, and connect to our network by 01/2014. We will operate the FACTs device under a variety of network conditions and demonstrate how generation could be used to support the system under abnormal operating conditions. The knowledge learnt from this element of the project will be disseminated through a technical paper. The dissemination will be supported by a site visit for interested parties to the FACTs device location. The paper and the visit will be completed by 07/2014. A final report will be included in the project closure documentation in 02/2015.
Development of a stronger relationship with distributed generation developers directly impacted by the Low Carbon Hub.	A telephone survey will be conducted by an external agency before and after the project (12/2010 and 02/2015 respectively). During the project we will continuously collect and review feedback, which will be formally reviewed at the four lessons learned sessions detailed in the project plan.
The capture of sufficient information to determine the business case for operating active 33kV ring networks using innovative solutions.	Project closure documentation (02/2015) will include a cost benefit analysis for each of the techniques deployed and the combination of all aspects.
Disseminate knowledge and evaluate the potential for similar projects throughout the UK.	The project closure documentation will detail the knowledge generated from the design, construction operation and commercial aspects from the Low Carbon Hub before 02/02/2015. The final project report will be shared with DNOs and IDNOs and interested parties along with: • An internet presence • ENA workshops • Publications • Appropriate industry conferences • Etc.

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The maximum amount of the Second Tier Successful Delivery Reward (which will not exceed the DNO Compulsory Contribution) that the Project will be eligible for is £350k.

11. BANK ACCOUNTS

The Implementing DNO has requested an exemption from the requirement in paragraph 3.66 of Section Two of the LCN Fund Governance Document to keep the funds from the Second Tier Funding for this Project in a separate bank account. The Authority has decided to grant this exemption subject to the conditions set out in this section.

The Implementing DNO must provide a financial tracking and reporting system which is functionally equivalent to a separate bank account for this Project. This means they must hold any Approved Amounts, the DNO Compulsory Contribution and all other funding from the Implementing DNO, External Collaborators and External Funders, that the Implementing DNO has identified within its Full Submission as being used to fund the Project, unless otherwise agreed by Ofgem in a memorandum account[11] which is capable of providing all the information that would be available from a separate bank account. This memorandum account must:

(i) show all transactions relating to (and only to) the Project;

(ii) be capable of supplying a real time statement (of transactions and current balance) at any time;

(iii) accrue expenditures when a payment is authorised (and subsequently reconciled with the actual bank account);

(iv) accrue payments from the moment the receipt is advised to the bank (and then subsequently reconciled with the actual bank account);

(v) calculate a daily total; and

(vi) calculate interest on the daily total according to the rules applicable to the account within which the funds are actually held.

The Implementing DNO's auditors must review the systems and processes that the Implementing DNO is proposing to use to conform to the requirements set out in this section and provide a signed statement to Ofgem that the systems and processes are fit for purpose, before the Project is initiated and any funds are spent.

The Implementing DNO's auditors must provide an annual report to Ofgem to confirm that the Implementing DNO is conforming to the requirements set out in this section.

The Implementing DNO must provide an audited schedule of all the memorandum account transactions, including interest (calculated according to subpoint (vi) above), as part of its detailed progress reports[12] to Ofgem.

The Implementing DNO is still required to comply with the remainder of paragraph 3.66 (in relation to the date on which the funds will be deposited and the requirements of use) and the rest of the LCN Fund Governance Document, and for the purposes of such compliance the requirements set out in this section are considered to comprise the Project Bank Account.

13. USE OF LOGO

[11] Or equivalent unique code within their financial system, if approved as functionally equivalent by the Implementing DNO's auditors. For this direction, the term memorandum account will also refer to the equivalent unique code if the auditors approval has been obtained..

[12] The detailed report is described in Section Two, paragraph 3.68 of the LCN Fund Governance Document.

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9 Millbank London SW1P 3GE **Tel** 020 7901 7000 **Fax** 020 7901 7066 **www.ofgem.gov.uk**

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The Implementing DNO and External Collaborators or partners[13] may use the LCN Fund logo for purposes associated with the Project but not use the Ofgem or Ofgem E-Serve logos in any circumstances.

14. AMENDMENT OR REVOCATION

As set out in the LCN Fund Governance Document and this Project Direction, this Project Direction may be amended or revoked under the following circumstances:

(i) if the Implementing DNO considers that there has been a material change in circumstance that requires a change to the Project Direction, and the Authority agrees (paragraph 3.70 of Section Two of the LCN Fund Governance Document); or

(ii) if Ofgem agrees to provide Discretionary Funding, which requires the re-issue of the Project Direction (paragraph 3.78 of Section Two of the LCN Fund Governance Document); or

(iii) if the Implementing DNO applies for Discretionary Funding to cover a decrease in Direct Benefits and the Authority decides it would be in the best interest of customers to make changes to the Project Direction before the Discretionary Funding would be awarded (paragraph 3.77 of Section Two of the LCN Fund Governance Document).

15. HALTING OF PROJECTS

This Project Direction is subject to the provisions contained in paragraphs 3.79 to 3.83 of Section Two of the LCN Fund Governance Document relating to the halting of projects. By extension, this Project Direction is subject to any decision by the Authority to halt the Project to which this Project Direction relates and to any subsequent relevant Funding Direction issued by the Authority pursuant to CRC13.16.

In the event of the Authority deciding to halt the Project to which this Project Direction relates, the Authority may issue a statement to the Implementing DNO clarifying the effect of that halting decision as regards the status and legal force of the conditions contained in this Direction.

NOW THEREFORE:

In accordance with the powers contained in the LCN Fund Governance Document issued pursuant to Part E of CRC13 (Low Carbon Networks Fund) of the Licence the Authority hereby issues this Project Direction to the Implementing DNO in relation to the Project.

This constitutes notice of reasons for the Authority's decision pursuant to section 49A of the Act.

Rachel Fletcher
Partner, Distribution

[13] As listed in Box 23 of the Full Submission pro-forma.

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Signed on behalf of the Authority and authorised for that purpose by the Authority
17 December 2010

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Appendix P – Scottish Power – Peer review letter

SP ENERGY NETWORKS

22nd of May 2015

To whom it may concern

Re: Low Carbon Hub Closedown Report – Peer Review

I am writing on behalf of SP EnergyNetworks to confirm that I have undertaken a peer review of the WPD close down report for the Low Carbon Hub LCNF Tier 2 project.

In doing so I can confirm that the report is clear and understandable and provides sufficient information to enable a DNO, not closely involved in the project, to effectively consider whether to implement the project's learning in to business as usual activities.

Through this review process I have had an open dialogue with WPD to relay small additions / further clarity on several aspects of the report; I have it on good faith that these will be addressed prior to the report being published.

Yours faithfully

GMURPHY

Geoff Murphy

Technology Development Manager
SP EnergyNetworks