Project FALCON
Knowledge Capture and Dissemination

September 2015

www.westernpowerinnovation.co.uk

WESTERN POWER DISTRIBUTION
FALCON

Contents

Executive Summary

This document provides a summary of the Knowledge Capture and Dissemination (KCD) workstream and stakeholder engagement processes, integrated across each individual workstream of Project FALCON.

The primary role of the KCD workstream was to ensure each specific workstream in the project was actively collecting, recording and sharing learning where possible. The KCD Lead was also to champion this work and collate relevant material for supporting both internal policy change, integration into Business as Usual (BAU) and targeted dissemination areas.

A further portion of this workstream related to stakeholder engagement, from identification, through management of and active interaction with relevant areas. This piece of work was primarily completed by the KCD partner, The Open University (OU). The section on Stakeholder Analysis contained in sections 4-7 is authored by them with the support from the FALCON team.

From the inception of the project, learning was one of the key elements of Project FALCON and our strategy from the start was to consider three main areas throughout the lifecycle of FALCON:

1. What we wanted to learn from the start;
2. What was learnt along the way; and
3. Dissemination of our learning with relevant audiences.

As part of the Project's contractual obligations, there were a number of Successful Delivery Reward Criteria (SDRC[1]) deliverables as well as ongoing internal milestones.

This document will look at the KCD approach as two separate subsets of work – Knowledge Capture and Dissemination, and Stakeholder Analysis and Engagement. It will also look at what has worked well and what could be improved for future projects, both for BAU and further innovation initiatives.

In summary our conclusions are that despite some challenges throughout the lifecycle of the project, there has been valuable learning from it and in particular in the following examples:

- Telecoms: WiMAX is currently perceived to be too high cost when compared against other technologies, however this hypothesis will be tested further as part of the proposed Telecoms Templates Network Innovation Competition (NIC) project;
- Engineering: The energy storage trials delivered strong results, despite still being a high cost to deploy; meshed networks delivered load changes but not on the heavily loaded source breaker during peak; the Automated Load Transfer (ALT) algorithms did have a beneficial impact on losses and overhead minimum voltages whilst Dynamic Asset

[1] These are shown in Appendix B.

Rating (DAR) showed that use of real time dynamic ratings is hugely variable despite the modelling;

- Commercial Trials: deemed widely successful; generating significant learning about how Demand Side Response (DSR) could be utilised by a DNO. It was discovered that whilst the capacity used on the 11kV trial network was indeed useful, there were more significant benefits to be explored on higher voltage networks; and
- SIM: A complex 11kV network simulation system was developed and used to model the network evolution for the trials area forward from 2015, out to as far as 2050 under a range of scenarios. This tool used a detailed nodal model of the network (the subject of the Authorised Network Model workstream). Load models obtained from the FALCON Energy model, a cost model and a large software system centred on a kernel element based on the IPSA power analysis tool. This tool worked but was complex to implement and is being further developed and refined to yield more results in the coming months.

SECTION 1

Introduction & Overview

1.1 Background

Project FALCON was awarded funding in December 2011 by Ofgem. At the proposal stage there were a number of partners who collaborated to deliver the bid - Logica (now CGI), Cisco, Alstom, University of Bath (UoB), Aston University and the IVHM Centre at Cranfield University.

The Project was originally structured around a series of distinct phases, namely: mobilisation, design, build, trials and finally consolidate and share.

FALCON was spread across a set of workstreams, some with dependencies on others, whilst others operated individually. The main workstreams were as follows:

- Engineering Trials – encompassing Dynamic Asset Rating (DAR), Automated Load Transfer (ALT), Meshing and Energy Storage;
- Commercial Trials – encompassing Demand Side Response (DSR) via Distributed Generation (DG) and load reduction (LR);
- The Scenario Investment Model (SIM) – a new 11kV modelling tool developed to consider future network constraints and how to address them; and
- Telecoms workstream – an enable for the engineering trials and also for the LVM data capture which can be used to validate the early outputs of the Energy Mode.

This document will describe our approach firstly to Knowledge Capture (and Management of) and secondly to Dissemination. The final piece of this document looks at the Stakeholder Engagement workstream, a subset of the KCD workstream, led by the OU.

1.2 Scope

The KCD Lead was responsible for developing and coordinating the knowledge capture and dissemination activities of all parties, and managing the relationships initially with the UoB and the OU and more latterly with the OU alone.

The Project Initiation Document (PID) stated that a key requirement was to capture learning, communicate it internally, externally and implement it into ED1[2] and BAU activities, as appropriate.

The Project was required to provide the UK with evidence for the future planning of investment in the electricity grid. In particular, DNOs and power companies not directly involved in FALCON, need to be able to learn from the project and effectively employ its models, methods and insights in the planning and development of their own 11kV networks.

Knowledge arising from FALCON was expected to fall into three broad categories:

- Findings, of interest to the end-users of the SIM (e.g., the SIM's recommendations in given circumstances and the manual for operating it);

[2] RIIO-ED1 is the DNO price control mechanism that has to be approved by Ofgem

- Knowledge about the processes involved in the SIM's development, (e.g., how decisions were made, what solutions were rejected and why); and
- Public knowledge and attitudes about low-carbon power (which will be evaluated and influenced as part of FALCON.

Within the first category – the core findings of the project – there are two subcategories of learning:

- Learning from the physical testing that will be carried out to inform the SIM (e.g. load testing of cables) and
- Learning from the SIM's development and use.

To maximise the value of the knowledge generated by the Project it must be recorded, stored, effectively shared with the right parties, resulting in appropriate learning and behavioural change and the relevant dissemination to appropriate stakeholders and/or customers where appropriate.

The Project was required to produce new policies for transferral into BAU where new procedures or new technology are developed and adopted for use in the Business.

The Project was also required to inform internal knowledge management procedures to support best practice in both low carbon and BAU work.

The KCD lead took over responsibility for those aspects of the workstream that were originally envisaged as within the UoB scope, with the exception of Stakeholder Engagement analysis which contracted directly with the OU as opposed to sub-contracted in the previous arrangement. In addition the KCD lead took a more proactive role over the selection of events and coordination of dissemination activities.

SECTION 2

Approach

2.1 Approach to Knowledge Management

During the bid and design phases, the UoB were the appointed project partner to capture knowledge and support dissemination accordingly.

Following a period of review and discussion after the start of the build phase it was decided that KCD should be brought in house within the project team and the existing partner contract was ended. It was felt that by having such a key part of the project both on site and led by a team member with a DNO background, it would be more productive and deliver the quality expected by a project such as FALCON.

The existing approach was re-assessed and an adapted KCD strategy agreed with Ofgem as part of a formal change to the project.

Each Workstream Lead was expected to retain an ongoing learning document, with this working best in the Telecoms workstream, with a diarised storybook being retained by the Lead. Whilst this enabled the ongoing capture of learning, it also provides a historic detailed record of the both the benefits and challenges of some of the process. This approach is being considered as the most successful, cost effective way of individual leads maintaining a personal record.

Below, we go on to describe the “revised” KCD approach and how KCD was managed within the confines of the project.

A number of formats and regular review points were agreed with each team member at the outset – this ranged from group workshops and team meetings, through to individual interviews and site surveys or accompanied visits, with each approach tailored to the relevant personnel to limit intrusion, but maximise effectiveness.

During the bid and design phase, a number of questions were posed that were expected to be relevant to each workstream and these were retained as the early learning outcomes. If they began to fall out of scope, or became less relevant as the project moved along, this would be captured in the progress reports. An example of these, published in our original Project Initiation Document (PID) is shown in Appendix A.

This began to grow a suite of early learning outcomes and led on to form wider high level topic areas, expected to be key to discovering how each of the techniques could be relevant to the industry, to each other and to inform next steps. Figure 1 below, provides an indication of how it was expected these outcomes would be addressed. I.e. by moving them from concept, into WPD Policy and/or disseminating them into the relevant stakeholder section.

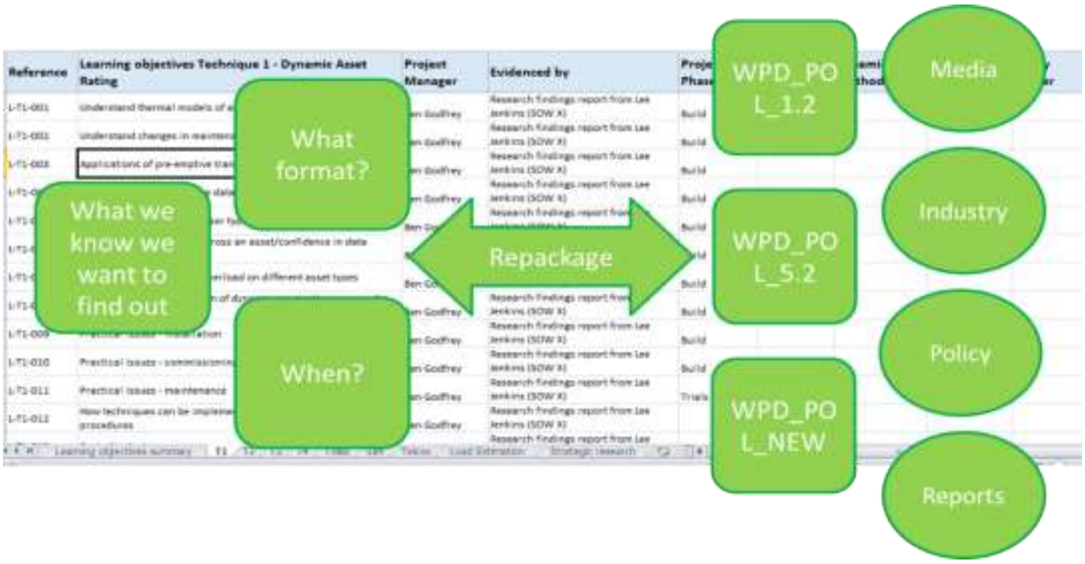

Figure 1 – Learning Outcomes

Whilst these early outcomes provided somewhere to work from, there was as much desire to discover and capture the learning that was not predicted or foreseen.

The very nature of an R&D project did mean there was likely to be 'negative' learning, so every effort was made to continue to communicate this across the team on a regular basis. Where something may have been a challenge for FALCON, it remained vital that this was communicated to our colleagues elsewhere to ensure the same path was not followed, or to simply allow the industry to benefit from FALCON's new learning. When a process didn't go according to plan or deliver the anticipated results, it was important to reinforce this fact to maintain the KCD strategy.

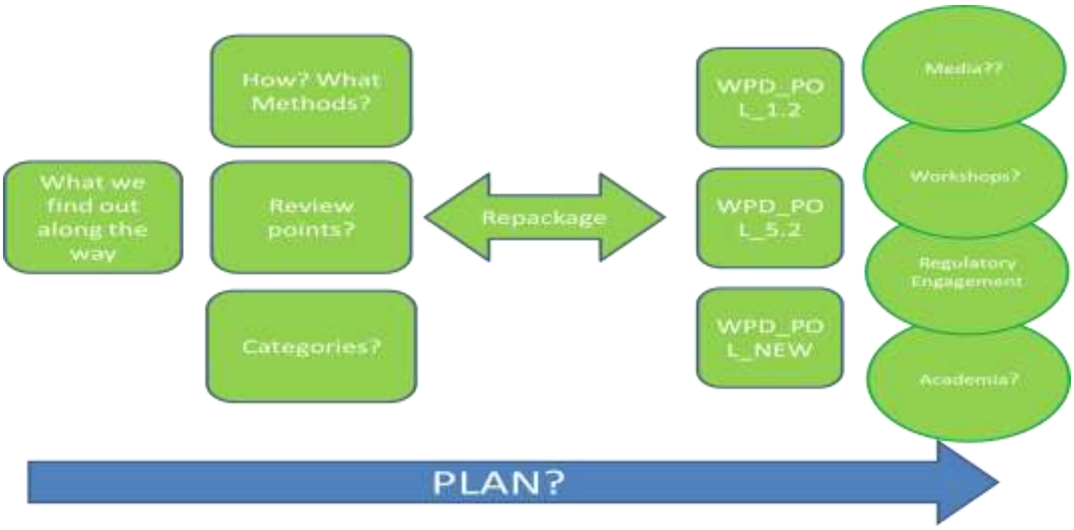

Figure 2 New Learning

A purpose made spreadsheet was developed, to allow smaller pieces of learning to be captured on a regular basis across each workstream area. The intention being that both throughout the Project and towards the end, each area of learning could be shared on a targeted basis, as opposed to a blanket approach, which given our experience to date on similar projects across the industry, had led to broader dissemination schemes. We felt that by maintaining tighter grouped areas of knowledge, we could offer more to our stakeholders in a targeted approach.

The spreadsheet was built to encompass the ‘what do we want to learn outcome’ and integrate the key ‘what did we pick up along the way’ outcomes. Each line item would be assigned an owner, a timestamp, how/if it was integrated into BAU and where it would be disseminated, where relevant.

As the Project progressed, it was agreed to cluster these learning outcomes into a hierarchal format to make it easier for both reporting and recording in the future and to balance the volume of smaller learning areas that was being collected.

The simple learning hierarchy is described in the picture in Figure 3 below, with learning outcomes being grouped into a learning topic.

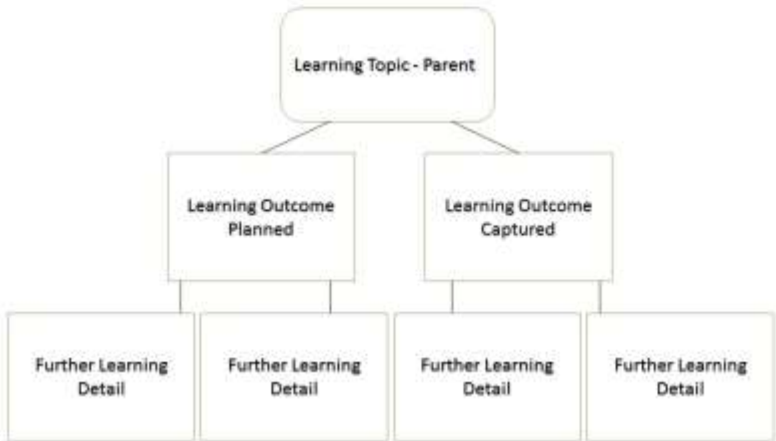

Figure 3 – Learning Hierarchy

This approach allowed any detail to be collated at any level before being added to the database of learning for the Project. Furthermore, by developing broader learning topics for each workstream, the reporting process was supported with a structure as the Project drew to a close. Again, this also went on to inform our dissemination strategy and areas of relevance pertinent to each stakeholder grouping.

As the Project closed out, the data could also be retained by WPD for research in the future or to reflect on what worked when re-developing processes and technology.

At the outset of the Project, each learning outcome, topic area or item of knowledge capture was to fall into one of the eight categories covering WPD's low carbon learning:

- Customer Engagement;
- Project Management;
- Construction Process;
- Technology & Equipment;
- IT & Telecommunications;
- People and Culture;
- Industry Processes & Regulation; and
- Stakeholder Analysis.

Each area of learning is linked to the relevant category allowing WPD to take a view at a high level, how each of their innovative projects informs the industry, or the business and more importantly in what area.

From the outset, it was understood that FALCON would deliver heavily in learning around Technology & Equipment and IT & Telecommunications, as opposed to Customer Engagement, for example. Whilst FALCON was designed to support the customer, much of the work related to 'behind the scenes' developments as opposed to customer change or interaction, with the exception of the DSR trials. This resulted in wider interest from technology providers, other industry members and engineering stakeholders.

2.2 Approach to Dissemination

A balance between those things that would be done in BAU, such as wider industry event appearances, through to arranging specific FALCON engagement events was needed throughout. Whilst the desire to benefit from the multitude of conferences in the UK was there, it was also apparent that these had to be selected carefully, as both preparation time and indeed the event itself invariably required a large amount of resource.

The mobilisation through to mid-build phase was managed by the University of Bath appointed at the outset. The initial plan was to disseminate learnings using a number of communication vehicles. These included a bespoke Low Carbon UK website managed by University of Bath, as well as a number of podcasts designed by University of Bath and The OU along with a regular newsletter.

During the Build phase, University of Bath were replaced and an in house appointment was made, as explained in the previous section.

As such, the approach was updated to take a more targeted stakeholder engagement view and utilise as many cost effective measures as possible. A workshop led by the FALCON KCD Lead including Corporate Communications, the FALCON Project Manager and the outsourced PR unit was held, to identify and agree an updated strategy for dissemination. Whilst digital media, such as podcasts, remains popular and effective, it became time consuming and it was felt as much could be made through exploiting as many other channels as possible, except without the added costs of digitisation.

The Communications Plan was updated accordingly and the role was split into two key areas – internal direct dissemination and external dissemination. The plan was adopted to integrate both the measureable dissemination pieces, such as the SDRC requirements, as well as those focussed on other key areas of the industry.

The internal piece of work was aimed to both increase awareness inside WPD, and begin any transfer into BAU of technology, via normal policy channels, as well as raise the project profile with a series of articles in the internal company magazine, Powerlines, distributed to 30,000 employees past and present. An internal bulletin board on the Corporate Intranet to support informing the business was also created.

The SIM workstream also engaged with a user group containing both strategic planner users and 11kV planners. A regular newsletter for this user group was also issued.

External dissemination was made up of a number of different channels including:

- The completion of the existing podcasts from University of Bath;
- A FALCON Newsletter – explaining and sharing direct data from each of the FALCON Workstream areas;
- WPD Innovation Online – a refreshed FALCON website to include all documentation published to date and media links;
- Social Media – a new social media channel was created to embed the technique videos, podcasts and dissemination events. A LinkedIn profile was also created to share event details;
- Dissemination Conferences – WPD led conferences were planned to share major milestones and achievements;
- Speaking Roles – a number of wider industry events were targeted for specific engagement purposes and to consult with stakeholders on results and findings; and
- Model Presentations – the FALCON team presented at larger events as well as smaller more niche areas, utilising the innovative technique display models that were designed and built.

Table 1: Dissemination Soundbite

Sean Rendall
‘Thameswey recognised FALCON as an opportunity to add value to our distribution networks by enabling further participation in Demand Response schemes. The presentation to our board was useful to gain support for this drive into innovative schemes.’

Source: Sean Rendall, Operations Manager, Thameswey Group (FALCON Commercial Trials Participant).

Being conscious of the levels of dissemination, one of the aims was to consider how many dissemination channels there were, the cost and associated carbon footprint with each of them and any quantifiable measures available, such as footfall, questions or direct feedback. Whilst some of the events are widely attended, it was most relevant to the team, that the attendance be relevant to the project and not become a wider DNO stakeholder session, for which other major events were held.

The external dissemination also encompassed more formal contact with our colleagues in the industry and those involved in policy. A number of SDRC targets were agreed and amongst these, a number of different consultations were both necessary and useful to achieve them. Whilst this meant feedback was an important next step, it also provided the industry an opportunity to consult on our proposal and benefit from any learning available at that time.

A year planner was designed, with resource borne in mind, to ensure that the KCD Lead, Project Manager, Programme Manager and Project Sponsor had clear dedicated timeslots to engage with internal and external stakeholders.

Table 2: Presentation Soundbite

Robert McNamara
'Our joint dissemination event with the WPD FALCON team was a real chance for our stakeholders to learn more about the Project and really engage the key players in feedback.'

Source: Rob McNamara, Executive Director, SmartGridGB/TechUK.

The FALCON speaking and stakeholder facing engagements varied from formal presentation events, such as that at MK Dons, to local informal briefing sessions with technology providers, partners and industry stakeholders.

It was at this early stage, on reflection, that one of the best dissemination pieces was created in the form of five interactive models demonstrating the four engineering techniques and DSR. Whilst the models were effective in communicating stand alone, they were convenient enough to be able to present to any audience, from children, to Senior Engineers simply by altering the explanation to the suit the person/s listening. Figure 4 shows some of the many events the models were displayed and demonstrated at.

Further detail on our dissemination activity is included in Appendix C of this document.

Figure 4: Varied FALCON Speaking Engagements

Source: FALCON Team

2.3 Stakeholder Engagement

The OU were retained after the University of Bath contract ended, to continue in their support capacity. As a local stakeholder they were engaged to support the KCD workstream through stakeholder analysis, qualitative analysis and assist with the dissemination activities in general.

The purpose of stakeholder analysis was to identify priority stakeholders and modes to manage relationships with them. The approach to stakeholder analysis in this project defines a stakeholder as:

'Any group or individual who can affect or is affected by the achievement of the organisation's objectives' (Freeman 2010:46)[3].

Prioritising stakeholders was an ongoing process undertaken by members of the FALCON team. Specialist inputs in stakeholder engagement were supplied by the OU team to support this ongoing process.

The early approach was to identify those associated with FALCON and identify categories for each grouping. This was to follow a project-centric logic with priority stakeholders identified in light of the project objectives.

Engagement was undertaken iteratively, consequently stakeholder engagement was modified as the Project progressed and new stakeholders joined or emerged. Priority stakeholders were identified during the mobilisation, design and build phases and modes of engaging them were identified. As the build phase moved into the trials phase these were further developed to allow appropriate dissemination and engagement during the conclusion(s) and sharing phases.

The broader approach to stakeholder engagement was to stimulate a two-way dialogue with stakeholders involved in FALCON providing and gaining meaningful feedback. This was done by using three wider modes of engagement:

1. **PASSIVE:** Informing/explaining – the release of information to stakeholders as a means to be open and transparent about the objectives. Information includes decisions taken by the Project that may affect or be of interest;
2. **INVOLVED:** Consultation – engaging stakeholders to provide advice on the Project's decisions and/or objectives;
3. **ACTIVE:** Collaboration/partnership – looking to achieve objectives that are mutually beneficial to both the Project and the stakeholders involved.

As the Project progressed into the trials phase, it was expected that from a number of events, semi-structured interviews and discussions, both internally and externally, a solid level of understanding could be achieved.

[3] Freeman, R, E., 2010. Strategic Management: A Stakeholder Approach (digitally printed version). Cambridge University Press, UK.

This stakeholder engagement piece was also designed to continue throughout the Project internally, to look at both cultural change, awareness and impacts the Project had across the key internal stakeholders. A series of interviews, meetings and workshops were conducted internally throughout the FALCON lifecycle, by the KCD Lead supported by the OU. These were with relevant members of the Business and the Project, with a focus on, but not limited to:

- The Future Networks Manager – responsible for all innovation activity across WPD and Programme Manager for both FALCON and other similar schemes;
- The Distribution Manager – responsible for the entire geographical area where the FALCON trials operated;
- The FALCON Project Manager – responsible for the day to day operation of FALCON and any additional liaison between the Business and the Project team;
- The FALCON Workstream Leads – both contracted specialists and internal Future Networks team members;
- FALCON Engineering – both BAU team members and FALCON specialist staff involved in the installation and operation of FALCON systems; and
- Project Partners – those providing specialist support roles such as CGI.

There were also a number of more informal sessions with installation teams and fitters who were involved in the actual installation and/or operation of some of the engineering and communications equipment. Much of this was completed on site to capture changes, improvements or to support the writing of reports, dissemination pieces or internal policy submissions.

Table 3: Consultation Soundbite

Ian Cooper
'We (UK Power Networks) really appreciated our knowledge sharing visit to FALCON's energy storage project and found it useful to attend. Seeing first-hand the equipment installed and being able to discuss insights from the FALCON team was helpful in preparing for the operational phase of the Smarter Network Storage project.'

Source: Ian Cooper, Smarter Network Storage, Future Networks, UK Power Networks.

SECTION 3

Key Findings – Knowledge Capture & Dissemination

3.1 Knowledge Management

A number of areas of knowledge management grew during this Project and the approach has both informed and supported other similar projects in house.

Historically BAU projects have been solely engineering led, with fewer research and development projects taking place in the areas across low carbon development. Whilst the Project was keen to learn in the defined scope of itself, it was also expecting to support best practice in knowledge capture and dissemination as a whole.

Overall, the Project can be deemed successful in terms of knowledge gained in new areas. Whilst the team remained keen to alleviate every small challenge where possible, the very nature of an R&D project is to identify where these types of challenge actually exist.

The Project produced vast areas of learning for both WPD and the industry. There are some key points coming from the process, including:

3.1.1 Key Learning

- Due to the nature of the business operations, with maximum cyber security and thus limited external connectivity, much of the KCD process operated independently of the main business unit;
- The geographic spread of the main business unit, the Project partners and the specialist support staff meant that regular team days were crucial in the early parts of the Project;
- The original KCD Lead was a remote academic partner. Whilst their approach differed from the in house lead, it became apparent that having this role at the heart of the Project on a daily basis, not only allowed the ongoing championing of the role, but also the effective support of it;
- Conflicting workloads for required staff need to be prioritised in advance in accordance with the Project plan;
- Contract and partner management requires a thorough approach and regular agreed review dates to ensure the scope remains fit and the deliverables on target; and
- A pre-planned programme of events and review points with relevant parts of the business to be agreed at the outset, with defined dates clearly identified and made known.

3.1.2 Recommendations

- The early development of an online repository and/or library for the both the internal capture of knowledge and a separate managed output direct to the internet for external knowledge sharing; and
- The build of a suitable database to replace the spreadsheet formats to aid in knowledge capture.

3.2 Dissemination

It was identified early on that dissemination is a large area and certain parts of the Project would naturally attract more attention than others. For example, as energy storage became a more exciting global topic as FALCON progressed, more interest was received in this area of the Project. The real benefit of this type of increase to Technology Readiness (Levels) being that organic dissemination was produced i.e. specific information requested from FALCON without a substantive need to carry out stakeholder analysis (or the identification of stakeholder groupings).

There is a large industry in media and dissemination itself and along with this comes fairly regular requests for speaking appearances or content provision for many of the utility, smart grid or innovation conferences.

The Project was very keen to maintain the best use of resource and time, bearing in mind the carbon footprint of travelling great distances for short periods of time.

Some areas of dissemination were far more successful than others and some much more cost effective than others.

3.2.1 Key Learning

- The dissemination plan worked well. With a plan to complement the stakeholder engagement strategy, planning the year ahead to meet targets and deliverables (such as SDRCs) was generally successful. Such plans need to be reviewed every month to ensure maximum resource efficiency when taking into account team members geographic spread;
- After the appointment of an in house lead, the volume of digital output that was in the original plan was reduced. Podcasts and digital media are effective tools for communication, however, there were more cost effective communication methods available, such as a regular industry newsletter and the utilisation of existing social media channels (the WPD YouTube channel, Twitter and LinkedIn profiles were all created during FALCON);
- By far one of the most successful pieces of commissioned work, was the design and build of a suite of interactives models that demonstrated each intervention technique. The models were designed so the presenting part could effectively target them at any audience whatsoever. They are shown here;
- Some Project areas naturally attracted significant interest over others. For example the development of electrical energy storage during the Project allowed for organic dissemination as the findings became more apparent;
- It became clear that certain areas were more suitable to certain audiences rather than the previous, one size fits all methodology. With such a wide ranging Project scope and moreover, set of findings, we have found the stakeholder groupings much more relevant to disseminating more detailed findings;
- The webinars conducted in the later stages were very successful indeed. With zero travel necessary, it was estimated that for an audience of 50, at an average journey time of two hours return, a broad economical saving was made of ~100 people hours. On top of this, the carbon footprint was negated completely; and

- By directly engaging editorial staff, we ran a number of in print and online feature articles in many of the mainstream industry publications, including E&T (The IET's magazine), Utility Week and tdworld.com.

3.2.2 Recommendations

- Customer engagement for this Project was lower than other similar projects across the business. This was due to the engineering and 'behind the scenes' software driven targets, however, we believe a demonstration day, or event, could have been held for local residents both at the depot and at a key town centre location to show how DNOs are working towards the future together;
- Schools engagement requires a significant amount of planning when compared to normal dissemination channels. Whilst FALCON was successful in presenting to local schools, it became more apparent that dovetailing into both academic years, appropriate school children and planning outings was very hard. The process for example, to invite a group of science and engineering students, to the Project depot in Milton Keynes, was arduous as both a number of pre site checks, permits and written permissions were required well in advance, making it too late for this Project to continue with a visit;
- WPD worked with a local energy charity with existing relationships, to expedite engagement with Industrial and Commercial organisations within the trial area, for the purposes of identifying potential participants for the commercial trials. It was apparent after a very short period of their attempted engagement that they would either require significantly more training or strict limits on the extent of the discussions into which they could participate alone. In order to manage the accuracy of any public message, WPD needs to maintain ownership of the process and ensure that the process is strictly monitored; and
- When engaging potential participants for DSR, many of the industrial and commercial facilities within the trial area are owned by National or International organisations. This typically resulted in any decision makers and key stakeholders who required to be consulted, being located outside the trials area of the potentially the entire DNO license area. This will need to be addressed as this work moves towards BAU.

Table 4: Dissemination Soundbite

Mei Lin Lim
'Malaysian utility, Tenaga Nasional Berhad's (TNB) visit to Western Power Distribution was very informative. The openness in knowledge sharing on FALCON engineering trials, Cisco technology on the communications as well as areas of other consideration, has given useful insight which has helped TNB's Smart Grids plan in moving forward.'

Source: Mei Lin Lim, Cisco APAC, Singapore Division.

SECTION 4

Stakeholder Analysis

4.1 Summary for Decision Makers

The following section on Stakeholder Analysis is written by the OU team, engaged to support the KCD workstream.

This section of the report focuses on stakeholder engagement undertaken as part of FALCON with reference to two of the larger workstreams of commercial trials and energy storage. Whilst ongoing stakeholder engagement took place across all workstreams, these two areas had greater interaction with end energy users, third parties and other parts of the industry. Interviews and workshops were held with all key actors organising and participating in the FALCON trials.

A dialogue-based mode of stakeholder engagement between the interviewer and interviewees allowed feedback from priority stakeholders and multiple perspectives on the FALCON trials to be gained.

The FALCON commercial trials have made the following contribution to developments of DSR on the distribution network level:

- **Network Scale and load profiles**: DSR may be more suitable on the 33kV or 132 kV networks rather than the 11kV network as this provides the critical mass of organisations with distributed generation and/or load reduction capacity from which DSR can be sourced. However, some big cities may have sufficient potential energy partners within 11kV areas;
- **Commercial viability**: Distribution Network Operators (DNO) can deploy DSR to manage network constraints and defer capital investment needed for reinforcement measures. The cost of reinforcing distribution networks increases with voltage levels, so deploying DSR on the 33kV or 132 kV networks may therefore be most commercially viable; and
- **Contractual arrangement**: The contractual arrangements developed in FALCON's commercial trials were influenced by the broader developments in the DSR market. The shared service concept initiated in FALCON and further developed by the Electricity Network Association (ENA) aims to promote interoperability between DSR programmes. This could enable organisations with DSR capacity to take part in several DSR programmes. Benefits that DSR may provide to organisations participating in such programmes includes additional revenue streams, contribution to energy and carbon management and enhanced corporate social responsibility credentials. However participation in DSR should not restrict core business operations. Further detail is included in the Commercial Trials final report.

For the commercial trials we conclude that development and implementation of DSR to be used on the distribution network as a standard technique is likely to require further process and institutional innovation. Institutional innovation to enable DSR refers to change in the formal and informal rules of how things are done to facilitate DSR arrangements between a DNO and its network customers. Such arrangements could mean that DNOs can be involved in energy partnerships with network customers that have DSR capacity. Process innovation to enable DSR refers to changes in processes necessary for both DNOs and potential energy partners to operate and manage DSR. The FALCON commercial trials show that relationships between DNOs and potential energy partners can be made both with and without aggregators.

The engineering trials included energy storage techniques such as new battery technologies that allow the flow of power from the network to be managed as batteries are charged or discharged. Technically this was successfully demonstrated, but the cost was uncompetitive compared to conventional network reinforcement. Additionally, even if energy storage is useful for DNOs, current regulations prevent them from owning assets such as batteries as they invoke a form of energy trading, an activity in which a DNO cannot engage without correct licensing in place. Thus institutional structures (such as regulations) need to be taken into account when developing and implementing novel techniques.

The findings of stakeholder engagements in the engineering trials can be structured around three inter related aspects:

1. Technology;
2. financial and commercial; and
3. institutional and regulatory.

This framework for analysing the engineering aspects of the FALCON trials may help identify important insights to disseminate to relevant audiences.

4.2 Introduction to Stakeholder Engagement

This presents key insights gained from stakeholder engagement undertaken by the OU's FALCON team[4]. This section is structured as follows:

- Introduction;
- Method;
- Findings;
- Comparative Analysis;
- Discussion; and
- Conclusions

4.3 Approach to Stakeholder Engagement

The approach to stakeholder engagement in FALCON followed a project-centric logic as presented in section 2.3. Stakeholders were engaged in an ongoing process involving three interlinked components:

1. **Project objectives and development phases**. This refers to the overall objectives of FALCON and the phases through which it developed. Three main project phases were delineated: 1) Project set up, design and build; 2) Project trials; and 3) Conclusions and

[4] Matthew Cook; Per-Anders Langendahl; Helen Roby; Trevor Collins; and Stephen Potter

sharing. Rationales for engaging stakeholders in these phases were determined by the FALCON project objectives and modified as the project developed.

2. **Prioritising stakeholders**. This refers to the process of identifying stakeholders that are relevant to the project's phases and outcomes[5]. Stakeholders associated with FALCON were categorised and priority stakeholders identified such as trial participants (e.g. aggregators and industrial or commercial customers), members of the FALCON team and/ or WPD.
3. **Modes of engagement**. This refers to various strategies for engaging prioritised stakeholders using the ladder-model (Arnstein, 1969[6]), which illustrates the level of stakeholder participation in different modes of engagement. Three discrete modes of engaging priority stakeholders were identified: 1) Informing/ Explaining; 2) Consultation, and 3) Collaboration/ Partnership. These modes of engagement are described below and in Appendix E.

These modes of engagement (i.e. informing/ explaining, consultation and collaboration/ partnership) were variously deployed in FALCON to engage priority stakeholders. For each mode of engagement, the following methods were identified to engage stakeholders:

- **Informing/ Explaining**: This mode of engagement was deployed in FALCON to inform and/ or explain particular aspects of the project to stakeholders and to disseminate project findings. For example, podcasts were produced and physical models developed for each FALCON technique. These podcasts and models are displayed on the project website and the models are also used to showcase FALCON at public events. Other methods deployed in FALCON to inform aspects of the project to stakeholders include newsletters and social media. Reports and presentations were developed to disseminate project findings;
- **Consultation:** This mode of engagement was deployed in FALCON to enable feedback to be secured from priority stakeholders involved in the project trials. For example, a series of semi-structured interviews were conducted by the OU team with stakeholders involved in the commercial and engineering trials. Other forms of consultation took place in FALCON, such as workshops with participants in the FALCON trials; and
- **Collaboration/ partnership**: This mode of engagement was deployed in FALCON with stakeholders involved in the project lifecycle. For example, Cranfield University is a partner in FALCON and involved in the development of the SIM.

This section of the report is largely concerned with the insights gained from FALCON stakeholders using a consultation mode of engagement based on two-way dialogues. This mode of engagement enabled lessons learned about the techniques deployed in FALCON to be identified. Lessons learned from stakeholders matter for two reasons. First, the trials needed stakeholder inputs in order to proceed. For example, the DSR trials in FALCON needed inputs from aggregators and Industrial and Commercial network customers participating in the trials providing DSR capacity. Thus, insights on such stakeholders' roles in, perspective on and experience of the trials were important. Second, insights gained

[5] Please see section 2 on methods selected for identifying and prioritising stakeholders

[6] Arnstein, S. R., 1969. A Ladder of Citizen Participation. Journal of the American Institute of Planners, V. 35:04

from FALCON can inform subsequent smart grid initiatives based on techniques that augment the management of electricity distribution networks.

4.4 Stakeholder Analysis Methodology

This section describes the methods selected and used for identifying and prioritising stakeholders and to collect and analyse data from prioritised stakeholders.

A stakeholder analysis was undertaken as part of FALCON to identify stakeholders. This stakeholder analysis broadly followed the approach identified by Frederick et.al. (1988):

- Map stakeholder relations by assessing groups or individuals who can affect or are affected by the organisation's objectives;
- Map stakeholder coalitions, e.g. developing stakeholder categories;
- Assess the nature of stakeholder's interests and power;
- Construct a matrix for prioritising stakeholders;
- Develop strategies for stakeholder engagement; and
- Monitor changes in organisations objectives and shifting stakeholder coalitions;

Stakeholders were identified in ongoing review meetings by the OU team with members of the FALCON team, notably the KCD Lead. An internal workshop was also organised by the OU team in collaboration with members of the FALCON team to identify and prioritise stakeholders. Participants at this workshop reviewed selected work streams in FALCON (e.g. the commercial and energy storage trials) to identify modifications of these work streams, including roles and relations with stakeholders, and prioritise stakeholders with whom to engage in dialogue based consultation.

Qualitative data were collected via semi-structured interviews. This approach stimulated a two-way dialogue between the interviewer and interviewees and was therefore consistent with the consultation mode of stakeholder engagement. Data were collected from the following priority stakeholder groups engaged in the project trials:

- **Aggregators**: Organisations that specialise in DSR and who participated as suppliers to FALCON to facilitate the commercial trials;
- **Participating organisations**: Non-domestic network customers (e.g. Industrial and commercial electricity customers) that participated in the commercial trials by providing DSR capacity; and
- **Internal actors**: Individuals employed by the FALCON project and/ or WPD.

4.5 Data collection

Data were collected from priority stakeholders detailed above to gain in-depth insights on FALCON. As such data were collected on priority stakeholders' roles within, perspective on and experience of the FALCON trials. Methods identified to collect data included interviews and workshops and are described subsequently.

4.5.1 Interviews

A total of 26 interviews were conducted with priority stakeholders associated with the engineering and the commercial trials. These semi-structured interviews were based on a set of themes and questions (see Appendix H), which were prepared before each round of interviews. Importantly, the semi-structured approach enabled further questions to be asked as interesting lines of enquiry opened up during the interview. This approach allowed interviews to proceed in an open-ended and flexible manner (Robson, 2011[7]) and was consistent with the consultative approach to stakeholder engagement. An interview guide[8] was developed and included:

- A list of interviewees;
- A set of prepared interview themes; and
- An interview schedule.

The interview guide was developed in an iterative fashion. Interview themes and questions were developed for the first round of interviews. Findings from the first round of interviews informed subsequent interviews until the trials were completed.

The majority of interviews were audio recorded and transcribed for analysis. Two of the interviews conducted with internal stakeholders were not audio recorded for practical reasons, but detailed notes were taken during these interviews. Good access to internal stakeholders enabled notes to be subsequently clarified to validate the data collected and facilitate subsequent analysis.

4.5.2 Workshops

Workshops were completed to collect data from internal stakeholders in particular. This method was selected as it enabled a multi-way dialogue between workshop participants to be developed on particular aspects of the trials. Three workshops were organised by the OU team in collaboration with the FALCON KCD Lead. The focus of these workshops and participants varied:

- The first workshop focused on identifying an approach to stakeholder analysis and engagement in FALCON. Participants at this workshop included the OU team and members of the FALCON team representing both the engineering and the commercial trials. An approach to stakeholder analysis was presented at this workshop by the OU team to members of the FALCON team. The outcome of this workshop was an agreed approach to stakeholder analysis and engagement;
- The second workshop was led by the OU team to review selected work streams in FALCON, notably the commercial and energy storage trials, identify modifications in these work streams, including roles and relations with stakeholders, and prioritise key stakeholders to engage. Participants at this workshop included the OU team and members of the FALCON team, notably, the project manager, the knowledge capture lead, the commercial trials lead and the engineering trials lead. The outcomes of this

[7] Robson, C., 2011. Real World Research (3rd Edition). John Wiley and Sons, Ltd, UK.

[8] Please see Appendix H for the complete interview guide

workshop included 1) a list of stakeholder groups, and 2) potential stakeholders to engage via interviews; and

- The third workshop was led by the OU team to identify lessons learned about the commercial trials in light of the feedback gained from stakeholders involved in these trials. Participants at this workshop included the OU team and members of the FALCON team, notably the Commercial Trials Lead, the KCD Lead and the Project Manager. Insights gained from stakeholder interviews were presented to participants at this workshop, which stimulated a discussion that focused on developments of DSR on distribution networks. The outcome of this workshop included 1) lessons learned about the commercial trials gained from stakeholders involved, and 2) the contribution of the FALCON commercial trials to the development of DSR on distribution networks

4.6 Data analysis

The purpose of data analysis was to interpret, quantify and make sense of the feedback on the FALCON trials gained from stakeholder interviews and to identify lessons learned about the FALCON techniques. Since data collected via interviews are rich and complex textual narratives, we followed Miles and Huberman's (1994) approach to data analysis which reduces data to something that is manageable and enables meaningful interpretations to be made. A flexible template approach based on three interlinked elements was selected for this purpose:

- Data reduction: The process of reducing a large amount of data into something that is manageable;
- Data display: Presenting data in a meaningful way; and
- Drawing conclusions: Identifying what the data has to say.

Analytical categories were developed to allow the large amount of data collected to be clustered into key themes. Here, initial analytical categories were consistent with the interview themes, while new themes emerged as data analysis proceeded. A number of tables (please see section 3) were also developed to present data in a meaningful way. Conclusions were subsequently identified. An overview of the analytical categories for each stakeholder group is presented in Table 4.

Table 5: Themes for data analysis

Stakeholder groups	Analytical categories
Aggregators	Business activities and core skills. Motives for participating in the trials. Role in the trials. Comparing generation with load reduction. Performance reliability. Future development in the DSR market and the role of aggregators in particular.
Participating Organisations	Business activity and energy consumption. Motives for participating in the trials. Role in the trials.

Stakeholder groups	Analytical categories
	Future development in the DSR market and the role of participating organisations in particular.
Internal Stakeholders	Role within WPD and/ or the FALCON trials. Purpose of the trials. Success and challenges in implementing the trials. Key lessons learned so far into the trials.

Data collected via interviews with stakeholders from the groups detailed above were analysed and findings generated for each group, which are presented in the next section.

SECTION 5

Key Findings from Stakeholder Engagement

5.1 Introduction

This section presents the results from interviews for both the engineering and commercial trials. Results from interviews are presented for each stakeholder group and structured around the analytical themes. These results were also detailed in interim reports produced by the OU team, including a section in the final FALCON report on the commercial trials. In the final FALCON report on the commercial trials, findings from stakeholder interviews emphasised differences and similarities between seasons 1 and 2 of the commercial trials. In this report, results from stakeholder interviews are presented in aggregate form.

5.2 Aggregators in the FALCON commercial trials

In Table 4 we present the results from the interviews with aggregator firms. These specialist firms operate in the DSR market and joined FALCON to identify and recruit participants that were physically located in the trial area and could provide DSR to FALCON's commercial trials. These commercial trials were undertaken over two winter seasons; season 1 was from November 2013 to February 2014 and season 2 from November 2014 to February 2015.

Table 6: Themes for analysis and results from interviews with aggregators

Themes for analysis	Results from interviews with aggregators
Business activities and core skills	Firms specialising in DSR, an energy capacity service offered to utilities, e.g. the National Grid. Core skills include 1) Understanding the user cases for DSR, 2) Establishing relationships with energy partners[9] to provide DSR, 3) Co-developing DSR programmes, and 4) development and use of control and monitoring equipment to manage DSR.
Motives for participating in the trials	The LCNF projects led by DNOs, including FALCON, may provide commercial opportunities for aggregators and grow the DSR market.
Role in the trials	Aggregators played an intermediary role in the trials. They were asked to provide distributed generation[10] and/ or load reduction from their energy partner's sites as requested by the FALCON trials. Aggregators were unable to identify adequate sites that would reduce load for the FALCON trials. DSR sites for generation were successfully supplied.
Comparing generation with load reduction	Since load reduction involves turning equipment down or off, it must be carefully managed as it may affect the energy partner's business operations. An advantage of load reduction for the energy partner is the knowledge they may gain about their energy consumption from undertaking a site survey with the aggregator. However, energy consumption identified for DSR via

[9] 'Energy partner' is a term used in the DSR market and refers to an organisation (e.g. non-domestic electricity users) that provides DSR to the market in collaboration with an aggregator. In FALCON, organisations providing DSR to the FALCON project are called 'participants' in the commercial trials.

[10] Distributed generation (DG) is also known as embedded or dispersed generation. DG is electricity generating plant that is connected to a distribution network rather than the transmission network (Ofgem online, 2015, available at: https://www.ofgem.gov.uk/electricity/distribution-networks/connections-and-competition/distributed-generation)

Themes for analysis	Results from interviews with aggregators
	load reduction may lead to continued reduction of energy consumption rather than temporary reduction, which limits the capacity available for DSR. DSR in the form of generation is therefore favoured over load reduction because it can be managed with limited impact on clients' business operations. An advantage for energy partners using generation is the opportunity it presents to test and maintain electricity standby and backup equipment[11].
Performance reliability	Performance reliability refers to the consistency of the DSR capacity provided by an aggregator and/or participating organisation. To ensure performance reliability and avoid failure to respond to a DSR call, the following strategies can be deployed by an aggregator: 1) an aggregator can establish relationships with several energy partners and develop a capacity buffer to ensure that more capacity is available than asked for by a DSR user (e.g. a DNO); 2) develop engineered solutions (e.g. smart metering equipment) to monitor energy partner's site and performance associated with DSR; 3) develop and maintain a technology platform (e.g. a control room) that can oversee DSR capacity available and the demand for DSR on the market. Aggregators also noted that purchasers of DSR such as the National Grid and DNOs should offer sufficient payment for such services to secure necessary investment. In addition, by establishing enduring DSR programmes in the market that allow for long-term contractual arrangements between aggregators, its energy partners and users of DSR (e.g. DNO), this could help improve performance reliability among suppliers of DSR and help secure returns on investment for aggregators.
Comparing FALCON with other DSR programmes	Notification of dispatch: This was altered from a 30 minute notification in the first set of trials to a one week notice to participating organisations and aggregators in the second set of trials. This change enabled aggregators and participating organisations to better plan DSR activities and continue to engage with other DSR programmes such as Short Term Operating Reserve (STOR)[12]. Other DSR programmes tend to have much shorter time interval between requests and dispatch, e.g. minutes. Mode of dispatch: The FALCON trials did not have automated dispatch, which is a common feature in more enduring DSR programmes such as STOR involving a large number of service providers. This reflects the short term nature of the FALCON trials. As such automation may form a part of subsequent DSR initiatives that are business as usual (BAU) for DNOs. Payment structure: The FALCON trials offer payment for utilisation only, whereas many other DSR programmes such as STOR offer payment for both availability and utilisation. The FALCON commercial trials were modified in the second season to test a method that would allow aggregators and their energy partners to participate in other DSR programmes, e.g. STOR. This modification was prompted by the

[11] Electricity standby and backup equipment is a type of distributed generation.

[12] STOR: is a year-around DSR programme developed by the National Grid to help balance electricity supply and demand peaks

Themes for analysis	Results from interviews with aggregators
	shared service concept identified in the FALCON trials season 1[13]. The shared service concept was well received by aggregators since it enables them to engage an energy partner to provide DSR for a DNO and to the National Grid but at different times.
Future developments in the DSR market and the role of aggregators	Commercial opportunities: Aggregator firms seek commercial opportunities for DSR services across the energy sector including with National Grid and DNOs, and through retail and energy trading. DSR led by DNOs may offer commercial opportunities for aggregators and grow the DSR market in the short term. User cases: The potential user cases for DSR include: 1) reserved capacity to ensure consistency of power supply; 2) balancing renewable electricity generation; 3) managing network constraints; 4) avoid or defer network reinforcement; 5) managing network connections involving load control, and 6) energy trading. Shared services (or not): The DSR market might either become more competitive and exclusive (e.g. one asset for one DSR programme) or become more complementary and inclusive (e.g. one asset for several programmes).

Key insights gained from the findings of the data collected from aggregators detailed in Table 5 are summarised below. In general, DNOs do not build ongoing commercial relationships with network customers[14], other than through connection agreements. Thus, DNOs are unlikely to have requisite organisational capabilities to provide commercial DSR. Instead, aggregators often establish relationships in the DSR market. The work of aggregators to develop DSR, or more formally, the practices of aggregation in the DSR market, includes the following:

- **To identify potential energy partners and build relationships** with these to provide DSR. This requires the ability to understand both business operations of various organisations with DSR capacity and the user case for DSR, e.g. with the National Grid and DNOs;
- **To develop and implement control and monitoring equipment** to aggregate DSR capacity at multiple sites and provide these to utility firms when requested; and
- **To establish contractual and commercial arrangement** to enable DSR, and co-develop DSR programmes with utility firms. DSR on the distribution networks represents a potential growth in the DSR market and commercial opportunity for aggregators.

[13] The concept of shared services for DSR was initiated in Project FALCON and has been further developed by the Energy Network Association. For more detail please see the following report by the ENA: http://www.energynetworks.org/modx/assets/files/news/consultation-responses/Consultation%20responses%202014/Demand%20Side%20Response%20Concept%20Paper_revised.pdf

[14] The term network customers in this report refers to a DNO's customers such as households and non-domestic organisations connected to the distribution networks.

5.3 Organisations Participating in the FALCON Commercial Trials

A number of organisations were recruited by aggregators to provide DSR for the FALCON commercial trials. These organisations are located in the FALCON trial area (Milton Keynes) and operate in a variety of sectors, including logistics, higher education, water utility, district heating and health care. Three of the participating organisations were interviewed and one of these organisations had a direct relationship with WPD. The findings from the interviews with participating organisations are detailed in Table 6.

Table 7: Themes for analysis and findings from interviews with participating organisations

Themes for analysis	Findings from interviews with participating organisations
Business operations and energy consumption	Organisations participating in the FALCON trials are characterised as large electricity users with very different business operations, e.g. a water utility, a university and a district heating scheme. These organisations have embedded and distributed electricity generation on their sites which can be used for DSR, such as diesel generators or combined heat and power units.
Motives for participating in the trials	Four motives for organisations' participation in the FALCON trials were identified in the interview data, including: 1) **Financial aspects**: DSR can help organisations reduce the costs associated with energy use and/ or to provide an additional revenue stream. For example, one organisation noted that DSR (e.g. FALCON trials) provided an important income that covers the cost of investing in distributed electricity generation, e.g. combined heat and power plant. 2) **Corporate Social Responsibility (CSR)**: engaging in DSR programmes can help organisations with their CSR agenda. For example, one organisation who is a large electricity user noted that engaging in DSR programmes allowed it to support national energy supply and low carbon initiatives and thus contribute to broader environmental and social goals. 3) **Energy Management**: DSR can help organisations better understand their energy consumption and identify energy saving measures and reduce their carbon footprint. 4) **DSR developments:** Participating organisations view the FALCON trials as an opportunity to learn about DSR, to engage in a novel DSR development and build new forms of relationships with their DNO. For example, one organisation noted that participating in the FALCON trials may provide the opportunity for participation in future trials and/ or enduring DSR programmes on the distribution network.
Role in and experience of the trials	The role of participating organisations was to provide DSR using their own generators (e.g. CHP, diesel) and/or via load reduction, e.g. turning flexible loads such as cooling or pumping, down or off. Overall, the experience of the trials was good. More specifically, organisations familiar with DSR noted that the contract was clear and concise making it easy to understand and adopt. Furthermore, the one-week notice was useful to

Themes for analysis	Findings from interviews with participating organisations
	those organisations participating in DSR programmes (e.g. STOR) or other utility schemes, e.g. TRIAD[15] and DUoS[16]. The majority of the organisations provided DSR by generating electricity. One organisation reduced load. The nature and characteristics of business operations was identified as an important factor that influenced the ability and willingness of organisations to provide DSR, load reduction in particular. For example, one organisation tried to provide DSR via load reduction but was unable to identify sufficient capacity in requisite time scales without compromising its core business operations. The majority of participating organisations provided DSR via an aggregator. This was because these organisations had established relationships with aggregators and preferred to provide DSR through these. For example, one participating organisation noted that it was convenient to provide DSR via an aggregator since DSR events occurred outside office hours. However, the organisation also noted that dealing directly with a DNO rather than an aggregator would be preferred in future trials. Organisations new to DSR noted that implementing DSR on their site required consultation with multiple departments to address contractual and technical aspects.
Future development of the DSR market and the role of participating organisations	Overall, organisations participating in the trials have an interest in DSR developments and participating in future programmes. Participating organisations noted a number of implications for further involvement in DSR including the following examples: : 1) load reduction can be provided as long as it does not compromise core operations; 2) providing DSR via generation may lead to a decline in the lifetime of the assets used for generating electricity, e.g. standby and backup generators; and 3) Organisations lack information about the DSR market.

Key insights gained from the findings of data collected from participating organisations detailed in Table 6 are summarised below. These organisations have DSR capacity in the forms of distributed generation and/ or load reduction. Load reduction was achieved from only one organisation, while others provided generation. Overall, DSR was successfully deployed in the trials. However, the interviews with participating organisations identified a number of issues that should be considered in further developments of DSR:

- **Organisations may need to develop routines to manage DSR** - most organisations are currently accustomed to a consistent electricity supply. In contrast, DSR requires organisations to take action to reduce electricity consumption and/ or operate standby generator(s) when requested by the purchaser of a DSR service, e.g. DNO and National

15 Triad: Triad is the charging methodology used by National Grid to pass on the costs associated with the 3 largest GB Winter peaks in electricity demand. Some large users try to predict these and avoid them, thereby avoiding large charges in April.

16 DUoS: is the financial scheme through which DNOs recover a portion of the cost associated with distributing electricity around the country.

Grid. Thus, for an organisation to provide DSR, it may need to develop new routines/procedures/working practices that enable continuous and active management of DSR activities;

- **Business Operations** – most of the organisations that participated in the FALCON commercial trials use electricity supplied via distribution networks as their primary source of power. These organisations also have their own electricity generation (e.g. CHP units, standby generators) to maintain their core business operations. DSR can therefore be disruptive as it requires actions to reduce electricity load and/ or operate standby generation to participate in a DSR scheme, e.g. FALCON. Both actions may impact core business operations and/ or comfort levels. Furthermore, DSR often requires equipment for monitoring electricity consumption, which may be installed by an aggregator, to manage DSR activities. Such monitoring equipment may also, to some extent, control electricity consumption on an organisation's site, which can be intrusive; and
- **Potential value of DSR** - participating organisations noted financial, CSR and energy management values associated with DSR. Financial value refers to the additional revenue or reduced cost of energy that participants providing DSR may receive. CSR value refers to DSR schemes contributing to the security of national electricity supply and helps decarbonise the energy sector, which in turn gives rise to social and environmental benefits. Energy management value refers to a better understanding of energy usage and reductions in electricity consumption in their operations, which in turn may also reduce an organisation's carbon footprint. Overall, based on the potential values identified, participating organisations expressed an interest in engaging in further developments in the DSR market. However, responses from organisations differed in this regard. For example, one organisation emphasised the benefits of securing an additional revenue stream via DSR while another organisation emphasised the benefits of carbon reduction and energy management via DSR.

5.4 Internal Stakeholders Engaged for both the Commercial and the Engineering Trials

The findings from interviews with internal stakeholders, which include individuals employed by FALCON and / or WPD, are presented in Table 7. The majority of these interviews concentrated on the engineering trials with a focus on energy storage, but one interview was concerned with both the commercial and engineering trials.

Table 8: Themes for analysis and findings from interviews with internal stakeholders

Themes for analysis	Findings from interviews with internal stakeholders
Role within WPD and/ or the FALCON trials	Internal stakeholders engaged in interviews included a) FALCON team members and b) project supporters within WPD. FALCON team members included the Engineering Trials Implementation Lead, Future Networks Manager, Distribution Manager, Innovation & Low Carbon Networks Engineering, and a Consulting Engineer. Project sponsors and supporters included the Policy Manager and Future Networks Manager.

Themes for analysis	Findings from interviews with internal stakeholders
Purpose of the trials	Across the FALCON project, the purpose was to develop and test solutions that can defer conventional network reinforcement and resolve network issues in the future.
Success and challenges in implementing the engineering trials	**Implementation**: Refers to the setup, design and build of the energy storage trials. Since FALCON was an innovation trial and involved novel techniques (e.g. energy storage), challenges included 1) translating the concept of energy storage into practical techniques that can be investigated; and 2) integrating the energy storage techniques within the 11kV distribution network. Here, implementing energy storage techniques could not follow a standard procedure. Rather, the trials followed an iterative process, which allowed techniques to be modified in light of results generated. **Running the trials**: Since FALCON was an innovation trial, techniques were tested alongside BAU operations. A key challenge noted by participants in FALCON was that the trials required organisational resources (e.g. people's time from BAU activities) to develop and maintain equipment used in the FALCON trials. However, the priorities and objectives of FALCON are different from BAU operations. While BAU activities tend to focus on resolving immediate issues, the trials focused on solutions that may help a DNO resolve issues in the future. This challenge was addressed by implementing the trial in such a way that individuals involved in FALCON could run the trials while minimising their impact on BAU activities. **Stakeholder engagement**: Local communities (e.g. a housing association) were engaged in the engineering trials to enable requisite equipment (such as batteries) to be installed at various sites. Standard engagement procedures were successfully adopted in these instances.
Key lessons emerging from the commercial trials:	**The suitability of DSR on distribution networks**: The commercial trials suggest that DSR on the 11kV network may not be viable because at this scale there tends to be few clusters of large non-domestic network customers with DSR capacity. Rather, DSR may be more successfully deployed at a larger network scale (e.g. the 33kV and 132 kV networks) where DSR capacity can be sourced from a wider geographical area with a greater number of potential participants. **Financial aspect**: Deploying DSR on the higher network scales matters from a financial perspective since upgrading the network at this level is far more costly compared to the 11kV. **Recruiting participants**: Further testing may explore other routes to access DSR participants. For example, a direct relationship between the DNO and participating organisations instead of one brokered through an aggregator. **The DSR landscape**: Since DNOs are new actors in the DSR market, an internal stakeholder noted that DSR on the distribution network should develop in such a way that it conforms to the broader DSR landscape in the power sector. For example, if DSR on the distribution network can work in parallel with STOR then organisations are more likely to join.
Key lessons emerging from the energy storage trials	**Technical success**: The energy storage trials show that the deployment of batteries on the network has been largely successful but not without challenges. **Institutional and commercial barriers**: In the case of a DNO, techniques involving batteries are not commercially viable or supported by existing regulatory frameworks. The cost of owning and operating batteries may not be supported by investment strategies, or consistent with how DNO

Themes for analysis	Findings from interviews with internal stakeholders
	investments are regulated. DNOs do not hold licenses to trade electricity, which are required to operate energy storage commercially. A DNO may benefit from energy storage that is operated and owned by a third party, but such an arrangement would require reassurance that the energy storage delivers a service to the DNO without it owning the asset.

Key insights gained from the findings of data collected from internal stakeholders detailed in Table 7 are summarised below:

- **Implementation and running the trials**: The main challenge of the energy storage trial was to investigate how the concept of energy storage could be integrated into the 11kV distribution network and to investigate how this technique may actually work in practice. This challenge was addressed in FALCON by adopting an iterative approach to implementation in the trials. This enabled issues to be identified and necessary modifications to the techniques to be made as the trials proceeded;
- **Lessons learned**: The energy storage trials were designed, built and tested alongside BAU operations. This presented FALCON with an opportunity to reflect on the workability and suitability of each technique (e.g. energy storage) to manage distribution networks with new intervention techniques. Lessons learned from the trials may therefore inform moves toward BAU phases of technology readiness; and
- **Regulatory and Institutional barriers**: DNOs operate in highly regulated environments. Thus, the way in which DNOs are regulated influences innovation and change in this sector. For instance, while energy storage may be useful for DNOs, current regulations prevent them from owning requisite assess such as batteries. Energy storage can also invoke a form of energy trading, in which DNOs cannot engage without appropriate approvals.

Insights gained on the commercial trials from internal stakeholders show that context matters for developing DSR on the distribution network. Contextual factors refer to the characteristics of network customers and the commercial viability of DSR, which varies across scales. Developments in the DSR market are an important contextual factor that influences the development of DSR on the distribution network. Key contextual factors identified are:

- **Network Scale and load profiles**: Despite being connected at 11kV, DSR may offer wider accrued benefits to the 33kV or 132k. Distribution networks at these ‘higher’ scales cover several 11kV networks and are therefore likely to include sufficient organisations with distributed generation and/or load reduction capacity from which DSR can be sourced;
- **Commercial viability**: DNOs can deploy DSR to manage network constraints and defer capital investment needed for reinforcement measures. Seen in this way, the commercial viability of DSR is assessed in light of the costs associated with reinforcing the network. The cost of reinforcing distribution networks differs between scales. In general terms, the relative unit cost of reinforcing distribution networks increases with

voltage levels: it is relatively low at 11kV, but increases at the higher network levels of 33kV and 132kV. Deploying DSR to the benefit of 33kV or 132 kV networks may therefore be more commercially viable for a DNO since greater capital investment may be needed for reinforcement at these scales; and

- **Contractual arrangement**: The contractual arrangements developed in FALCON's commercial trials were influenced by developments in the DSR market. Notably, these trials were developed to work in parallel with the National Grid's DSR programmes, e.g. STOR. A number of contractual features were identified in the FALCON commercial trials that enabled participants to take part in other DSR programmes. For example, the contract offered utilisation payments to participating organisations, which means that they were paid for the capacity they provided. In contrast, other DSR programmes (e.g. STOR) often include payments for availability as well as utilisation to ensure that the providers of DSR are available should DSR capacity be requested. Moreover, FALCON provided one week notice to participants in the trials. This notice period made it easier for participants to undertake other DSR activities while participating in the FALCON trial.

Since context matters in smart grid development (DSR in particular), comparing FALCON with other smart grid projects should help consolidate and further develop insights gained on the commercial trials. Thus, a comparative analysis of smart grid projects with particular reference to DSR elements of Smart Grids initiatives is presented in the following section.

SECTION 6

Comparative Analysis of Stakeholder Interactions in DSR Initiatives

6.1 Introduction to Comparative Analysis

The comparative analysis presented here compares FALCON with other smart grid projects, (principally funded from the LCNF) in order to contextualise and add value to the insights gained on DSR in Project FALCON. The smart grid projects identified for comparative analysis include:

- Western Power Distribution's FALCON;
- Electricity Northwest's Capacity-2-Customer (C2C);
- Northern Powergrid's Customer-Led Network Revolution (CLNR);
- UK Power Network's Low Carbon London (LCL); and
- Smart Grid Gotland in Sweden.

These smart grid projects were selected because the projects were led by DNOs operating in the same national and industrial context i.e. the distribution network in the UK. In addition, Smart Grid Gotland, Sweden was included to facilitate comparison with a smart grid project undertaken in an alternate national and industrial context. The method for comparing these smart grid projects is detailed below.

6.2 Method

The method deployed in this comparative analysis was exploratory. Such research typically aims to identify key issues that may warrant further investigation (Robson, 2011[17]). This means that each smart grid project was explored with the following questions in mind:

- What are project proponents trying to achieve in particular contexts?
- What are their motives to develop and test DSR?
- What challenges associated with DSR have they identified?
- How have these challenges been overcome?

Data on the selected smart grid projects was sourced from project reports and podcasts. Guided by the questions detailed above, an understanding of each smart grid project was developed. Themes to facilitate a comparative analysis that identified differences and similarities between these smart grid projects emerged subsequently. The themes identified for comparing smart grid projects include:

- **Purpose of the project**: This theme explores the aims and objectives for developing smart grids stated by the project proponents;
- **Network Context**: This theme aims to identify the location (e.g. urban, rural, and industrial) and network scale (e.g. high or low voltage) at which the smart grid project is situated;
- **DSR activities and key actors**: This theme explores activities and key actors involved in the DSR trials of particular projects;

[17] Robson, C., 2011. Real World Research (3rd Edition). John Wiley and Sons, Ltd., UK

- **Potential of DSR**: This theme explores the potential of DSR on the distribution network; and
- **Key project findings**: This theme explores key challenges identified to deploy DSR and ways to overcome these challenges identified in the projects.

The smart grid projects identified for this comparative analysis are described in the next section.

6.3 Smart Grid Projects

The smart grid projects are presented in the following table:

Table 9: Western Power Distribution: FALCON commercial trials

Analytical categories	Description
Purpose of the project	The aim of this project was to investigate how new 11kV network techniques worked in practice and to simulate their use in different scenarios. This aimed to determine the best ways to manage the network problems expected to arise from increased low carbon technologies and generation. The project can broadly be divided into two main parts: 1) The technique trials, which involved installing equipment (e.g. energy storage device), creating commercial frameworks (e.g. DSR) and operating the techniques on the network in the Milton Keynes area; and 2) the simulation tool and the supporting elements, calculated the likely load increases, determined constraints on the network and modelled the result of applying the possible techniques.
Network Context	This project took place on the 11kV network in Milton Keynes, which is a rapidly growing city and does not currently suffer from an overloaded distribution network. Thus, this location provided an opportunity to develop and test aspects of smart grid developments (e.g. DSR) that can be deployed to meet future demands on the distribution network.
DSR activities and key actors	Two types of DSR were tested and included generation and load reduction, which can be called upon when requested by the DNO. DSR was drawn from organisations' existing generation capacity, and/ or their ability to reduce load. Organisations participating in the trials were recruited by WPD directly or via aggregators. Participating organisations were notified half an hour in advance in Season 1 and a week in advance in Season 2. Events occurred at peak periods during winter evenings November to February.
Potential of DSR	DSR can be applied to manage constraints on the network, and defer or avoid the need for capital investment to reinforce network infrastructure.
Key findings	In this trial, more DSR capacity was sourced from organisations providing DSR via generation compared to load reduction. Network scale was found to be important when deploying DSR for two reasons: 1) DSR capacity, and 2) financial gain to defer or avoid network reinforcement. The DSR market (e.g. supply and demand of DSR in the market) needs to be considered when developing DSR on the DNO network. The Shared Service Framework is an initiative identified in FALCON to support DNOs in the DSR market.

Table 10: Electricity Northwest (ENW): Capacity-2-Customer (C2C)[18]

Analytical categories	Description
Purpose of the trials	This project aimed to increase the capacity of the network in order to defer reinforcement and support fault management. Most of the time, only half the available capacity of the electricity network is used, with the other half reserved for emergency use when faults occur. This emergency capacity can also be released to meet increased demand on the network, like opening the hard shoulder on the motorway to allow for more traffic without widening the road. DSR was deployed as a post-fault measure in this project, which means that DSR was requested by the DNO after a fault had occurred on the network.
Network context	This project was located on Electricity Northwest's high voltage distribution network, which is situated in densely populated areas (e.g. Manchester), industrial and suburban regions in the north of Manchester, and rural areas, e.g. the Lake District and Cumbria.
DSR activities and key actors	In this project, DSR was developed and tested as part of the connection agreements between the DNO and its network customers and focused on aspects of managed supply. This allowed ENWL to control the consumption of contracted network customers and interrupt the electricity supply to these when faults occur. Existing and new network customers were recruited to the trials either directly by the DNO or via an aggregator. Automated forms of DSR involving monitoring and control equipment were developed and tested with the network customers in this trial.
Potential of DSR	DSR as a post-fault measure allows the DNO to defer reconnection to selected contracted customers when restoring the network post fault. Network customers with managed supply contracts were paid to provide DSR, or benefit from faster connection at lower cost. DSR may also enhance customers' green credentials since C2C may contribute to decarbonising the UK power sector.
Key findings	Network customers needing new connections and existing customers familiar with DSR were successfully recruited. Several insights about the contractual arrangement with network customers providing DSR were identified, such as ways to make the contract suitable for the customers (e.g. via payment arrangements) the duration of a response and the frequency of calls for DSR. The way DSR was embedded in contracts (e.g. connection agreement) with new and existing network customers was found to be a suitable strategy to recruit customers to the trial.

[18] Project Close Down Report available at: http://www.enwl.co.uk/docs/default-source/c2c-key-documents/c2c-closedown-report-v1-1-01-april-2015-.pdf?sfvrsn=4

Table 11: Northern Powergrid: Customer-Led Network Revolution (CLNR)[19]

Analytical categories	Description
Purpose of the trials	The purpose of this project was to develop and test new techniques and commercial arrangements on the distribution network to support the uptake of low carbon technologies and distributed generation, e.g. wind power. DSR formed a key part of this project.
Network Context	Four test-bed networks were identified and used in this project. These were 1) Urban network in Rise Carr, Darlington, 2) Rural network in Denwick, Northumberland, 3) PV cluster in Maltby, South Yorkshire, and 4) Heat pump cluster in Hexham, Northumberland. These test beds enabled solutions to be tested at different network scales and geographic contexts.
DSR activities and key actors	Two types of DSR were tested, static DSR and on-demand DSR. Static DSR is tariff based and uses price signals to inform network customers about the status of the network and stimulate shift in electricity consumption. On-Demand DSR involved network customers are paid to reduce the amount of electricity they take out from the network when requested by the DNO. Aggregators played an important role in the CLNR project as partners co-developing aspects of the DSR trials, e.g. identifying and contracting energy partners to provide DSR for the distribution networks.
Potential of DSR	On-demand DSR can be applied to manage network constraints and to avoid or defer reinforcement measures. DSR provides network customers with an additional revenue stream.
Key findings	Recruiting network customers to become energy partners and provide DSR is a key challenge to a DNO because the number of potential energy partners is somewhat limited. Network customers may not have knowledge and/ or experience of DSR, which can make the recruitment process difficult. DSR provided via load reduction can be disruptive and intrusive for the network customer because it may affect the customers' business operations.

Table 12: UK Power Network: Low Carbon London (LCL)[20]

Analytical categories	Description
Purpose of the trials	The purpose of this project was to develop and test a range of solutions that could assist a DNO to operate and maintain the network in cities in the future. The DNO in London faces a critical challenge of meeting the need of increased electricity demand while finding it increasingly difficult to reinforce the electricity network infrastructure.

[19] Project Close Down Report available at: http://www.networkrevolution.co.uk/project-library/project-closedown-report/; and Developing the Smarter Grid: Industrial and Commercial and distributed generation customers, available at: http://www.networkrevolution.co.uk/wp-content/uploads/2015/03/IC-Final.pdf

[20] DNO Guide to Future Smart Management of Distribution Networks Summary Report, available at: http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-(LCL)/Project-Documents/LCL%20Learning%20Report%20-%20SR%20-%20Summary%20Report%20-%20DNO%20Guide%20to%20Future%20Smart%20Management%20of%20Distribution%20Networks.pdf

Analytical categories	Description
	The solutions included methods to monitor use of low carbon technologies and distributed generation, and involved implementing smart meters and DSR.
Network Context	This project took place on the distribution network in London, which is a densely built and populated region, where reinforcement measures are often costly and potentially disruptive.
DSR activities and key actors	DSR from business and domestic customers was tested in this project. Residential DSR was tariff based, smart meters were installed in customers' homes by an electricity supplier[21] , i.e. not the DNO. Smart meters provided dynamic time of use tariffs to network customers. The electricity supplier was a project partner. Business DSR was based on contracts with large non-domestic electricity users who were paid to provide DSR by operating stand-by generation or load reduction. Aggregator firms played an important role in the LCL project as partners co-developing the trials.
Potential of DSR	Tariff based DSR can be applied by DNOs to manage network constraints. Network customers can help alleviate constraints on the network by reducing their electricity demand in response to price signals. This approach can also be applied to increase electricity demand during times of peak renewable energy production. Business DSR can also be applied by DNOs to manage network constraints and to defer or avoid network reinforcements.
Key findings	A key finding identified in this project is that DSR can be deployed to flatten the load curve profile by shifting demand to off peak times. Used in this way, DSR has to be timed carefully to have a positive effect on the DNO's load curve. A potential issue arising from shifting demand in this way are payback peaks: Network customers that provide DSR by reducing consumption may do this for a short period of time after which their electricity consumption increases rapidly. This approach therefore may postpone network constraints rather than resolve them.

Table 13: Smart Grid Gotland[22]

Analytical categories	Description
Purpose of the trials	This smart grid project is ongoing and led by the energy company Vattenfall. Among others, this project aims to identify measures that can balance electricity generated from renewable and intermittent power sources. An important feature of this trial is to support the integration of more wind power in the electricity distribution network. Wind power is an intermittent source of energy and may not always be available when electricity is needed. This project therefore investigated DSR to address this issue.
Network Context	This project is situated on the island of Gotland. This island is like a miniature Sweden, with a mixture of industrial and residential electricity users. Thus, the island represented a good test bed for developing smart grid solutions that can be applied across Sweden.
DSR activities and key actors	Tariff based DSR is tested to stimulate network customers to consume electricity during times of peak renewable electricity production, and vice-versa.

[21] Electricity suppliers work in a competitive market. They buy energy in the wholesale market and sell it on to customers.

[22] About the project, available at: http://www.smartgridgotland.com/eng/about.pab

Analytical categories	Description
	Smart meters are deployed in this project to inform network customers about price of electricity in real time and change electricity consumption accordingly. The smart meter used in this project can be connected to electrical appliances in the home (e.g. the heating systems) to provide an automated DSR response.
Potential of DSR	DSR can assist the network owner to integrate wind power and increase the effectiveness of wind power by steering peak demand towards peak production, and vice-versa.
Key finding	Stimulating residential customers to reduce or shift demand in response to a price signal may require automated forms of DSR.

6.4 Comparative Analysis

This section presents the results of the comparative analysis in light of identified themes, namely:

- Purpose of the project;
- Network context;
- DSR activities and key actors; and
- Potential of DSR; and key project findings.

A summary of smart grid projects is provided in Table 13. Similarities and differences between these projects are identified and discussed subsequently.

Table 14: Summary of smart grid projects selected for comparative analysis

Projects and Themes	FALCON	C2C	CLNR	LCL	Gotland
Purpose	Develop a Scenario Investment Model and tool to operate a lower carbon network and reduce the need for reinforcement	Increase network capacity	Develop solutions to support uptake of LCTs and connecting distributed generation	Develop solutions to operate distribution networks in low carbon cities with significant network constraints	Balancing renewables to integrate wind-power
Network context	11kV network in Milton Keynes	High voltage network covering urban, sub-urban and rural regions	Urban and rural parts of the distribution network	Distribution network in London	Distribution network on the Island of Gotland
DSR activities	Generation and/ or load reduction;	Managed supply contracts;	Tariff based DSR and on-demand DSR; involving	Tariff based DSR; standby generation and load reduction;	Steering peak load towards peak

Projects and Themes	FALCON	C2C	CLNR	LCL	Gotland
and key actors	involving participating organisations and aggregators as suppliers	involving both new and existing customers	both industrial and residential customers; aggregators as partners	involving industrial, commercial and residential customers; aggregators and electricity supplier as partners	production via tariff based DSR; involving industrial and residential customers
Potential of DSR	Manage constraints; defer/ avoid network reinforcement	Increase network capacity, restoring network post-fault	Manage constraints; Defer/ avoid Reinforcement	Manage constraints; defer/ avoid reinforcement,	Balancing renewables
Key findings	Network scale and DSR landscape matters	Contract design matters	Recruit customers is a key challenge	Payback peak	Tariff based DSR may require automated responses

Based on the summary of smart grid projects presented above, similarities and differences between these projects are detailed below in light of the analytical themes.

Purpose: The overall purpose of the selected smart grid projects was to develop and test new techniques that can be deployed by a DNO to operate and maintain the distribution network infrastructure in a low carbon future. This purpose reflects an image of what low carbon futures might entail in terms of changes in the load on the network and the need for smart grid innovations. For instance, proponents of the smart grid projects studied (e.g. Ofgem and DNOs) anticipate increased electricity demand due to new loads arising from low carbon technologies (LCTs), such as electric vehicles and heat pumps. The uptake of renewable and intermittent power generation (such as solar PV and wind power) may create reverse power flows from network customers into the distribution networks. It is likely that the uptake of LCTs and renewables will affect the load on distribution networks making network planning increasingly complex. Thus, motives for developing smart grids are influenced by expected changes in load profiles (e.g. increased electricity demand and reversed power flows) arising from the need to decarbonise the power sector in general.

Network context: The analysis shows that the context in which the network is located matters to the development of DSR measures. For example, findings in the FALCON project suggest that DSR might usefully be deployed to benefit the 33kV or 132 kV rather than the 11kV because of contextual factors, e.g. network customer profiles and commercial viability. In contrast, findings from the LCL project located in London, which is a global city, where land prices are high and sites to accommodate further infrastructure are scarce and expensive, suggests that DSR on the 11kV network may be commercially viable in such contexts. Indeed, DSR on the 11kV network in London and other world cities may be more financially efficacious than in other locations, such as Milton Keynes.

Load profiles of network customers in a city (e.g. London) are likely to change because of increased demand arising from new loads (e.g. electric vehicles) and an increasingly urbanised population. In contrast, networks located in rural or industrial regions (e.g. Electricity Northwest) may face changes such as reduced demand or reversed power flows due to the uptake of renewables and distributed generation.

In summary, contextual factors, including network scale, customer load profiles and type of region in which the network is located, affect DSR viability. These important factors should therefore be considered in the choice, development and application of subsequent DSR initiatives.

DSR activities and key actors: Activities associated with key actors involved in DSR varied between the smart grid projects. Here we delineated three types of DSR activities:

- **Pre-fault**: DSR is deployed to prevent faults on the network. The DNO requests capacity from contracted network customers (e.g. large electricity users) and/ or aggregators, e.g. generation or load reduction. Key actors include the DNO, large electricity users and aggregators. The FALCON trials are an example of pre-fault DSR.
- **Post-fault**: DSR is deployed after a fault has occurred on the network has occurred and is used to delay restoration of electricity supply to contracted network customers. In this way, the electricity supplied to network customers that are not providing DSR can be restored faster and network customers contracted to provide DSR can be restored at a later stage for which they are compensated. The C2C project is an example of post fault DSR, in which key market actors such as the DNO, large electricity users and aggregators. While the same actors are involved in pre-fault and post-fault DSR, the main difference is how DSR is used, i.e. to prevent a fault or to restore the network post-fault.
- **Tariff based**: DSR is deployed to stimulate a shift in electricity demand to off-peak using price signals via a smart meter. Key actors include the DNO, electricity supplier, domestic and commercial network customers. Smart Grid Gotland and LCL are examples of tariff based DSR. Key actors are different here compared to pre-fault and post-fault DSR. For example, electricity suppliers rather than aggregators are involved to engage network customers to enable DSR from these. Tariff based DSR may be more suitable to engage domestic customers.

Potential benefits of DSR: DSR can provide multiple benefits for different stakeholders, such as DNOs, organisations with DSR capacity and electricity users. The LCL, CLNR and FALCON projects show that DNOs can deploy DSR to manage network constraints as well as to defer or avoid reinforcement. The C2C project shows that DSR can be effectively used when network faults arise. These projects also show that organisations with DSR capacity may benefit from DSR programmes as these can provide additional revenue streams, reduce energy costs and enhance their CSR credentials. Projects trialling tariff based DSR (e.g. LCL project and Gotland) suggest that electricity users may benefit from lower network charges. From a policy and regulator perspective, (e.g. Ofgem) DSR may help reduce climate change emissions associated with the power sector.

Key project findings: This theme explored key challenges to deploy DSR and ways to overcome them. The need to recruit participants to ensure the viability of DSR was common to all projects studied. From this comparative analysis, three key aspects of participant recruitment were identified:

- **Network scale**: It was noted in the FALCON and other LCNF trials that the process of recruiting participants to provide DSR for the distribution network may be affected by scale. For example, an 11kV network that covers an area in which there may only be a few potential participants that can provide DSR. By contrast, a higher network scale (e.g. 33kV network) is likely to have a greater number of potential participants from which DSR can be sourced due to the larger geographical area. Thus, network scale matters to participant recruitment because the number of potential participants is likely to increase at higher network scales and their larger geographical area. A greater number of participants is important to a DNO as this may improve the reliability and viability of DSR.
- **Commercial arrangements**: This aspect of participant recruitment refers to how the relationships between actors involved in a DSR scheme are established to make DSR viable. Three key aspects of the commercial arrangement were identified in the comparative analysis; these are
  - **Aggregators**: In many smart grid projects, notably within LCNF (e.g. LCL and CLNR), aggregators were partners in the projects and were recruited to these projects to co-develop the DSR trials in collaboration with DNOs. The aggregators were also engaged in these trials to recruit participants and provide DSR for trials;
  - **Contract**: In other smart grid projects (e.g. FALCON and C2C) the contract played a key role in recruiting participants. For example, the contract in FALCON was (re)designed (for season 2) to conform to the broader DSR landscape so that organisations involved in other DSR programmes could participate in the FALCON trials. In the C2C project, DSR was embedded in contracts for existing and new connection agreements to fit the network customer's business operations. Importantly, aggregators were involved in both FALCON and C2C, but their role was more of a supplier to the trials than as a partner in the trials; and
  - **Smart meter**: In tariff based DSR (e.g. Gotland), the smart meter played a key role as these were used to communicate information about electricity consumption and price to both the utility firm and network customers participating in the trials.
- **Automation**: Since DSR involves the aggregation of capacity from multiple sites, certain levels of automation could make DSR more viable. For example, in Smart Grid Gotland, automatic forms of response including electrical appliances which are connected to smart meters and automatically switched off during times of peak demand were investigated. Such automated arrangements may promote customer participation since they do not have to continuously manage DSR activities in the home.

Overall, the FALCON commercial trials can be seen in the context of the smart grid projects discussed above. In all cases, the projects addressed aspects of fundamental shifts in the electricity market that impinge upon the distribution network – firstly emergent new demands, and secondly the growth in intermittent dispersed generation. The key lessons that have emerged relate to FALCON’s focus on interventions to manage network investments and the active network management that DSR involves. The following section picks up the Project’s key issues and lessons.

SECTION 7

Findings & Conclusions

7.1 Introduction

This section discusses the findings of stakeholder engagement undertaken as part of FALCON, and presents the conclusions of this work.

7.2 Discussion on the Commercial Trials

The FALCON commercial trials investigated the use of DSR to manage capacity on the 11kV network via novel commercial arrangements. The principal motivation identified for deploying DSR on the distribution network was that it may help a DNO to manage network constraints and defer or avoid network reinforcement. An important part of this trial was also to develop and consider two approaches to developing DSR at this scale. The first involves DSR provided by participating organisations directly to the DNO. The second is DSR provided via an aggregator acting as an intermediary. This section discusses the feedback on the FALCON commercial trials gained from stakeholders involved in this trial, notably aggregators, participating organisations and internal actors.

For aggregators, the FALCON commercial trials, including DSR trials in other LCNF projects may lead to additional commercial opportunities for aggregators. The DSR market in the UK is primarily used by the National Grid through their STOR programme. The potential for using DSR on the distribution network may grow the DSR market. DNOs engagement in the DSR market may therefore have a positive impact on aggregator firms. In this FALCON trial, many relationships between the DNO and participating organisations were established by aggregators. Working as intermediaries, aggregators constructed and put in place requisite commercial arrangements.

The work of aggregators, or more formally, practices of aggregation were identified and include:

- To identify the use cases for DSR, e.g. to assist the National Grid to ensure consistency of electricity supply and to assist DNOs to address network constraints and to defer or avoid network reinforcement;
- To identify potential energy partners and build relationships with these to provide DSR. Crucially, this involves promoting the business case of DSR for potential energy partners;
- To develop and implement control and monitoring equipment necessary to aggregate DSR capacity at multiple sites and provide these to utility firms when requested; and
- To establish contractual and commercial arrangements that enable DSR, and co-develop DSR programmes with utility firms.

For participating organisations, DSR may be commercially interesting as it potentially offers additional revenue streams, avoids costs, contributes to energy and carbon management and supports CSR credentials. However, feedback from organisations suggests that they are of course naturally interested in providing DSR as long as it does not restrict their core operations. For example, DSR from load reduction may restrict activities or affect comfort levels, since it can require organisations to turn energy consuming equipment down or off. DSR may also require new business routines to be developed to perform continuous and active management of on-site assets (e.g. standby generator) to provide DSR. This suggests that DSR presents trade-offs for organisations in which they assess the value of providing DSR in light of the potential impact that DSR may have on business operations. However, the trade-off between the value of DSR and potential restriction of business operations is likely to vary greatly between organisations.

Organisations participating in the FALCON commercial trials had very different core operations (e.g. university, water treatment and combined heat and power operator) and the value of DSR identified by these differed. For instance, one organisation stated that the additional revenue stream gained from participating in DSR programmes (e.g. STOR and FALCON commercial trial) provided an important income to the business. Another organisation stated that the CSR credential gained from offering DSR, including the impact it has on energy management in the organisation formed the rationale for providing DSR. Thus, the business case for organisations to participate in DSR is an important aspect of DSR programmes. Aggregators play an important role in identifying the business case for DSR, for both providers (e.g. organisations with DSR capacity) and users of DSR, e.g. the National Grid or a DNO.

Interviews with internal stakeholders focused on a DNOs perspective on developments in the DSR market in general and the FALCON commercial trials in particular. For DNOs, DSR is not a standard technique to operate and maintain distribution networks. The LCNF trials offered DNOs an opportunity to develop and test DSR. Initial learning gained from the LCNF trials (e.g. Northern Powergrid’s Customer Led Network Revolution) identified the potential of using DSR on distribution networks. Further learning was gained from FALCON. The internal stakeholders stated that the FALCON commercial trials have made the following contribution to developments of DSR on the distribution network level.

- **Network Scale and load profiles**: DSR may be more suitable as a service on the 33kV or 132 kV networks rather than the 11kV network. Distribution networks at these ‘higher’ scales cover several 11kV networks and are therefore likely to provide sufficient organisations with distributed generation and/or load reduction capacity from which DSR can be sourced. However, as noted in the comparative analysis (please see section 4.3 on network context) the type of network customers connected to the distribution networks differed between regions. Some regions may have more potential energy partners to provide DSR than other regions.
- **Commercial viability**: DNOs can deploy DSR to manage network constraints and defer capital investment needed for reinforcement measures. The cost of reinforcing distribution networks differs between scales. In general terms, the relative unit cost of reinforcing distribution networks increases with voltage levels: it is relatively low at 11kV and increases at higher network levels, e.g. 33kV and 132kV. Deploying DSR at the 33kV or 132kV networks may therefore be more commercially viable for a DNO. However, there is greater coverage of 11kV than higher voltage assets.
- **Contractual arrangement**: The contractual arrangements developed in FALCON’s commercial trials were influenced by the broader developments in the DSR market and with the shared service concept in mind. The shared service concept refers to

developments in the DSR market in which DSR users (e.g. the National Grid and DNOs) can share DSR assets (e.g. organisation with DSR capacity) between them. This concept was initiated in FALCON and has been further developed by the Electricity Network Association (ENA). The advantage of a shared service framework is that actors with DSR capacity (e.g. non-domestic organisations) can provide DSR for multiple users of DSR at different times. In this way, users of DSR may not have to compete on the DSR market. Notably, the commercial trials in FALCON were developed so that DSR could be used for the distribution network and to work in parallel with the National Grid's DSR programmes, e.g. STOR. A number of contractual features were identified in the FALCON commercial trials that allowed participants to take part in other DSR programmes. For example, the contractual arrangement in FALCON offered utilisation payment to participating organisations, which means that they were paid for the capacity they provided. In contrast, other DSR programmes (e.g. STOR) generally includes payment for availability as well as utilisation to ensure that the providers of DSR are exclusively available should DSR capacity be requested. FALCON provided one week notice to participants in the trials. This notice period made it viable for participants to undertake other DSR activities as well as FALCON.

- **Process innovation that requires active and continuous management**: DSR is a technique that fundamentally involves commercial arrangements. Development of new commercial arrangements can be described as an innovation process that requires active and continuous management for both the DNO and participating organisations (including aggregators should they be involved). Process innovation (e.g. the development and implementation of DSR) is different from conventional reinforcement measures involving capital investment. While DSR requires new organisational routines to be built and new forms of relationships with network customers to be made, conventional reinforcement can be maintained with existing organisational routines. Thus DSR requires a DNO and its customers to develop new ways of working compared with the technical interventions necessary for network reinforcement. DSR also involves a different relationship with commercial customers, accepting that some part of the assurance for continuity of power supply will rest outside the direct control of the DNO. The understanding developed in FALCON of partnership contracts is important and may indeed, represent an institutional innovation.

7.3 Discussion on the Energy Storage Trials

The objective of the energy storage trials in FALCON was to deploy new battery technologies that allow the flow of power from the network to be managed as the battery is charged or discharged. The advantage of energy storage is that it can be used to manage network constraints. Interviews were conducted with internal stakeholders involved in these trials and members of the WPD Future Networks Team. These interviews focused on the implementation of the trials and key lessons learned from them.

Implementation: The implementation of the energy storage trials broadly comprised two main sets of activities:

1. Translating the concept of energy storage into a technique, and

2. Integrating the technique into the 11kV distribution network to investigate how it works in practice.

The trials proceeded in an iterative fashion: Techniques were modified as results arose in the trial.

Lessons learned: The energy storage trials were designed, built and tested alongside BAU operations. This presented FALCON with an opportunity to draw lessons from the trials that may help techniques move towards BAU phases of technology readiness. In many instances, the Technology Readiness Level[23] (TRL) framework is used to estimate the maturity of new technology in various industry sectors including energy. While this framework includes steps necessary to guide technology development from idea to development, implementation and to fully operational, it may leave important aspects of technology development out. For instance, the TRL framework makes little reference to regulatory (e.g. how DNOs are regulated) and institutional aspects (e.g. routines and culture of DNOs) that may influence technology development, and the viability of new techniques. Interviews with internal stakeholders provided insights on institutional aspects of the energy storage trials.

Regulatory and Institutional factors: DNOs operate in highly regulated environments. Thus, how DNOs are regulated influences innovation and change in this sector. For instance, while energy storage may be useful for DNOs, current regulations prevent them from earning income from owning the assets necessary for this, such as batteries. Operating energy storage can also invoke a form of energy trading, in which DNOs cannot engage without appropriate approvals. Institutional factors refers to the common habits, culture and routines, or simply put – 'this is how we do things around here' (Edquist, 1997)[24]. New techniques may or may not conform to the institutional structures of DNOs. Institutional structures need to be taken into account in developing and implementing novel techniques.

7.4 Discussion on the Approach to Stakeholder Engagement in FALCON

The consultation mode of engagement was identified and adopted in FALCON. This dialogue-based mode of stakeholder engagement between the interviewer and interviewees allowed feedback from priority stakeholders and multiple perspectives on the FALCON trials to be gained. Semi-structured interviews were used to collect data from stakeholders. This method was deployed in an exploratory fashion and as such enabled interviews with stakeholders to be open-ended and flexible allowing the interviewer and the interviewee to identify new themes for discussion as interviews proceeded. Since the trials broadly extended over two years, this allowed interview themes and questions to be modified as the trials developed and new stakeholders joined the trial. Feedback gained from stakeholder interviews influenced modification in the commercial trials and identified

[23] Please see Appendix F for an overview of the TRL framework

[24] Edquist, C. 1997. Systems of Innovation, Institutions and Organizations, London: Pinter

lessons learned for dissemination to relevant audiences. In addition, workshops were used to collect data and generate insights on the trials with internal stakeholders. Three workshops with internal stakeholders were organised by the OU team. These workshops focused on:

1) Identifying an approach to stakeholder analysis and engagement;

2) Identifying stakeholders groups relevant to FALCON and prioritising stakeholders to engage for interviews, and

3) Reflecting on feedback from stakeholder interviews undertaken as part of the commercial trials to identify lessons learned.

7.5 Conclusions – Commercial Trials

This section presents the conclusions drawn from stakeholder engagement in FALCON.

For the commercial trials we conclude that stakeholder engagement has provided multiple perspectives on DSR and identified lessons learned from these trials. Multiple perspectives were gained from stakeholder interviews and include:

- For aggregators developments of DSR on the distribution network can enable growth in the DSR market and provide commercial opportunities. Aggregators expressed an interest in the shared service framework as it enabled DSR on the distribution network to work in parallel with other DSR activities, e.g. STOR;
- For organisations participating in the trials, developments in DSR can add value to the business in terms of an additional revenue stream, energy and carbon management and CSR credentials. However, organisations noted that they can participate in DSR as long as it does not restrict core business operations; and
- For the DNO, developments of DSR represent a process innovation that may require active and continuous management for both the DNO and participating network customers. A number of contextual factors that may influence developments of DSR on distribution networks were identified and include:
    - Network scale and load profiles: The number of organisations with DSR capacity is likely to increase at a higher network level (e.g. 33kV and 132kV) compared with the 11kV network. However, the type of network customers from which DSR can be sourced may vary according to regional characteristics, e.g. urban, rural and industrial.
    - Commercial viability: Insights gained from FALCON highlight the need to ensure that DSR is commercially viable. The business case for DSR is important for both participating organisations as well as the DNO. Many relationships between the DNO and participating organisations were established by aggregators, who thus play a key role in making DSR commercially viable.
    - Developments in the DSR market: The shared service concept was initiated in FALCON and suggests that the DSR market should become more inclusive and complimentary (e.g. capacity from one DSR asset can be provided to many users of

DSR) rather than exclusive and competitive in which capacity from a DSR asset is contracted to one DSR programme. A DNO is likely to benefit from these inclusive and complementary developments in the DSR market.

- Operability: While the FALCON commercial trials was a trial scheme that expanded over two years, several aspects were identified that may need to be addressed for DSR to move into business-as-usual operations within a DNO, including:
  - Automation: In the FALCON trial, DSR activities were not automated. However, for DSR to become more frequently used by a DNO it is likely that it will require some form of automation. Since a DSR programme may include multiple energy partners, automation could assist in the development of efficacious DSR arrangements with a broad spectrum of these.
  - Monitoring and control: DSR requires monitoring and control equipment (e.g. smart meters) to be installed on energy partners' site to manage DSR activities. The design and function of such a smart meter may usefully provide added value to participating customers and the DNO.
  - Recruiting participants: The relationship established between the DNO and energy partners providing DSR is of particular importance to the viability of any DSR programme. Thus, strategies for recruiting participants are needed.

For the commercial trials we conclude that development and implementation of DSR to be used on the distribution network as a standard technique is likely to require process and institutional innovation. Institutional innovation to enable DSR refers to change in the formal and informal rules of how things are done to facilitate DSR arrangements between a DNO and its network customers. Such arrangements could mean that DNOs can be involved in energy partnerships with network customers that have DSR capacity. However, in contrast to conventional reinforcement measures, DSR requires not only institutional innovation but also process innovation necessary for both DNOs and potential energy partners to operate and manage DSR. The FALCON commercial trials show that relationships between DNOs and potential energy partners can be made both with and without aggregators.

7.6 Conclusions – Energy Storage Trials

For the energy storage trials, insights gained from stakeholder interviews can be divided into three inter-related categories; these are:

1) Technology;

2) Commercial and financial; and

3) Institutional and regulatory.

Technology: This category refers to the novel devices deployed in the engineering trials (such as a battery unit) which was connected to the network to store energy. In this category, the availability of the device and its performance are important aspects considered in the trial. For example, batteries were acquired via a tendering process, which suggests that a supply of suitable batteries exists. Performance refers to what the battery can do, such as storing power at times when the supply of electricity outweighs demand, and releasing power back onto the grid when demand is high. However, integrating such novel devices within existing infrastructure may be challenging. For example, locations for energy storage devices can be difficult to identify because they can be large in size and require additional infrastructures, e.g. buildings.

Commercial viability: These aspects of the engineering trials refer to investment processes and ways of realising potential benefits associated with energy storage. It was noted in the FALCON trials, and elsewhere in the power sector, that batteries are expensive devices. Investment is needed to reduce the cost of manufacturing batteries and in making these more applicable to DNOs. Lower cost batteries may emerge from investments in other battery applications, such as electric vehicle developments. Electric vehicles also hold potential to provide DSR capacity in Vehicle-to-Grid (V2G) arrangements. Thus, energy storage may provide multiple benefits for different actors. For example, batteries may be used by a DNO to manage network constraints and for other actors to trade on the energy market. However, the cost of energy storage devices for a DNO currently outweigh the benefits it may provide.

Institutional and regulatory: This refers to how DNOs operate and are regulated. While energy storage may be useful for DNOs, current regulations prevent them from owning the assets required for energy storage, as operating energy storage can invoke a form of energy trading, an activity in which a DNO cannot engage under current regulatory arrangements. Another option for a DNO is to purchase DSR capacity from energy storage devices owned by a third party. Purchasing DSR rather owning and controlling such assets may require new institutional and commercial arrangements.

7.7 Concluding Remarks

Findings of stakeholder engagements in the engineering trials can be structured around three inter related aspects:

1) Technology;

2) Financial and commercial, and

3) Institutional and regulatory. Here, technology is understood as the devices deployed in the trials with particular reference to availability, performance and integration.

Financial and commercial aspects refers to processes of investing and realising the potential benefits of, for example, energy storage. Institutional and regulatory refers to the appropriateness of, for example, energy storage to how DNOs operate, including how they are regulated. Importantly, this frame for analysing the engineering aspects of the FALCON trials may help identify important insights to disseminate to relevant audiences.

Overall, stakeholder engagement in FALCON was successfully deployed. It has identified and prioritised stakeholders and built and maintained relationships with these to ensure the project’s success. Indeed, multiple and diverse stakeholders have been engaged throughout FALCON with various strategies deployed to engage these stakeholders, e.g.

informing, consulting and collaboration. This report focused on the findings from dialogue-based engagement with prioritised stakeholders. This dialogue-based approach to stakeholder engagement (also called consultation) enabled multiple perspectives on the FALCON trials to be gained from various stakeholders. Feedback from prioritised stakeholders also generated insights on the trials that can be disseminated across relevant audiences.

Appendices

A Original Learning Objectives from Project Initiation Document

Table 15: PID Learning Objectives

Technique 1 – Dynamic Asset Rating	Technique 2 – Automated Load Transfer	Technique 3 – Meshed Networks
How long does a cable take to heat up to its maximum operating temperature when subjected to high load? How long does it take for the cable to cool when the load is reduced? What would be the effect of short term high loading on overhead lines and their sag? Can we create a dynamic load profile and use this information to amend our existing summer/winter ratings? Can the circuits provide a robust alternative for supporting 1st and 2nd circuit fault?	How effective is automated load transfer in reducing peak flows? Are voltages on the network improved by load transfers? Is there any significant decrease in losses? What improvements are there to CMLs and CIs?	How easily can meshed networks be applied on rural/suburban networks? Are different configurations preferable depending on the load density? Are voltages on the network improved? Is there any significant decrease in losses? What improvements are there to CMLs and CIs? What are the protection issues that need to be overcome?

Source: Project FALCON Project Initiation Document

B Successful Delivery Reward Criteria

Table 15: SDRC Deliverables

Task	Due Date	Complete on time
Commercial agreements in place with Logica, Cranfield University, University of Bath, Alstom, Cisco and Aston University.	28/02/2012	✔
SIM design blueprint complete by September 2012, a prototype visualisation developed and shared with the industry.	30/09/2012	✔
An initial report on the effectiveness of using estimates as an alternative to physical substation monitoring will be written by September 2012.	30/09/2012	✔
Load scenarios based on a range of low carbon uptakes in the trials area will be created for use by the SIM by October 2014.	31/10/2012	✔
SIM built and [an updated run] will take place to identify network 'hotspots' by September 2013.	30/09/2013	✔
The Engineering Intervention Technique trials 1-4 will be deployed onto the network and the results loaded on the SIM (the outcomes of the trials will be used to modify the model, which feed into the SIM). The results will be analysed and available for dissemination by December 2014.	31/12/2014	✔
The Commercial intervention technique trials will be deployed onto the network. The results will be analysed and dissemination by December 2014.	31/12/2014	✔
Assess the suitability of the Method for mainstream adoption and produce and optimum investment plan by 30th September 2015.	30/09/2015	✔

Source: Project FALCON

C Dissemination Listings

This listing offers a short snapshot of some of the dissemination activities undertaken by FALCON. This is not an exhaustive list, but includes links where possible.

Reporting:

- Demand Side Response (DSR) Commercial Trials Season 1 (details the outputs of the first set of DR trials carried out during Winter 2013/4) – June 2014.
- Ofgem Project Progress Report (twice yearly report to the industry regulator with an up to date commentary on the Project) – June 2015.
- Ofgem Project Progress Report – December 2014.
- Ofgem Project Progress Report – June 2014.
- Load Estimation Initial Report – April 2013.

Press Releases:

- December 2013 – joint press release with Thameswey, a trials participant, for the DR Winter trials.
- December 2013 – Flexitricity (commercial aggregation service provider for the DR trials to Project FALCON) press release for Thameswey partnership.
- December 2013 – WPD press release to announce success of first DR 'event'.
- October 2013 – WPD press release announcing FALCON's presence at European Utility Week.
- May 2013 – WPD press release to recruit customers for DR trials.
- February 2013 – Airspan, one of the communications technology suppliers announce their involvement with Project FALCON.
- January 2013 – Sentec press release for Gridkey device.
- December 2012 – joint press release with Cranfield University to confirm SIM design specification.
- UCL press release on energy model collaboration with WPD.

Events and Conferences:

- Utility Week Live – 2015 – presenting and on display.
- DR & Future Networks, ICC, March 2015 presentation.
- Navigant/ENA session on DSR.
- Smart Energy Analytics presentation, London.
- Smart Grid GB Industry knowledge sharing presentation.
- June 2014 – DR trials results dissemination event at stadiummk.
- Energy Storage World Forum April 2014.
- Smart Cornwall December 2013 – WPD Presentation.
- October 2013 – European Utility Week.
- September 2013 ESTA Members Conference Milton Keynes.
- Telecoms for Smart Grids September 2013.

- Distribution Automation Europe 2013 (Telecoms).
- Utility Week – Demand Response and FALCON Project.
- Grid Analytics for Smart Grids – WPD Presentation.
- LCNF 2013.
- CIRED 2013 – Session 3 – June 2013.
- European Demand Response and Dynamic Pricing June 2013.
- May 2013 GE Digital Energy Summit.
- Low Carbon Vehicle 2013 (MK).
- The IET – Power in Unity.
- LCNF 2012.
- A balancing act – WPD event.
- European GEODE event.

Newsletters, flyers and leaflets:

- FALCON Newsletter April 2015
- FALCON Newsletter April 2014.
- DR participant recruitment flyer – April 2013.
- Project FALCON public information flyer – April 2012.

Other Partner/Supplier/Industry Dissemination

- Aston University – PEMD conference.
- Anglian Water Annual Report (p.57).
- Energy Storage Operators Forum and the Good Practice Guide.

Digital Media:

- Project FALCON video.
- Smart Grids by Western Power Distribution.
- FALCON podcast.
- Demand Response event summary June 2014.
- Energy Networks Association industry video for LCNI.
- Cisco, a Project partner with the Telecommunications Blueprint for Grid Modernisation.
- Smart Grid News report on battery storage for FALCON.

Press – Print and Online:

- Transmission & Distribution World 2014 – tdworld.com.
- Local Newspaper, MK Citizen – February 2012.
- The Engineer magazine publication.
- Engerati online database of FALCON.

- Solar Power Portal FALCON article.
- Rob Samuels, energy blogger hosts his WPD interview.
- Green Tech Media FALCON report.
- Fierce Smart Grid FALCON report.
- The IET's magazine E&T – December 2014 feature article.
- Energy Now Magazine.

Case Studies:

- Project partner, Cisco's customer case study.
- US Department of Energy case study on energy storage.
- Tollgrade Lighthouse case study showing overhead line monitors from the Project supplier Tollgrade, who have provided the sensors required for overhead line monitoring data.
- IPSA case study on Project FALCON, who have worked in the development of the SIM.

D Stakeholder groups

Stakeholders associated with FALCON have been categorised into stakeholder groups. Stakeholders engaged over the lifetime of FALCON are labelled priority stakeholders. Table 16 provides an overview and short description of the stakeholder groups and priority stakeholders identified.

Table16: Stakeholder groups and priority stakeholders identified in FALCON

Stakeholder Groups	Description of stakeholder groups	Priority stakeholders
Policy/ Regulators	Actors involved in developing policies and regulations to promote a secure, affordable and low carbon energy supply. Ofgem through the LCNF provides financial support to FALCON and is interested in the learning outcomes from this project to understand its impact on current and future regulatory development and to promote knowledge sharing within the electricity industry.	DECC, Ofgem (LCNF)
System/ Distributor	Actors who own and maintain electricity network infrastructure, including transmission and distribution networks. These stakeholders have a profound interest in the learning outcomes from FALCON.	National Grid; DNOs; IDNOs; ENA and ENFG
Demand Side Response Market	Actors involved in commercial arrangements involving demand side response measures. Aggregators are both participating in the commercial trials in FALCON and are interested in the knowledge gained in these trials.	Aggregators; Community Energy Groups; Energy Service Companies; Product industries
Customers	Actors that use electricity. Industrial and commercial Customers participate in FALCON and/ or have particular interest in the knowledge gained from these trials.	Industries in the trials region
Milton Keynes Community	Actors in the community in which the trials are taking place with particular interest in the knowledge gained in these trials.	MK Council Low Carbon Steering Group; Transport Catapult; Local Academia
Technology providers	Actors involved in developing and providing technologies used in the FALCON trials or other smart grid projects, and have a particular interest in the knowledge gained in these trials.	Alstom, Aston University, General Electric
Internal stakeholders	Individuals or departments within the WPD organisation supporting FALCON and/ or have particular interest in the knowledge gained from the project.	Future Networks Team; Policy; Distribution

E Modes of stakeholder engagement

Various modes of stakeholder engagement are presented in Table 17.

Table 17: Modes of stakeholder engagement (inspired by Arnstein, 1969)

Modes of engagement	Description	Methods
Informing/ Explaining	Release of information to stakeholders as a means to be open and transparent about the organisation's objectives. Information includes decisions taken by the organisation that may affect or be of interest to stakeholders. Related to this mode of engagement is explaining what the organisation is trying to achieve. This mode of engagement offers little opportunity for stakeholders to influence the organisation's achievements. Stakeholder participation in this engagement strategy is therefore labelled passive. Style of dialogue is often, but not necessary one-way.	Social media, reports, brochures, and project models
Consultation	This mode can be used in situations where feedback from stakeholders is needed. Stakeholders can be engaged to provide advice on the organisation's decisions and/ or objectives. This degree of stakeholder participation is called involved with two-way dialogues between the organisation and stakeholders established.	Interviews, focus groups and workshops
Collaboration/ partnership	This mode can be deployed to achieve objectives that are mutually beneficial to both the organisation and the stakeholders involved. Stakeholders can be engaged through collaboration or partnership to bring particular skills or resources that are deemed useful to the organisation to achieve its objectives. This degree of stakeholder participation is here labelled active and is based on two-way or multi-way dialogues.	Strategic alliances, collaboration under contract

F Technology Readiness Level framework

Table 18: Technology Readiness Levels

TRL Level	Description
Research	
TRL 1: Basic Research	Scientific research begins to be translated into applied research and development.
TRL 2: Applied Research	Basic physical principles are observed, practical applications of those characteristics can be ‘invented’ or identified. At this level, the applications is still speculative: there is not experimental proof or detailed analysis to support the conjecture.
Applied Research	
TRL 3: Critical Function or Proof of Concept Established	Active Research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of technology. Examples include components that are not yet integrated or representative.
TRL 4: Laboratory Testing/ Validation of Components/ Processes	Basic technological components are integrated to establish that the piece will work together.
TRL 5: Laboratory Testing of Integrated/ Semi Integrated System	The basic technological component are integrated with reasonably realistic supporting environment so it can be tested in a simulated environment.
TRL 6: Prototype System Verified	Representative model or prototype system is tested in a relevant environment.
TRL 7: Integrated Pilot System Demonstrated	Prototype near or at planned operational system requiring demonstration of an actual system prototype in an operational environment.
Pre-Commercial Deployment	
TRL 8: System Incorporated in Commercial Design	Technology is proven to work; Actual technology completed and qualified through test and demonstration.
TRL 9: System Proven and Ready for Full Commercial Deployment	Actual application of technology is in its final form; Technology proven through successful operations.

G Interview Guide

This interview guide outlines the approach to data collection from prioritised stakeholders for both the commercial and the energy storage trials in FALCON.

The purpose of data collection for prioritised stakeholders is to gain in-depth insights on their role within and perspective on the trials. Qualitative data will be collected via semi-structured interviews. This approach allows in-depth insights to be gained from interviewees and is based on a set of prepared themes and questions, which allow interviews to be open-ended and flexible. The interview guide will include the following:

- a list of interviewees;
- schedule of interviews; and
- a set of prepared question themes.

The interviews were recorded (where possible) and transcribed providing that consent is given by the interviewees. Potential interviews for both the Commercial trials and the Engineering trials are detailed below, including a schedule to review interview progress.

H Interview Guide and Schedule for the Commercial Trial

Table 19 presents an overview of the interview guide for the commercial trials including (1) stakeholder groups, (2) key stakeholders to engage with for interviews, (3) timing of interviews and (4) a set of prepared questions for each stakeholder category.

Stakeholders groups relevant to the commercial trials were identified both at the internal FALCON workshop held on the 16th of October 2014 and at stakeholder review meetings.

- Key external stakeholders include aggregators and organisations participating (or not) in the commercial trials. These external stakeholders were selected because of their potential involvement in and contribution to the Demand Side Response (DSR) trials.
- Key internal stakeholders include the Control Room Manager and the Future Network Manager. These internal stakeholders were selected because of their role within Western Power Distribution was seen relevant to deployment of DSR trials.

The timing of interviews were identified at stakeholder review meetings. The questions prepared for this interview guide are set out to explore the role and perspective of the key stakeholders regarding the commercial arrangement being trialled in FALCON.

The questions consider the findings from the interviews conducted with key stakeholders after season one (S1) of the commercial trials and changes made in the design of the commercial trials for the second trial period. The questions were developed by the OU team in collaboration with the knowledge capture lead and the commercial trials lead.

An overview of the interview guide detailing priority stakeholders, interview themes and questions is presented in Table 17.

Table 19: Interview themes and questions for each stakeholder group

Stakeholder group	Interview themes	Interview questions
Aggregators	Business activities and core skills	What do you do as a business? What DSR programmes are you involved in? How is your firm differentiated from other firms?
	Motives for participating in the trials	Why are you participating in these trials?
	Role in the trials	What is your role in the trials? Has your role changed between 1st and 2nd trial, if so how?
	Comparing generation with load reduction	Initial trial results strongly favour generation over load reduction, why do you think this is the case? Do you think it will change?
	Performance reliability	Performance reliability is important to DSR, what do you think can be done to ensure this?

Stakeholder group	Interview themes	Interview questions
	Future development in the DSR market and the role of aggregators in particular	What are the major threats and opportunities to the DSR market? How do you see the UK market developing in relation to DSR across the potential service purchasers? Do you see conflict between any of these and if so how would you expect these to be addressed? What is your view on future developments of aggregators within the DSR market?
Participating organisations	Business activity and energy consumption	What do you do as a business? What is energy used for in your business? Are you involved in any DSR programmes other than the FALCON trials? How does DSR compare with other aspects of energy management?
	Motives for participating in the trials	Why are you participating in the trials?
	Role in the trials	What is your role in the trials?
	Future development in the DSR market and the role of participating organisations in particular	What are the major threats and opportunities to the DSR market? What is your view on future developments of aggregators within the DSR market?
Internal Stakeholders	Role within WPD and/ or the FALCON trials	What is your role within WPD and/ or FALCON trials?
	Motives of the trials	What do you see is the purpose of the trials?
	Success and challenges in implementing the trials	What did you initially expect to get out of FALCON? How have things turned out? What have been the challenges in implementing the trials? How have these challenges been addressed?
	Key lessons learned so far into the trials	What lessons have emerged so far? What lessons might be prioritised for dissemination?

Western Power Distribution (East Midlands) plc
Registered in England and Wales No. 2366923
Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB

Western Power Distribution (West Midlands) plc
Registered in England and Wales No. 3600574
Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB

Western Power Distribution (South West) plc
Registered in England and Wales No. 2366894
Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB

Western Power Distribution (South Wales) plc
Registered in Wales No. 2366985
Registered Office: Avonbank, Feeder Road, Bristol BS2 0TB