Low Carbon Networks Fund Full Submission Pro-forma

Section 1: Project Summary

1.1 Project Title:
Activating Customer Engagement (ACE)

1.2 Funding DNO:
Northern Powergrid (Northeast) Limited

1.3 Project Summary:

The ACE project will develop and trial innovative customer engagement techniques and novel commercial arrangements to secure access to cost-effective demand-side response (DSR) for distribution network operators (DNOs), providing customers with rewards for their DSR and lower energy bills. The estimated net benefits for roll out at GB scale are £114m per annum.

Facilitating growth in low-carbon technologies (LCTs) to help achieve climate change targets will bring new challenges for DNOs. Heat pumps, electric vehicles and solar photovoltaic (PV) cells will increase thermal loading and cause voltage issues on distribution networks. Targeted DSR can help address these local network challenges, avoiding the deployment of more expensive solutions.

Understanding of the role of tariffs in unlocking DSR has been advanced in a number of recent trials, including the Customer-Led Network Revolution (CLNR) project. Using tariffs to release DSR can be difficult where the DNO's needs are location-specific and dynamic. Building on the learning from these projects, ACE will focus on ways that the DNO can use alternatives to tariffs to achieve voluntary customer participation in DSR.

The ACE project will establish and trial new techniques to engage and incentivise customers to change their behaviour and practices so that they move or reduce consumption in a way that relieves thermal and voltage issues caused by peak loading and by local generation at times of low load. The key outputs of the project will be:

- best practice guidance on engaging with customers to achieve a DSR response; and
- a DSR planning tool to enable DNOs to forecast network constraints and estimate the cost and potential for DSR to relieve those constraints in a particular geographic area, given the mix of customer types and demographics connected to the network.

The DSR planning tool will incorporate the statistically robust learning from the ACE and other DSR trials. The ACE project will therefore provide robust and widely applicable outputs to enable DNOs to access cost-effective and location-specific DSR that can be used practically by planners and designers in the mix of potential solutions to address future network constraints.

1.4.2 LCN Funding Request (£k): £5,621

1.4.3 DNO Contribution (£k): £0

1.4.4 External Funding - excluding from NICs (£k): £944

1.4.5 Total Project cost (£k): £7,405

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1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more Projects which are interlinked with one Project requesting funding from the Low Carbon Networks (LCN) Fund and the other Project(s) applying for funding from the Electricity Network Innovation Competition (NIC) and/or Gas NIC.

1.5.1 Funding requested from the Electricity NIC or Gas NIC (£k, please state which other competition):

1.5.2 Please confirm if the LCN Fund Project could proceed in absence of funding being awarded for the Electricity NIC or Gas NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☐ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

Project partners: Durham County Council, Durham University, Newcastle University

Collaborators: Oswald Consultancy (creators of the Gen Game)

External funders: Durham County Council (staff costs), EU Structural and Investment Funds Growth Programme (not yet confirmed, application is ongoing).

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
2 January 2014	31 October 2017

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title:	**1.8.3 Contact Address:**
Andrew Spencer LCNF Project Delivery Manager	98 Aketon Road Castleford WF10 5DS West Yorkshire
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Section 2: Project Description

This section should be between 8 and 10 pages.

2.1 Aims and objectives

The ACE project will trial non-tariff DSR measures with customers to address network constraints in specific network locations. It has two main objectives:

- To test innovative customer engagement methodologies and commercial arrangements to elicit a localised DSR response for DNOs.
- To develop and test a DSR planning tool to allow DNOs both to identify the future potential constraints in a particular location and to assess the size, cost and reliability of the potential DSR capability. The tool will be developed using the ACE DSR trial results, be made flexible to accept new learning and will incorporate the learning from other completed DSR trials.

Problem which needs to be resolved

Electricity networks face a number of critical challenges as the GB economy moves towards a low-carbon future. Ageing assets will need to be replaced and additional network capacity will be required to accommodate the growth in load and generation as the number of low-carbon technologies (LCTs) grow to 2030 and beyond. The electrification of heat and transport, driven by the need to reduce carbon emissions, may significantly increase peak demands on the distribution networks and increasing levels of low-carbon generation are moving distribution networks away from the traditional model of unidirectional power flows. GB DNOs must maintain safety and quality of supply and meet their statutory obligations by efficiently delivering electricity while facing the challenges which the low-carbon transition presents. The growth in LCTs such as heat pumps, electric vehicles and solar PV cells will increase thermal loading and cause voltage issues on distribution networks.

- The increased thermal loading could take some assets above their rating, bringing forward asset reinforcement requirements, and increasing costs.
- The voltage issues will constrain the connection of additional generation unless novel techniques are developed to maintain voltages within the statutory limits.
- Connection of LCTs could be constrained or trigger reinforcement projects for phase balance to be maintained.

Traditionally, capacity has been delivered by providing higher-rated assets or new circuits through capital investment. The CLNR project has trialled a range of alternative smarter solutions, such as the use of Real Time Thermal Ratings (RTTR) devices to enhance the capacity of transformers, overhead lines and underground cables, storage solutions (i.e. batteries) to address voltage and power flow problems and tap changers at primary and distribution transformers which deal with issues of voltage rise. Some of these are already proving cost-effective for network planners and designers. However these technical solutions do not represent the full solution to the challenges which DNOs are facing. Storage solutions are currently expensive, limiting their widespread use by DNOs, RTTR comes with a degree of uncertainty due to its weather dependence and therefore may work best with some form of DSR, and conventional tap changers affect all the feeders and phases that they control in the same way so they are not effective at dealing with the problems of feeder voltage, and possibly phase voltage, imbalance. As a result, DNOs are increasingly testing the availability and cost of releasing capacity by contracting DSR from connected customers. DSR involves providing customers with an incentive to reduce or shift demand at certain times of day. The electrification of heat and transport, while having the potential to significantly increase the load on the network, may also increase the amount of potential DSR available to DNOs in the future, by increasing the amount of demand that is flexible.

The CLNR project has already considered how DSR can be activated through the use of time

of use (ToU) tariffs, where measurable shifts in the timing of energy use have been recorded in the evening peak. However, further analysis (e.g. Sustainability First, 2012, http://www.sustainabilityfirst.org.uk/gbelec.html) and evidence in our literature review, Appendix 5) suggests that there is further untapped 'flexibility capital' that could be activated through alternative forms of customer engagement. This is because there are barriers associated with accessing DSR from customers by using tariff signals alone.

- *Location-specific and temporary requirements*. Tariff signals may not be suitable for delivering the very local, and potentially temporary, response sometimes required by DNOs and it is not practical for DUoS charges to be that location-specific.
- *Small financial gains*. Analysis for the CLNR shows that the financial gains to individual customers from undertaking DSR for DNOs can be small and not sufficient by themselves to outweigh the inconvenience of engaging in it.

Method being trialled to solve the problem

Given these issues, there is significant value in investigating how communities can be activated to respond to specific local network issues faced by a DNO, through the use of non-tariff DSR interventions. We aim to expand the toolkit for DNOs to include a method to predict and then release a robust set of cost-effective non-tariff DSR options for consideration alongside other technical solutions for network planning. Non-tariff DSR can help a DNO tackle the problems of increased thermal loading and voltage issues and will provide additional options to those technical solutions already being developed as part of the CLNR and other LCN Fund projects. Specifically non-tariff DSR could relieve thermal and voltage issues caused by LCTs in three ways.

- *Direct control of demand*. For example, appliances could be controlled remotely to reduce load at peak times.
- *Static profile balancing*. This would aim to encourage participants to habitually shift their use of certain appliances. Customers could shift load from peak times to any other time, or to specific times of low load / high generation to help address voltage issues.
- *Dynamic profile balancing*. Dynamic balancing could encourage participants to shift their use of certain appliances from peak load times to times of low load / high generation occasionally upon receipt of a signal from the DNO. The signal could be sent based on dynamic forecasting undertaken by the DNO using RTTR devices and weather forecasts.

Non-tariff DSR measures are especially suited to solve these issues because DNOs can target them on a particular point on the network. In addition, they have the advantage of offering customers a means of voluntarily engaging with and receiving benefits from the provision of DSR, without incurring risks. There are two parts to the ACE project method.

Method part 1: Innovative customer engagement methodologies and incentives

The objective of part 1 of the ACE project is to generate learning on how best to engage with different customer types by testing the cost and effectiveness of accessing DSR through non-tariff interventions from a range of customer types and across a range of energy practices. The detailed design of the interventions will be an important first stage to this work. This design will draw on new and innovative research in this area from the social sciences. Experts from Durham and Exeter Universities will advise us in this work.

At this stage, we have based the design of our interventions on analysis of research gaps, promising results and best practice in other contexts. Emerging evidence from the CLNR project has also informed the development of these interventions (Appendix 6). We have identified three main research gaps, as follows:

- Most trials of non-tariff interventions have focussed on energy efficiency rather than on time-shifting of demand. While we can draw useful learning from the energy efficiency

trials (e.g. on the types of interventions which engage customers), additional learning can be delivered through trials which focus on DSR, which is more useful to DNOs.

- Where the impact of non-tariff interventions on DSR has been examined, trials have generally been based on small samples, and are not necessarily representative of a wide range of GB customers. The ACE trials therefore aim to focus on customer and community groups (schools, local authorities) which can be found in every DNO area and to target engagement interventions designed to have a wide appeal. Furthermore, our demographic analysis demonstrates that the majority of GB customer types (86%) are represented in the County Durham trial area (Appendix 9).
- While the New Thames Valley Vision project has looked at non-tariff interventions for I&C customers, no UK trial has focussed specifically on public sector I&C customers, who may respond differently, given their different motivations, backgrounds and user profiles. We are therefore focussing on these customers in our I&C trial.

We also wish to build on best practice from interventions which have shown promising results (see Appendix 5 for more detail):

- Feedback on behaviour and social norm information have been found to reduce energy consumption.
- Using competitions and providing information through games have been shown to play an important role in encouraging behavioural change.
- Community groups and public commitments foster a sense of team involvement, can increase incentives to act differently and community rewards encourage co-operation.
- Trials have demonstrated that parents learn from their children in energy and environmental issues, and children can act as messengers to provoke behaviour change in households.

Based on this, we decided on the following measures:

- *school programmes*, including engaging customers through information provision and competitions;
- *wider community* interventions to drive changes in behaviour and practices among households in a local setting through internet-based games; and,
- *targeting local authority I&C* premises through provision of advice, competitions, public pledges and awards involving local authority employees.

These interventions have been identified through analysis of best practice and research gaps in the literature (Appendix 5), and learning on customer engagement from the CLNR (Appendix 6). They have been chosen based on two criteria: (i) initial small scale trialling, or trialling overseas, has demonstrated their potential as solutions; and (ii) they are likely to provide a solution across a high proportion of the GB network. Our partners in Newcastle University will also trial combinations of the DSR response achieved with a range of complementary network solutions using simulation and emulation.

Method part 2: DSR planning tool

The key objectives of this part of the method are to produce a DSR planning tool that will enable DNOs to:

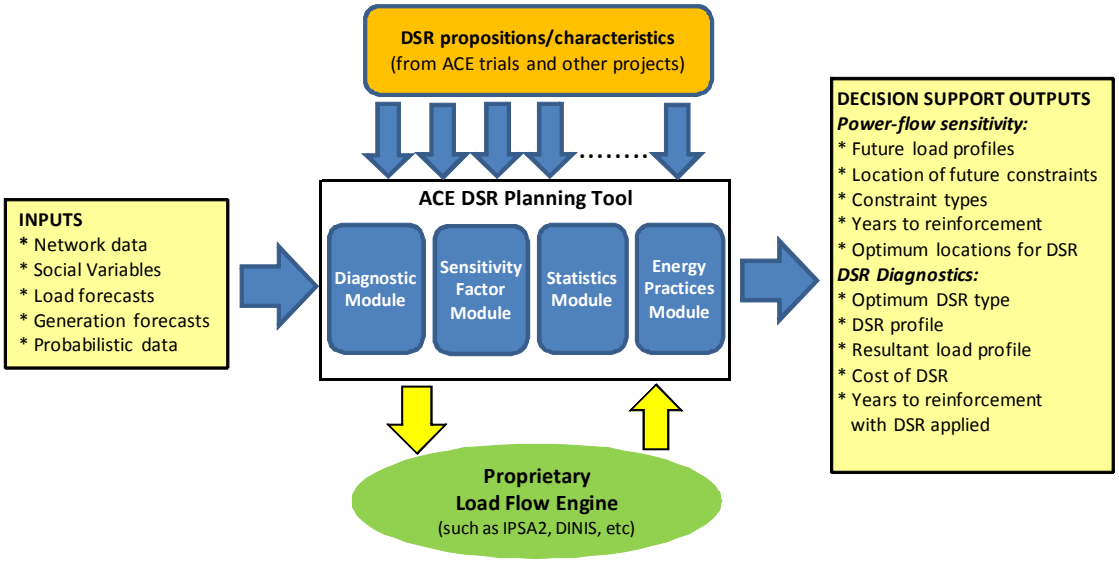
- Identify parts of their networks that are likely to face future constraints, particularly thermal and voltage issues due to the growth of low carbon technologies;
- Identify the points on the network where the application of peak load reduction would help to address these constraints; and
- Identify the DSR potential at these locations, the probability of receiving the required response and the cost of that response, based upon the characteristics of the customers connected.

The DSR planning tool presents a novel approach to selecting and implementing DSR. It will enable users to identify, based on the types of neighbourhood demographics or energy uses driving the constraint, how much DSR potential is available and the degree of confidence that could be applied to it.

It will be a probabilistic tool which can incorporate the variability in DSR response. To populate the tool, we will draw on the results from the trials from ACE part 1 and also assess the results of other relevant LCN Fund projects and wider research.

The DSR planning tool will therefore provide an important role in pulling together the range of research on DSR that is being undertaken and translating this research to allow it to be practically applied in DNO decision making. The tool will also help determine when it is cost-effective to combine the use of DSR with other techniques such as RTTR, storage or smarter voltage control.

Figure 2.1: DSR planning tool overview.



Trials being undertaken to show the method works

Method part 1: Innovative customer engagement methodologies and incentives

To test the responsiveness of households to different non-tariff DSR techniques, we will design and trial a series of customer engagement interventions in specific locations aimed at delivering the required level of DSR. We will run the trials over a two year period to test the persistence of the DSR, and hence its value as a long-term solution for DNOs.

The detailed design of the customer engagement methods to trial is a critical part of the project. At this stage, we have determined the main dimensions of the trials required to enable us to achieve our objectives and have ensured that the design of the interventions is consistent with the criteria for assessing DSR options currently being developed in Workstream 6 of the Smart Grid Forum (an assessment against these draft criteria is set out in Appendix 8).

The key features of the trials are summarised in Figure 2.2.

Figure 2.2: Trial overview - Routes to engagement, customer types, and interventions.

Customer engagement routes		Customers	DSR response to be tested: Profile balancing (static)	Profile balancing (dynamic)	Direct control
Schools	Education, individual and community competitions	Up to **500 residential**	✓		
Wider community	Individual and community competitions, on-line games	Up to **2000** residential customers	✓	✓	✓
Local authority	Advice, public commitments, league tables and awards	Around **40 local authority buildings**	✓		

Schools trials - We plan to trial the engagement intervention in 10 schools, targeting 500 households. This trial will include a programme of engagement measures aimed at using schools to act as a community hub and engender action by pupils' households, and possibly their neighbours, to adjust their energy use. The responses sought from these communities will be to test static profile balancing:

- encouraging a shift of load away from the traditional evening peak; and
- encouraging a shift of load to periods of low load / excess generation e.g. from solar PV.

The responses will be monitored at the household level using smart plugs with whole house monitoring, and progress fed back to the school and made available for parents. The data collected and the visualisations that will be fed back to the schools will allow competitions and comparisons between pupils. This will then foster co-operation among pupils, to encourage competition between classes and ultimately between schools. The motivations for the school to participate will be the engagement of its pupils in a topical area as well as engagement across the community. Prizes will also be offered. We have secured an agreement with Durham County Council for access to all its schools which will ensure that we can select a range of schools that offer a good mix of representative social demographics, and user profiles in areas with a particular feature such as a high load due to heat pumps, or a high generation output from a cluster of PVs.

Wider community trials using internet-based engagement – We plan to run trials based upon the Gen Game with 650 households in three trials, covering 1950 households in total. The trials will be used for direct control, and static and dynamic profile balancing to address peak loading and voltage issues. To achieve recruitment at these levels, we will need to target recruitment at more than 1950 households in total. The recruitment process will provide learning in itself because in trialling the Gen Game, we are looking for learning in two areas: whether households are happy to participate in the DSR propositions offered, and how their energy use changes once they are participating. In the direct control trials, households, and possibly small businesses, located around a particular node on the network will be invited to participate in an internet-based direct control DSR proposition based on the Gen Game, developed by Oswald Consultancy. Customers will volunteer their domestic load for instant demand response as part of a fun and engaging community game with regular opportunities to win prizes.

The Gen Game was designed to provide frequency balancing services to the TSO and has already been developed and trialled at a small scale using Technology Strategy Board (TSB) funding. The game was used to incentivise participants to offer appliances of their choosing for direct control. Participants were provided with a self-install smart energy kit, capable of

monitoring their energy use and controlling appliances instantaneously and remotely from a centralised Gen Game control system. Points were awarded for the size of the load offered for control and the incentive was the use of a league table and a small weekly prize. The results of the trial showed the game to be very attractive to customers, that it has the potential to unlock DSR, and that there are no technical issues with the systems to run the game.

The ACE project will build on the success of the small-scale trial by trialling the game to achieve direct control on a wider scale. It will then develop the game further to test if the same approach can be used to incentivise customers to deliver a broader range of DSR offerings to include static and dynamic profile balancing.

Local Authority I&C trials - We plan to work with employees at around 40 local authority premises in the Durham area, which we will access through our partner Durham County Council. 750 Durham County Council properties have half-hourly meters from which the Council collects the data and historical metering data is available. The trial will use a combination of techniques including: provision of energy efficiency advice, comparisons, competitions for awards, and public pledges. These interventions will be aimed at achieving static profile balancing to address local network constraints.

Scope for expansion - We are also working with Durham County Council on a bid to access a further £514k from EU funding later this year. This money will be targeted at working with communities investigating opportunities to save energy. If successful we will use the funding to expand the number of participants in the school trials. This will allow variations to the trials and for example, experimentation with different approaches of conveying the information to families via children.

Method part 2: DSR planning tool

Alongside the trial of the non-tariff interventions, we will also test the DSR planning tool as it is developed. The tool will produce forecasts of future load on each point on the network and an analysis of the drivers of that load growth. These estimates will need to be validated with past network load data and tested to ensure they can incorporate the range of factors affecting load across all DNOs. Gaining DSR through non-tariff customer engagement techniques is new for DNOs and is very far from business as usual. As the model produces estimates of DSR potential we will test the outputs against the results from the trials in Method Part 1 and other relevant LCN Fund trials. We will liaise with DNOs to ensure that the outputs can be practically applied, and that the software is easy to use.

Solutions which will be enabled

The ACE project will provide practical tools and guidance which will allow DNOs to access cost-effective DSR, thereby enhancing the toolkit for tackling thermal loading and voltage problems. The ACE project will therefore help DNOs manage their networks more efficiently. It will help bring down bills for customers, both through a reduction in network costs and through energy savings associated with participating in these schemes. Customers will also benefit from the fact that they can voluntarily participate and benefit from the rewards of DSR without the risk of incurring higher costs. In particular, the project will produce two main outputs:

- best practice guidance on how to engage with customers to achieve DSR; and
- a DSR planning tool to identify future network constraints and to forecast the DSR flexibility likely to be available based upon an analysis of customer characteristics.

These outputs will feed into the development of recommendations for the update of ERP2/7 for the security contribution from DSR and recommendations for any changes to the regulatory or commercial frameworks to enable a wider scale take-up.

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2.2 Technical description of the project

This section provides a technical overview of the method being deployed and an outline of why it is innovative. In part 1 of the method, technology will be used for monitoring the network in the trial areas and for providing feedback of network data and customer data to provide stimulus for customer engagement. Part 2 of the method will develop a DSR planning tool which DNOs can apply to their own network areas.

Monitoring equipment

Network monitoring equipment will be required to confirm the constraints and observe the collective impact of changes in customer consumption on different nodes on the network. We will seek to reuse monitoring data and equipment from the CLNR trials where possible, for example to provide controls for the ACE trials. Each customer's consumption will also be monitored directly, either via a smart meter, by in-house monitoring/smart plugs or through half-hourly metering in the local authority I&C trials.

Systems for customer data analysis and appliance control

The Gen Game system for data collection and analysis will be used for the schools trials and the wider community trials to monitor whole house consumption and the consumption of individual appliances and, in the case of the wider community direct control trials, to issue direct control signals over the internet. The database behind the game can be arranged so that customers can be tagged to LV feeders, distribution substations, HV feeders and primary substations, enabling measurement and modelling of how much DSR capacity there is at each node on the network through continuous monitoring.

Our expert partners in Newcastle University will provide the systems for network data analysis, building on experience gained in the CLNR trials.

Technology requirements for simulation

We will use simulation for two purposes.

- *To understand the effectiveness of combinations of interventions*. It is likely that DNOs will also want to combine technical tools such as RTTR and storage with DSR to manage the network cost-effectively while maintaining the required security standards. We therefore propose to supplement the live trials with simulation of the impacts of combining non-tariff DSR interventions with technical interventions. This could include assessing the extent to which a marginal or unpredictable DSR response from a community can still defer reinforcement if used in conjunction with a modestly sized storage system.
- *To understand the effectiveness of interventions in future scenarios.* Simulation can also allow us to understand the effectiveness of interventions under 2020 and 2030 scenarios on networks (for example to test a range of future scenarios for demand), and to extrapolate and scale up the results of the experimental trials.

The Smart Grids Simulation and Emulation Laboratory at Durham and Newcastle Universities (which is also being used in the CLNR project) will be used to simulate network power flows. The laboratory allows for small scale real equipment to be used and interfaced in real time with a large scale model of the power system. It includes the capability for emulating small scale storage and flexible demand and generation. The distinctive feature of this laboratory is the ability to have real time power and control interactions between the physical emulation and simulated parts of this system. This functionality will play a central role in extending the trials and adding value to the results of the project. As this laboratory already exists, this work will not require the purchase of significant additional equipment.

DSR planning tool - technical description

In part 2 of the method, we will build on existing commercially available power-flow analysis tools and on research funded through the Innovation Funding Incentive (IFI) mechanism

and undertaken at Durham University which has created a theoretical interdisciplinary socio-technical methodology for quantifying the value of DSR in deferring network reinforcement. This work has produced a methodology which forecasts how many years load growth a section of network can accommodate before components exceed their thermal rating. The approach identifies components within the network which are thermally vulnerable and uses power flow sensitivity factors to assess the value of applying real power reductions, through DSR, at different substations to relieve thermally constrained components. This allows the technically most appropriate substation to be identified for the application of DSR actions. The methodology then socially characterises the load points by using publically available socio-demographic data to map out the number and type of customers connected at each substation. In-depth qualitative interviews were undertaken to identify which combination of demographic factors might lead to demand flexibility. These DSR flexibility rules can then be used with the socially characterised substations to theoretically gauge the potential of demand side participation from different customers across the network. These two solutions, the technical solution using power flow sensitivity factors, and the social solution using demographic factors, can then be combined to give a more holistic socio-technical DSR solution. The results from the trials in method part 1, as well as the results of other LCN Fund trials and wider research will provide the data to turn this from a theoretical to a practical methodology.

The tool will have two key sets of outputs:

- Power-flow sensitivity outputs that forecast the location of future network constraints and identify where best to apply DSR to relieve those constraints using network data, load growth forecasts and customer characteristics; and
- DSR diagnostic outputs that will predict the DSR potential at these specific geographic locations using the customer characteristics and the results from ACE and other DSR research projects for different DSR propositions.

Delivering the power flow sensitivity outputs

The first stage in developing the power flow sensitivity aspects of the tool will be to identify the period of time a section of network, using P2/6 assessment criterion, can accommodate year on year load growth and identifying when reinforcement would be required. For a given load growth, the length of time before reinforcement is required is the time taken for the loading of the network to reach the maximum rating of the most vulnerable component.

The tool will achieve this by interfacing with commercially available power-flow analysis tools to run scenarios that apply annual load growth percentages based upon assumptions on: housing stock projections including new build predictions; uptake of energy efficiency measures; electric vehicles; heat pumps; PV cells; wind; domestic-scale combined heat and power plants; and predicted year on year load growth.

The results from this analysis will identify the optimum network configuration along with the particular network constraint.

The development of the tool builds on an extensive academic body of work on power flow sensitivity factors (PFSFs) to calculate the value of reducing demand at each load point to relieve network constraints and to calculate which load point is technically the best from which to reduce demand in order to relieve the network constraints. Our development work will build on existing work including:

- Development of the long-run incremental cost (LRIC) pricing model for the Electricity Distribution Charging Methodology (EDCM) with Bath University and TNEI;
- Development of network risk models with Durham University; and
- Load curve profiles developed in the CLNR project.

Delivering the DSR diagnostic outputs

To develop the DSR diagnostic aspects the learning from customer participation in DSR will be modelled by capturing the social acceptability of DSR, and the cost of achieving that response, for different demographic groups from the trials in ACE method part 1 and other DSR trials. The ACE DSR trials in part 1 will seek to understand and gauge the different responses customers have to DSR and identify which customers are mostly likely to be willing to participate. The trials will also seek to identify which demographics will be most flexible in their payback of when the load will re-enter the network so that DSR can be used to solve rather than shift the network problem.

This learning will be built into the diagnostic tool by expanding on both the work carried out through the IFI funding at Durham University on the socio-technical methodology and the results from the CLNR domestic trials to enhance the geo-demographic classifications used. These geo-demographic classifications categorise customers according to a range of factors, such as (but not limited to) age, employment, education and house stock. This classification draws general conclusions about the characteristics and behaviours of the people with the underlying principle that similar people live in similar places, have similar lifestyles and do similar things. This methodology applies this principle by using geo-demographic data to classify different types of customers and gauge their potential response to engaging with DSR schemes.

The types of customers connected to each substation will then be identified by combining the substation locations with the geo-demographic classification. Data from the ACE DSR trials in part 1 of the project (and from other DSR trials) will then be used to quantify how each type of customer responds to demand shifting. This process will allow different substations to be ranked according to how acceptable DSR is to the customers who are connected to it.

Results from this tool can then be used to update inputs to the Transform model and to update the NPADDS model produced through CLNR with the aim of providing the information that a planner or designer needs to be able to rank the size, cost and reliability of the potential DSR against other options for making the required headroom available.

Outline of why the project is innovative

Part 1 of the ACE method is innovative because it is focussing on trialling promising but untested interventions to help DNOs access DSR without the use of tariffs. As outlined above, the interventions have been chosen based on identification of the research gaps in previous trials, and an assessment based on the literature of what are likely to be the most promising interventions.

Part 2 of the ACE method will build on previous research to produce an innovative tool to help DNOs make use of publically available data on demographics alongside the results of previous trials to factor DSR into planning and design in practice. This tool is innovative because it develops the results of all successful research on DSR into a practical resource for DNOs.

2.3 Description of design of trials

This section describes how we will ensure the trials produce results that are sufficiently robust for network planners and designers to use, while being no larger or more complex than necessary. The statistical robustness of our trial design has been tested by Newcastle University, who have estimated the sample sizes required to generate robust results (Appendix 7). Newcastle University will lead on the statistical analysis and methodology for the project.

Trial Location - We propose to run the trials predominantly within County Durham. The

exact location of the trials will be selected during the detailed trial design stage based on a consideration of demographics and user profile mix, smart meter density, and an assessment of the constraints on the local network (including the identification of heat pump and solar PV clusters). Durham provides ACE with an excellent cross section of the UK demographics with 86% of the population well represented (Appendix 9).

Control groups -We will take the most cost-effective and robust approach to gathering control group data against which these interventions will be compared. We factored in the cost of this based on a proposal received from a supplier for the provision of smart meter data for 2000 customers on flat rate and ToU tariffs. We will also use existing monitored networks on the CLNR trials and historical data from the CLNR trials to provide a further comparison.

Sample sizes - Newcastle University Applied Statistics Group have estimated the sample size needed to ensure statistical robustness using household consumption data from 5000 households collected as part of the CLNR trial. Based on this, it estimates a sample of 120 households is necessary to reliably detect a 10% difference in peak consumption between a particular group of households in the trial and those in the control group.
The sample sizes need to be sufficiently large to detect changes for individual customer types, to make the results applicable to DNOs in areas with a different customer and user mix. The trials are targeted at different selected customer groups. For example, in the schools trial we would only expect responses from customer groups with children. To take account of such differences in household type, we will aim for take-up of up to 500 households in each of the schools trial. The community trial is likely to appeal to a wider range of customer types so a higher sample size of up to 650 in each of the trials is required.

In the local authority I&C trial we plan to engage with local authority employees working at around 40 of the 750 half-hourly metered premises belonging to Durham County Council. We propose to focus the trial on the type of properties which are common throughout GB and have the greatest potential for DSR. The final size of the trial will be investigated at the trial design stage when we can investigate the consumption data of all the I&C premises owned by Durham County Council.

Time period - It is important that the DSR measured in the trials persists over time, providing a long-term solution upon which the DNO can rely. Therefore we intend to run the trials for local authority and community trials for two full years (two winters and two summers) to test that customer engagement and the benefits of the interventions do not taper away quickly.

Pilots - Where required, we will pilot interventions on a small scale before rolling them out.

2.4 Changes since Initial Screening Process (ISP)

The Second Tier Funding Request has since ISP from £6,000k to £5,621k. This follows a thorough review of the budget undertaken during bid preparation including the project partners agreeing detailed roles, responsibilities and accountabilities. It includes a new external contribution of £430k from Durham County Council in benefits in kind against the original scope of our project. In addition, together with Durham County Council, we have identified an additional source of external funding from the European Structural and Investment Funds. If successful with this funding application, it would enable us to further expand the scope of the project to the benefit of customers. In particular, it will allow us to increase the size and scope of the schools trial, testing our interventions over two summers and winters.

There are no other material changes since ISP.

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Section 3: Project Business Case

This section should be between 3 and 6 pages.

This section presents the business case to justify the project. It also provides greater detail on the costs of the project, and sets out how the project links to changes Northern Powergrid would like to make to its business over the next 5-10 years.

In line with guidance from Ofgem, all figures in this business case have not been discounted. We focus here on GB-scale benefits. Details on the estimation of project scale benefits are provided in Appendix 10.

3.1 Summary

The ACE project aims to increase DNOs' access to cost-effective DSR, and to facilitate their use of this DSR in network planning and design. It also aims to provide customers with opportunities to benefit from the provision of DSR services.

- Method part 1 will provide DNOs with new and highly cost-effective means for accessing DSR without the use of tariffs. These new types of intervention will engage with schools, local authorities and the wider community through the use of a range of approaches, including games, social norm comparisons, league tables and the provision of energy efficiency advice. Customers participating in the ACE interventions will gain tangible rewards.
- Method part 2 will then provide a DSR planning tool that allows DNOs to forecast load growth in specific geographic areas, identify any potential network constraints and then quantify the DSR potential, for consideration alongside other options for releasing network capacity in its investment planning. The tool will provide DNOs with a level of confidence for the application of the ACE DSR interventions, and other types of cost-effective DSR, by taking account of local network and demographic characteristics.

Our analysis shows the ACE DSR propositions and the DSR planning tool will deliver **£3.4bn net benefits to DNO customers to 2050,** which equates to **£114m per annum**.

There are many uncertain variables in the calculation of the benefits and these estimates represent the mid-point of a range of potential net benefit outcomes, ranging from **£836m** to **£6,020m** to 2050, which equates to **£28m** to **£201m** per year. The bottom end of this range is based on the highly conservative assumption that DNOs would be able to integrate DSR into their investment planning in the Base Case, even in the absence of the ACE tool. Despite this conservative assumption, even the bottom end of this range represents a significant return on LCN Fund investment, in just one year. Moreover, our sensitivity analysis shows that benefits would be even higher under a more optimistic scenario for LCT take-up and energy savings, where the range of benefits would increase to **£3,196m-£7,408m (or £107m-£247m annually).**

All DNO customers benefit from the ACE propositions but ACE DSR participants benefit more. The ACE DSR participants will gain through energy savings and the potential to win prizes (for households). These benefits are up to **£33 per year for each participating household** (this would be substantially higher if they are awarded a higher than average number of prizes). If communities choose to pool their prizes then there is real potential to create meaningful funds to provide material benefit to customers' neighbourhoods. For the I&C trials, the benefits are again meaningful at **over £2k per year for each local authority site**. For both customer types, these benefits are on top of the savings all customers will gain through the lower DUoS charges driven by the reduction in network reinforcement costs that the DNOs will be able to achieve through their access to this more cost-effective DSR.

Alongside these financial benefits there are a range of other benefits, such as:

- an increased feeling of control over energy use and costs for customers, gains from the knowledge that they are contributing to their community and saving carbon and fun they may have participating in games and competitions;
- a reduced risk of stranded assets due to the option value from using DSR instead of making capital investments;
- potential spillover benefits to the TSO, suppliers or generators, if local network issues tackled by ACE coincide with national level issues; and
- carbon savings beyond those which we have monetised, for example savings due to facilitating the roll out of low carbon technologies and reducing embedded carbon in network reinforcement.

These wider benefits have not been included in our calculation of net benefits.

3.2 Basis for the benefits range-estimates

To produce an estimate of the net financial benefits associated with the ACE method, we compare the ACE method against a Base Case in which we assume that DNOs will have options to deploy smart solutions, but will not have available the ACE interventions, or the benefit of the DSR planning tool.

We first describe the costs associated with the Base Case and then compare the Base Case costs with the costs of each of the interventions being trialled and of the ongoing use and maintenance of the proposed DSR diagnostics/forecasting tool.

All benefits are estimated between 2020 and 2050, based on the assumption that the method would take two years to roll out across the country (see Section 5).

Base Case costs

The Base Case describes the most efficient alternative method for releasing capacity on the GB Distribution System. We summarise our approach here and provide further details in Appendix 10.

We assume in the Base Case that DNOs are able to undertake a range of conventional and smart network reinforcement options such as storage, enhanced voltage control and RTTR. We include smart measures in the Base Case, instead of just comparing the options to traditional reinforcement, as we assume that all DNOs will build the learning from CLNR and other research projects into their future business plans. This, however, is a conservative approach because we assume that these potentially cost-effective technologies, which are not yet all part of DNO business plans, are all commercially available to release headroom in the Base Case.

For our benefits case, we produce a range estimate based upon two assumptions on the availability of DSR:

- For the upper boundary of our range-estimate, we assume that DNOs can access and use the full range of smart options, apart from DSR. This is a reasonable assumption, as without the DSR planning tool being developed in Method part 2, DNOs may not be able to integrate DSR into their planning and design decisions with the required level of confidence.
- For the lower boundary of our range-estimate, we assume the smart options available in the Base Case include DSR. In this case it is most likely that DNOs contract bilaterally with I&C customers to gain DSR, where they will have to compete with National Grid. It is therefore unlikely that they could access this DSR at a cost below the cost of STOR.

We therefore assume this DSR can be accessed at a cost comparable to the current cost of STOR plus transaction costs (£43/kW - see Appendix 10). We also assume that this Base

Case DSR is already associated with a 5% reduction in electricity use. This is highly conservative, as energy savings associated with DSR from I&C customers are likely to be more limited than the savings associated with DSR from households. This is because the DSR may be supplied from sources such as back-up diesel generators, rather than through changes in energy behaviour. We therefore present a less conservative sensitivity below, where we reduce the energy saving assumed to be already achieved in the Base Case by 50%. To quantify the Base Case, we used the Smart Grid Forum's Transform model. The Transform model determines when network assets will exceed their rating and judges which of a range of potential future mitigations are the most cost-effective to deploy.

Under the assumptions described above, the Transform model estimates that a mix of traditional and smart measures would be required to meet the requirements of the carbon plan. Under the Base Case for the upper boundary, no DSR is used. Total reinforcement costs are £33.1bn at GB scale. Under the Base Case for the lower boundary, 11.2GW of DSR is used until 2050. Total reinforcement costs are £30.4bn at GB-scale.

Method costs

To establish the net benefits to DNO customers of the ACE method, we compare Base Case costs to the method costs.

We estimate the weighted average cost of the ACE measures to be £17-£20/kW. These costs include fixed costs such as programme management and IT systems, and variable costs, such as teaching time, energy efficiency advice and the provision of smart plugs. For those measures that include prizes, the cost of these prizes is also included (£3/kW on average). Further details on this estimation are included in Appendix 10.

To determine the uptake and effectiveness of these measures, we ran these costs through the Transform model. The Transform model estimated that an average of 429MW of DSR in each year out to 2050 is taken up under these cost assumptions (54MW-429MW of additional DSR relative to the Base Case). The lower end of this range could be roughly equated to the ACE interventions being rolled out to 10% of the country, with each household or local authority building delivering a 10% reduction in peak demand. The upper end of the range takes account of the fact that the planning tool will also facilitate the incorporation of other types of DSR interventions into DNOs' investment plans.

Calculation of net benefits to all DNO customers at GB scale

Based on our assumed Method costs, the Transform model estimates that a mix of traditional reinforcement, smart technologies and DSR would be required out to 2050 in GB to meet the requirements of the Carbon Plan, at a cost of £29.9bn out to 2050 at GB scale. Comparing this to the Base Case implies the savings in network costs associated with the ACE interventions sum to between £480m and £3,220m to 2050.

A further saving to DNO customers is delivered by the energy saving associated with the ACE DSR propositions. Based on the literature review, we make the assumption that the ACE DSR propositions could deliver a 5% reduction in electricity use. For the lower bound of our estimates, we have conservatively assumed that this reduction had also been achieved in the Base Case so the energy saving is only applied to the additional MW released by ACE.

Taking into account the additional benefits to DNO customers through energy savings and carbon savings associated reduced energy consumption and losses, the net benefits rise to between £836m and 6,020m at GB scale up to 2050. These net benefits equate to between £28m and £201m per annum at GB-scale. Making a less conservative assumption regarding the energy savings that could have been achieved in the Base Case (reducing these assumed savings by 50%) increases the lower range estimate to £2,041m, or £68m per

annum. Furthermore, under a more a more optimistic scenario for LCT take-up, the range of benefits increases to between £3,196m and £7,408m or £107m to £247m annually (see Appendix 10).

These estimates do not include non-financial benefits to customers, for example from enjoying participating in the DSR or from gains from the knowledge that they are contributing to their community and saving carbon. They also exclude the following benefits:

- There are likely to be benefits associated with the **option value** from using DSR instead of making capital investments. DSR programmes do not require large upfront investments and can generally be delivered quickly when required in a certain location. Under conditions of uncertainty over the growth rate of demand in different localities, this may help to reduce the risk of stranded assets.
- There may also be **potential spillover benefits** to the Transmission System Operator (TSO), suppliers or generators, if local network issues tackled by ACE coincide with national level issues. Given the uncertainty around these measures, to be conservative, we have not included them in this business case.

As well as saving costs, we have estimated that these measures will directly **save 72,000 - 620,000 tonnes of carbon** to 2050 through a direct impact on emissions from reduced energy use, reduced losses and peak shifting. These have been included in our monetised benefits. In addition the method will help save further carbon emissions by facilitating the roll out of LCTs and intermittent low-carbon generation and reduced embedded carbon in network reinforcement. We have not monetised these further emission savings. The impact on carbon emissions is detailed in Section 4.

3.3 Breakdown of the net benefits

Table 3.2 shows the breakdown of annual GB-wide benefits across each of the customer groups, and for the upper and lower boundaries of our range-estimate.

Table 3.2: Breakdown of the GB-scale annual benefits

ACE benefits	Benefits to all DNO customers	Additional benefits to ACE households	Additional benefits to ACE I&C customers	Carbon Benefits	**Total net benefits**
Lower boundary	£16m	£11m	£0.5m	£0.5m	**£28m**
Mid-point	£62m	£49m	£2m	£2m	**£114m**
Upper boundary	£107m	£86m	£4m	£3m	**£201m**

The benefits are split into four categories:

- **Benefits to all DNO customers:** All customers, including participants in ACE, will benefit from reduced energy bills due to lower distribution use of system (DUoS) charges. These reductions are due to reduced expenditure on network reinforcement due to the ACE interventions. These benefits are net of the cost of prizes.

  Benefits to ACE participants (households or I&C): In addition to the benefits from lower DUoS charges, ACE participants will benefit due to reduced energy consumption. Households participating in the wider community games and in school competitions also have the potential to receive prizes.
- **Carbon Benefits:** These include carbon savings due to reduced energy consumption

and losses, and peak shifting. Carbon savings associated with the earlier roll out of LCTs have not been monetised.

Although the total benefit to I&C customers is small compared to households, this reflects the smaller number of participants, rather than a smaller value per participant. On average a local authority site will receive up to £2,195 per annum. At the same time households participating in ACE will receive up to £33 per year (this would be substantially higher if they are awarded a higher than average number of prizes)

3.3 Costs

We have developed a robust set of cost estimates for the delivery of this project, which have been based on estimates provided to Northern Powergrid by partners and draw heavily on the experience gained in the CLNR project. The total project cost is estimated to be £7,405k; the outstanding funding required is estimated to be £5,815k, leaving the Second Tier Funding Request at £5,621k. External funding of £944k is also included in Table 3.4.

Costs and external contributions are detailed in Table 3.4 below.

Table 3.4: Project costs by cost category

Costs by Cost Category	Project Costs (£k)						
	2013/14	2014/15	2015/16	2016/17	2017/18	Total	%
Labour	106	597	537	551	343	**2134**	**33%**
Equipment & Contractor	20	1549	1363	1204	856	**4992**	**77%**
Payments to users	0	0	7	36	29	**72**	**1%**
Other	7	99	37	37	28	**208**	**3%**
Total Project Costs	**132**	**2245**	**1944**	**1828**	**1256**	**7405**	
less benefit in kind (inc potential £514k EU funding)	-9	-274	-173	-303	-186	**-944**	**-15%**
Sub total	**124**	**1971**	**1771**	**1525**	**1070**	**6461**	**100%**
less 10% compulsory contribution	12	197	177	152	107	646	**10%**
Outstanding Funding Requirement	**112**	**1774**	**1594**	**1372**	**963**	**5815**	**90%**
Adjust for Bank interest						-194	**-3%**
Second Tier Funding Request						**5621**	**87%**

We have also made budget assumptions on how these costs are distributed across workstreams. Table 3.5 sets out our estimated costs by workstream.

Table 3.5: Costs by workstream: budget assumptions

Costs by Workstream	Project Costs (£k)						
	2013/14	2014/15	2015/16	2016/17	2017/18	Total	%
Part 1: DSR Trials	**96**	**1,380**	**1,413**	**1,238**	**731**	**4,857**	**75%**
Part 2: DSR Planning Tool	**37**	**860**	**537**	**592**	**522**	**2,547**	**39%**
Project Subtotal (Gross)	**133**	**2,239**	**1,950**	**1,830**	**1,252**	**7,405**	
less benefits in kind (inc potential £514k EU funding)	- 9	- 274	- 173	- 303	- 186	**- 944**	**-15%**
Project Subtotal (Net)	**124**	**1,965**	**1,777**	**1,527**	**1,066**	**6,461**	**100%**
less 10% compulsory contribution	12	197	178	153	107	**646**	**10%**
Subtotal (after 10% contribution)	**112**	**1769**	**1600**	**1375**	**960**	**5,815**	**90%**
Adjust for Bank interest						- 194	**-3%**
Second Tier Funding Request						**5,621**	**87%**

3.4 Contribution to business planning

The ACE project will make an important contribution to changes to Northern Powergrid's business and how it engages with its customers in the next 5-10 years and beyond. It will

investigate important questions around the scale of the DSR potential available from customers and how best to integrate knowledge of this capability into DNOs' business planning. The project will also develop the tools and approaches required to embed this learning into normal operations at Northern Powergrid and other DNOs, to enable release of this potentially cost-effective DSR capacity.

Specifically, the ACE project will contribute to business planning in two ways.

- The interventions being trialled in the first part of the method will provide the practical means for DNOs to engage with customers to cost-effectively access the localised DSR required to address a range of constraints. The trials will provide an understanding of the scale of the DSR resource available from different customer groups, the costs associated with accessing it and confidence levels for its deployment.
- The tool being developed in the second part of the method will forecast the future impact of LCTs at a more localised level based upon demographic analysis, and draw on the DSR trial results from the ACE project and more widely. It will provide Northern Powergrid and other DNOs with a diagnostic tool to ascertain the potential size, cost and confidence levels for achieving DSR in specific geographic areas, based on the demographic of the customer base. This will provide valuable information for planners and designers and will allow them to compare this DSR with other techniques available for releasing the required headroom and therefore allow them to select where to deploy DSR.

Overall, this project aims to allow Northern Powergrid and other DNOs to access DSR more flexibly at lower cost. This will allow the DNO to reduce the costs in future business plan submissions. If the ACE trials show that the interventions being trialled can deliver DSR cost-effectively, Northern Powergrid will factor the flexibility that could be accessed through the methods into its business plans.

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Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

(a) Accelerates the development of a low-carbon energy sector & has the potential to deliver net financial benefits to future and/or existing customers

This section describes the contribution of the project to the Carbon Plan, the financial benefits and the network capacity released.

Contribution to the Carbon Plan

The ACE project will deliver:

- Best practice guidance on how to engage with customers to achieve a cost-effective DSR response; and
- A DSR planning tool to identify future network constraints and to forecast the DSR flexibility likely to be available based upon an analysis of customer types and demographics.

The solution will provide DNOs with an understanding of the extent to which thermal loading and voltage problems, which the growth of LCTs are expected to increase, can be addressed by encouraging customers to provide a DSR service. By doing this, the solution will contribute to the Carbon Plan in three ways.

- It will create the headroom to facilitate the ***roll out of LCTs*** such as electric vehicles (EVs), heat pumps and solar PV.
- It will help manage the impact of increases in ***intermittent generation*** on the distribution network.
- It will directly ***reduce carbon emissions.***

Roll out of LCTs

The growth in LCTs such as heat pumps, electric vehicles and solar PV cells will increase thermal loading and cause voltage issues on distribution networks. In the absence of innovative solutions for DNOs to manage the growth in LCTs more effectively their continued deployment will become the cause of network constraints.

ACE will facilitate the rollout of LCTs by providing DNOs with access to non-tariff DSR measures, which may be especially suitable to solve these issues because they can be targeted on a particular point on the network.

Specifically the type of DSR that the ACE project is looking to deploy will relieve thermal and voltage issues caused by LCTs, through:

- ***direct control of demand*** e.g. appliances to remotely reduce load at peak times;
- ***static profile balancing*** to encourage participants to habitually shift their use of certain appliances to off peak times or to specific times of low load; and
- ***dynamic profile balancing*** to encourage participants to shift their use of certain appliances from peak load times to times of low load / high generation occasionally on receipt of a signal from the DNO.

Once the solution has been established, it will allow capacity to be released more quickly than network reinforcement. We estimate that the use of non-tariff DSR will release network capacity at least four months sooner than traditional reinforcement. This estimate is based on minimum timescales for reinforcing HV distribution networks, and the assumption that once the interventions to access DSR have been established, they could allow the faster release of capacity.

Faster release of network capacity is likely to allow more rapid adoption of LCTs, including heat pumps, EVs and solar PV. Releasing network capacity will therefore contribute to the

Carbon Plan by facilitating emission reductions in the buildings, transport and electricity sectors.

Intermittent low-carbon generation

As identified above, the ACE project will provide DNOs with the ability to relocate load into periods with significant intermittent low-carbon embedded generation (PV or wind) to relieve localised voltage issues. This will include encouraging customers to use the output of their own solar PV within their homes, and time-shifting flexible load to match the output of off-site wind farms.

Reducing carbon emissions

The ACE solutions are likely to directly reduce carbon emissions in four ways:

- DNO access to DSR will reduce the required amount of asset replacement. This will also help reduce emissions associated with the electricity sector by avoiding the embedded carbon associated with asset replacement.
- Where the solution shifts demand from a period of peak demand to a period of low demand or high distributed generation, it will directly affect carbon savings. In general, the carbon intensity of the grid increases at peak times as less efficient fossil fuel generation is required to run compared to a period of low demand. Shifting demand away from the peak will therefore, on average, lead to a reduction in carbon emissions. This effect will be dampened by the growth in low carbon intermittent generation. We estimate that this will save 5,000tCO_2, valued at £0.3m.
- The solution is also likely to lead to an absolute reduction in overall demand. As customers become more actively engaged in their energy consumption, they are likely to choose to reduce energy-intense activities as well as shifting them, thereby reducing carbon emissions. We estimate that this will save 327,000tCO_2, valued at £50m.
- Moving more load away from the peak towards the low point in the day should lead to a reduction in overall losses relative to the Base Case. Based on the Transform modelling this was estimated at around 312GWh up to 2050. We estimate that this will save 14,000tCO_2, valued at £2.1m.

Financial benefits

The addition of the ACE method to the DNO toolkit will enable the DNO to free-up capacity more quickly and cost-effectively than the traditional solution of network reinforcement and most of the smart solutions being developed.

We have calculated the net benefits of ACE by comparing the expected costs associated with non-tariff DSR interventions to all the options that will be potentially available to DNOs using the Smart Grid Forum's Transform model. The advantage of using the Transform model to determine the Base Case is that it allows us to assume that all DNOs will build on the learning from CLNR and other LCN Fund projects by taking account of the fact that there will be smart alternatives to traditional reinforcement, such as storage, RTTR and enhanced voltage control, available in the future to release headroom. Our analysis suggests that the net financial benefit at project scale of the ACE Method is £3.6m between now and 2050. However, as outlined in Section 3, project scale is not a good benchmark for this project, due to the presence of fixed costs, and the small scale of the ACE trials. In reality, we would expect these measures to be rolled out at a significantly larger scale. The net financial benefit at GB scale is £3.4bn, which equates to £114m per annum. Further details on the estimation of these figures are presented in Section 3 and Appendix 10. In line with guidance from Ofgem, these numbers have not been discounted.

Network capacity released and replicability

As described above, the ACE method will release capacity on the distribution network more quickly than traditional asset reinforcement.

We have designed the interventions and the trials to ensure that the potential for GB wide roll-out is significant.

- The interventions are aimed at large local authority customers, household with children at school and representative wider communities. Focussing on designing interventions for customers that are widely represented right across GB means that once proven effective, these measures can be rolled out widely.
- The trial results will also be applicable across GB. We have conducted a demographic analysis of the County Durham area and are able to show that the trial areas will be able to include customer types representative of at least 86% of households across the GB distribution system. This means that learning from the trials will be widely relevant to areas beyond County Durham.
- The tool will be crucial for facilitating the application of the ACE interventions (and other DSR measures) to specific localities which differ in terms of their customer mix and network characteristics. It will allow each DNO to assess the cost, potential and likely effectiveness that different DSR measures will have in a specific local situation.

We have also assessed the amount of DSR that would be taken up by DNOs given the expected cost reductions associated with the Method. Our analysis using the Transform model shows that an average of 242MW of additional DSR could be released per year from 2020-2050 using these methods, in comparison to the base case.

We estimate that the method could be rolled out across GB two years after the end of the project. This would allow time to review the education and training requirements for roll-out to other DNOs, and adjust the interventions based on feedback, and reach a decision to roll-out.

(b) Provides value for money to distribution customers

This section sets out the benefits that can be attributed to the distribution network. It also sets out how we have taken steps to ensure that the Second Tier Funding Request represents the best value for money to distribution customers. Finally, it demonstrates that the ACE project is innovative and that significant new learning will be developed.

Size of benefits and learning that are applicable to the distribution system

As described in Section 3, we have estimated that the financial benefits associated with the ACE measures are £3.4bn to 2050 at GB level, or £114m per annum. 98.5% of these benefits are attributable to the distribution system and distribution customers, with the exception of the 1.5% representing monetised carbon savings.

The ACE method aims to reduce the costs of managing network constraints. Distribution customers will benefit through lower DUoS charges (following the reduction in costs to DNOs) as well as through participation in the creation of tangible financial rewards and potential energy savings associated with these measures. Those customers that provide DSR will be incentivised to do so through the use of community prizes and individual rewards, and any behaviour change they engage in will be voluntary. The appropriate level of rewards will be determined as part of the detailed trial design.

Alongside these financial benefits ACE will deliver a range of other benefits such as:

- benefits for customers from an increased feeling of control over energy use and costs, gains from the knowledge that they are contributing to their community and

saving carbon and fun they may have participating in games and competitions; and
- a reduced risk of stranded assets due to the option value from using DSR instead of making capital investments.

These benefits have not been included in the overall estimate of £3.4bn.

On some occasions, there may be some spillover benefits to other parties in the value chain (in particular in terms of reducing TSO, supplier and generator costs). However, for benefits to other parties to be realised, issues on distribution networks must coincide with national-level issues in the wholesale market and on the transmission network. While these may sometimes coincide, they are not likely to coincide where local issues are driven by the clustering of LCTs. We have therefore taken a conservative approach and assumed that there are no benefits to other parties. Therefore all of the estimated financial benefits, excluding the carbon savings, are attributable to DNOs and their customers. These carbon savings make up only 1.5% of the overall figure.

Value for money and procurement processes

We have undertaken a review of all of the major cost categories associated with this bid to ensure that best value for money is attained for DNO customers. As part of the project, an open competitive procurement process will be undertaken to ensure best value in respect of key areas of the project implementation. The following areas will be competitively tendered:

- the development of the software for the diagnostic network tool;
- the procurement and installation of the network and household monitoring equipment;
- marketing consultants to help design and deliver the interventions to households;
- the extension of the IT system associated with The Gen Game; and
- energy efficiency consultants to identify the peak shifting opportunities for I&C customers.

Innovation

Part 1 of the ACE method is innovative because it is focussing on trialling promising but untested interventions and methods of customer engagement to help DNOs access DSR. As outlined in Section 2, the ACE interventions have been developed based on identification of the research gaps in previous trials, and an analysis of best practice in other research / trials and the most promising interventions undertaken to date. None of the ACE measures have been trialled with DNOs in the UK context.

Part 2 of the ACE method will again build on previous research to produce an innovative tool to help DNOs make use of publically available data on demographics and the results of previous trials to factor DSR into planning and design in practice. Developing this innovative tool will involve testing ways to use the results of previous trials to inform planning and design decisions. The output will be complementary to existing tools currently in use by DNOs. We are not aware of any tool in existence or being developed elsewhere that currently has this functionality.

ACE could not be undertaken without the support of the LCN Fund because of the innovative nature of the method and the significant scale at which it must be trialled before planners and designers can have the confidence to build it into business as usual operations. Implementing the method without further development or trialling would entail operational and regulatory risks. Further development of the method is required during the project, and a greater understanding of its effectiveness needs to be developed, before the method could be applied as business as usual.

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(c) Generates knowledge that can be shared amongst all DNOs

This section describes the incremental learning that can be gained from the trial, the applicability of the new learning to other DNOs, the robustness of the methodology and the treatment of IPR. Plans to disseminate learning are covered in Section 5.

Level of incremental learning expected to be provided by the Project

ACE draws together a number of areas on which Northern Powergrid has been working and believes can be developed further:

- The CLNR trials have developed our understanding of potential technical solutions such as RTTR, voltage control and storage, as well as investigating DSR through ToU tariffs. That work identified the value of the technical solutions in some circumstances and highlighted barriers to accessing DSR through tariff signals alone. ACE aims to investigate the potential for alternative non-tariff interventions.
- We have been taking forward a programme of work with our partners at Newcastle and Durham Universities to improve our forecasting of network constraints methodology and understanding of DSR. ACE aims to test different methods for integrating this work into the part 2 of the method to trial a DSR planning tool that can identify DSR potential.

We have examined the literature to build on learning about which types of interventions are likely to yield significant DSR, and identified gaps in the previous research that ACE could address as well as areas of best practice that ACE can incorporate and build upon (Appendix 5). This review has found that ACE can add valuable learning by:

- focussing on time-shifting of demand as well as energy efficiency;
- basing the trials on samples that are representative of the GB population and large enough to provide statistically robust results;
- focussing on customer groups such as public sector I&C customers that have not been targeted in this way in previous GB trials;
- learning from successes in previous trials and focussing on games, school interventions and I&C energy efficiency advice; and
- building on existing programmes such as The Gen Game that can be tailored to a DNO context to provide incentives for direct control and peak shifting.

Applicability of new learning to other DNOs

The findings of this project will be applicable to a large proportion of the distribution networks in GB.

- The results will produce estimates for DSR potential which are statistically robust and, through the use of the DSR planning tool, can be applied to varying demographic/customer mixes.
- Our demographic analysis shows that our trial areas will be representative of 86% of GB household types. This means that the results of the trials will be widely applicable across GB.
- The trials have also been developed to target areas of demand where there are likely to be willing partners across the whole of GB. For example ACE has partnered with Durham County Council to gain access to its network of schools and its own I&C premises and employees. This partnership model can be replicated throughout GB.

Robustness of the methodology

Previous trials in testing non-tariff DSR have often not produced statistically robust results on which network planners can rely. To address this issue, we have enlisted our partners at Newcastle University to sign-off on our trial design and ensure that our sample sizes are

sufficient to deliver a rigorous trial. They will continue to work with Northern Powergrid throughout the trial. The cost of this bid has been set based on sample sizes consistent with meeting the objectives. Our analysis demonstrates that a sample size of around 500 households is sufficient for the school trials and 650 is sufficient for the each of the wider community trials. More detail is contained in the project description and Appendix 9.

The treatment of IPR

We will comply with the LCN Fund's requirements on IPR. All of the learning generated in the trial will be shared publically.

(d) Involvement of external partners and external funding

Northern Powergrid is joined on this project by three strategic partners and a key collaborator, each bringing a distinct set of skills and resources. Our partners and external collaborators will support the implementation and delivery of the project. Partner organisations have been chosen on the following basis:

- *Technical capability to undertake the work.* A necessary condition for participation in the project is that the partners have the technical capability to undertake the work.
- *Quality of the contribution to the project.* We have also assessed the potential quality of the contribution that each partner can bring to the project, for example in terms of their expertise and experience in the relevant field.
- *Cost and financial contributions.* We have compared the costs associated with each partner's participation, net of the financial contribution that they intend to make to the project.

Assessment of potential partners across these three criteria has ensured we are working with partners that can deliver a high quality project and value for money.

Project Partners

Local Authority: Durham County Council (DCC)

Role: DCC will provide the link to schools and public sector customers.

- It will provide access to schools to engage with teachers, provide project management support for the education intervention.
- It will provide project management support for access to council buildings and staff, as well as historic information on energy use programmes already in place.
- It will provide access to the wider community through its range of public buildings and community links.

Rationale for choice: In recent years, we have progressively built up our links with local authorities that have a strong interest in low carbon and sustainability issues. These have developed from ad hoc contacts relating to specific projects to wider engagement on our innovation work and business plan. DCC has played an active role in the annual Regional Stakeholder Forums held to share learning from, and seek comments on, our CLNR project. We have also had extensive input from local authorities, including Durham, as we put together our well-justified business plan. We identified local authority involvement in ACE as central, given their potential for consistent application of interventions in any local area and DCC expressed interest in working with us after attendance at a CLNR regional stakeholder workshop. There are several important benefits to working with DCC. First, it covers a wide geographical area with wide variation in customer demographics, ensuring results obtained will be representative at the national level. Second it has demonstrated a strong interest in increasing energy awareness across the community and has an in-house Sustainability Team focused on internal issues, and works with a wider Climate Change Strategy Group

across the local area. Third, it has agreed to provide access to a range of schools in the local area and a range of public sector customers for involvement in the project. Finally, it is providing a substantial external contribution to the project of £430k in labour with an additional £514k from EU funding to be provided to enhance the trials, should their bid be successful. This funding will be used to enhance the schools trials.

DCC has demonstrated strong commitment to the success of ACE and is highly unlikely to withdraw from the project due to the synergies with its own strategy and plan. In particular, in a climate where cost savings are crucial, managing the energy use in council buildings will deliver energy cost savings, keeping costs down for council tax payers. On top of this, the wider societal engagement aligns with the council's remit to reduce carbon emissions through a strategy of promoting energy efficiency and sustainability in the region. Commitments are included in DCC's core business plan.

Engineering and statistical expertise: Newcastle University

Role: The Newcastle team will provide engineering and applied statistics expertise to the development of the diagnostic tool in Method Part 2. They will also analyse the network data from Method Part 1 and help supplement the results of these trials by undertaking simulation of different combinations of interventions, and assessing the effectiveness of interventions under future scenarios. Professor Phil Taylor of Newcastle University will take the role of Principal Investigator on the project.

Rationale for choice: The Newcastle University academic team also provide continuity from the CLNR project. The Newcastle team have extensive experience in sustainability research on electrical distribution, the role renewable generation can play in this and in the large scale mathematical modelling and statistical analysis required for appropriate assessment of the ACE project. Importantly, they will also have access to the Smart Grids Simulation and Emulation Laboratory.

Social science expertise: Durham and Exeter Universities

Role: The Durham and Exeter team will provide expert input to the high level design of the interventions in Method Part 1 and on the evaluation and documentation of the results from a social science perspective.

Rationale for choice: Durham University are playing an important role in the CLNR project, and its involvement in the ACE project will provide important continuity. To draw in additional expertise around community engagement, the core team from Durham University that were involved in CLNR will be supported by Patrick Devine-Wright from Exeter University, who brings expertise in human geography and environmental psychology, and has wide experience in leading and delivering research projects relating to public engagement with energy use.

Key Project Collaborator

Design and delivery of online participation methods: Oswald Consultancy

In addition to our partners, one of our key collaborators will be Oswald Consultancy. Oswald are an engineering consultancy who in conjunction with JarmaCoe designed and trialled the Gen Game, a competition where domestic customers have the potential to win money by offering household devices to be turned off remotely using smart plugs in response to critical peak demands. To ensure that a games trial could be deployed within the timescales of the trial, we needed to find a game that had already been developed and trialled, and that could be developed further for use by DNOs to address a range of network constraints. We identified the Gen Game as having the most potential for use in this area. Oswald will lead development and implementation of the games intervention, drawing on

their experience of trialling the intervention on a smaller scale. In allowing the Gen Game to be trialled in the ACE project, Oswald are contributing £50k of 'benefit in kind' based on the previous TSB-funded development of this game.

External Funding

The ACE project will receive external contributions in a number of areas:

- use of Northern Powergrid monitoring assets developed as part of the CLNR project;
- use of Durham County Council educational resources and systems, and labour contribution to the value of £430k; and
- a potential additional £514k from EU funding, which Durham County Council are applying for. This will be used to expand our school trial, enabling us to increase the duration and scope of the trials.

(e) LCN Fund Tier Two: Relevance and timing

This section describes the relevance of the project to the move to a low-carbon economy, its use in future business plans and the appropriateness of its timing.

Addressing developments most likely to happen

In the move to a low-carbon economy, power flows across the distribution network will be increased by further electrification of heat and transport and continued growth of distributed generation. LCTs such as solar PV cells, when concentrated on particular points on the network, could also lead to voltage issues. The ACE method may be especially suited to solve network issues caused by LCTs because it includes interventions that can be targeted on a particular point on the network, possibly including individual phases, and do not rely on working with all the individual suppliers in a particular location.

Heat and transport electrification is central to the move to the low-carbon economy. ACE will help DNOs access DSR to manage the associated increase in peak demand. The Government has committed in the Carbon Plan to encourage the deployment of low-emission vehicles before 2020 by supporting R&D and demonstration, and by providing £300 million of customer incentives. The Government also plans to introduce significant incentives for the uptake of heat pumps. The Carbon Plan projects that more than 130,000 low-carbon heat installations will be installed by 2020 as a result of the Renewable Heat Premium Payment and Phase I of the Renewable Heat Incentive.

In the 2010s, heat and transport electrification policies are likely to create challenges for distribution networks in areas where the rollout of electric vehicles or heat pumps are clustered. By the 2020s, for carbon targets to be met, both types of technologies will need to be widespread.

Generation connected to the distribution network, including domestic micro generation, will increase the magnitude and complexity of flows on the network. For example, Northern Powergrid has observed that high PV density can double the voltage swing on a network, taking up twice as much of the +10%/-6% permissible tolerance and, with conventional solutions, requiring twice the infrastructure. The ACE project will allow DNOs to access cost-effective and locally specific DSR to help manage these flows. The Government's 2020 renewables target is likely to require around 30% electricity from renewable sources by 2020, with 1% of electricity expected to be from solar PV by 2020 (DECC, 2010, *National Renewable Energy Action Plan*). Strong incentives are already in place to encourage investment in PV and clusters are already causing issues in some areas.

Smart meter rollout to all domestic and SME customers will be complete by 2020. The

tools being developed by ACE to engender DSR from households are being designed to be consistent with the communications capability of smart meters, helping to provide another valuable use for smart meters on their rollout.

Used as part of future business planning

ACE will make an important contribution to changes to Northern Powergrid's business in the next 5-10 years. It will investigate a number of questions around the integration of DSR into DNOs' business planning and will also develop the tools required to embed this learning into business processes, for Northern Powergrid and other DNOs. If the ACE trials show that the interventions being trialled can deliver DSR cost-effectively, Northern Powergrid will factor the flexibility that could be accessed through the Method into business plans. For every kW of flexibility that can be accessed through DSR interventions, some network reinforcement or smart solution implementation could be deferred. To the extent that ACE allows Northern Powergrid and other DNOs to access cost effective flexibility through DSR, DNO costs in future business plan submissions are likely to be reduced.

Usefulness in the absence of the expected increase in LCTs

In the absence of the full expected increase in renewable generation and low-carbon technologies, the requirements for these methods may be lower. However, the fact that these technologies may cluster in certain areas means that even at low levels of overall rollout, challenges will be faced by DNOs in some areas. There are instances already of DNOs experiencing power quality and voltage issues. Most of the voltage complaints that Northern Powergrid receives are now for high volts, although the consequential reinforcement for diffuse generation has so far been minimal. Access to more and lower cost flexibility through ACE would therefore help DNOs reduce costs, even if lower carbon technology rollout is slower than currently forecast.

Appropriateness of timing

As set out in Section 6, detailed planning has been carried out to ensure the project can be implemented between 2014 and 2017 which will test the persistence of the techniques and will allow the method to be rolled out at a national level by the end of this decade. Given the numbers of heat pumps, electric vehicles and the penetration of intermittent and embedded renewables expected by 2020, there will be an even greater role for ACE to reduce costs to distribution customers by the end of this decade. We will ensure that the results from ACE are robust across forecast changes in the generation and consumption of electricity, as defined above. ACE includes the ability to assess possible future scenarios which would impact on DSR and influence any current understanding and applicability of results obtained.

(f) Demonstration of a robust methodology and that the project is ready to implement

The project methodology is set out in detail in Section 6

Detailed project plan – This is set out in Appendix 2.

Resources to deliver project – Northern Powergrid have joined with three strategic partners and a key collaborator chosen on the basis of technical capability, quality of their contribution in terms of expertise, and their cost and financial contributions. This process will ensure high quality outputs and value for money. Other contributors will be recruited via a process of competitive tendering.

Timely start to project - The project plan sets out that we expect the detailed trial design and establishment of the trial areas to begin in Q2 2014 and complete in Q3 2014, and for customer engagement on the trials to commence in Q4 2014. This is possible due to the

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Evaluation Criteria continued

strong partners we have in place and roll through from CLNR, our experience at installing network monitoring and also from the fact that the trials are based upon game technology which has already been developed and successfully trialled at a small-scale and which we believe can be modified for a DNO context. The full project plan is shown in Appendix 2.

Customer impact of project implementation **-** The project is testing how customers respond to and engage with non-tariff based incentives, however participation is voluntary. Participating customers will have the opportunity to experience the potential benefits of providing a DSR service via the incentives that will be provided under the trial. Non-participating households will experience no change in their energy supply. The level of participation that can be achieved through a range of incentives is an output that ACE is testing. Full details of the impact on customers are set out in Section 8.

Costs and benefits of the project, uncertainties, potential for cost overruns or shortfalls in benefits **-** The costs and benefits of the project have been set out in Section 3. While there is a high degree of uncertainty around the benefit estimates, the outputs are robust to changes in assumptions. The cost-benefit analysis will be reviewed in the evaluation of the method in the project itself. Our approach to dealing with cost overruns is set out in Section 6.

Robustness of methodology **-** A robust methodology is central to ACE. That is why we have enlisted our partners at Durham and Newcastle Universities to help develop and design the trials and ensure that our sample sizes are sufficient to deliver a rigorous trial. The cost of this bid has been set based on sample sizes consistent with meeting the objectives and producing results which are relevant and applicable in other parts of the GB network with a different demographic mix.

Quality of the successful Delivery Reward Criteria **-** The successful delivery reward criteria are set out in Section 9 and comply with Ofgem's principles.

Verification of all information in proposal **-** All information and evidence used in this bid to support the case for ACE is referenced and more information can be provided should Ofgem wish to see it.

Risk mitigation **-** The risk register mitigation and contingency plans and ability of the ACE project to deliver learning with low levels of take up of LCTs and renewable energy are contained in Appendix 4.

Project suspension **–** Section 6 sets out the conditions under which the project would be suspended.

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

5.1 Learning dissemination

We have identified a set of learning outcomes.

- A standardised approach for DNO planners and designers to more accurately analyse the future constraints which will be experienced due to the growth in the use of LCTs and how these might vary for different demographic groups. The approach will use existing / developing tools and techniques, network data and published forecast data that DNOs can currently readily access.
- A DSR planning tool that uses published data to determine the potential DSR capacity and the level of confidence in its achievement at specific points on the network based on the different sectors / demographics connected to the network at that point.
- Best practice guidance, based on experience from the trials, for DNOs to access low cost DSR from a range of customer types using a range of engagement methodologies.
- All the materials, processes, tools and contacts found to be effective for the engagement of customers to take part in each DSR proposition.
- The principles behind the algorithms in the gaming platforms that are proven by the trials to deliver a positive DSR from customers.
- Empirical data taken from network monitoring and anonymised customer monitoring data to demonstrate the effectiveness of the interventions trialled on the project.
- A comprehensive review, using evidence from customer interviews and surveys, on the attitudes of customers to the DSR concept before and after the trials, their views on the incentives on offer and review of the practices that they change in the home and at work, where applicable, to deliver the outcomes incentivised by the DSR signals put to them during the trials.
- Recommendations to feed into the changes to Engineering Recommendation P2/7 for taking into account the security contribution from DSR.
- Recommendations for any changes to commercial or regulatory frameworks to enable the wide scale roll out of the DSR techniques that are proven to be effective by the ACE project.

Disseminating the learning, the practical tools and guidance and recommendations to allow wider implementation will be a core part of the ACE project.

Learning is a two way process and the ACE project recognises the need to communicate with a wide audience to test ideas as they are developed and to disseminate the outcomes of the trials. The key audiences will be other DNOs, those responsible for policy and regulation and the research community. It will also be important to consult with and educate customers and customer / community groups in the principles and benefits of DSR both from a network and a customer perspective. Communication with these stakeholder groups will aim to raise their level of understanding and, where relevant, encourage them to contribute information and views and to participate in the trial.

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Knowledge dissemination continued

Knowledge dissemination will focus on five target groups.

- **Other DNOs.** To deliver the benefits of DSR to customers it is important that all DNOs are provided with the practical tools and guidance to deliver these opportunities and, more important than that, that they have the confidence to deploy the form of DSR recommended by the ACE project as one of the tools that they can use to facilitate the growth in LCTs in a way that is efficient and sustainable. The dissemination of learning to other DNOs will be a priority focus throughout the whole of the project. All the key learning outcomes will be published on the ACE project website and all DNOs will be kept informed via bulletins, webinars and DNO knowledge sharing events set up specifically for DNOs by the ACE project as well as via the annual LCN Fund conference. Other DNO future networks employees will be invited to take part in a DNO competition based upon the wider community trials for direct control and peak shifting. This will give them first-hand experience on how these propositions work and also to give them the opportunity to feed back suggestions for improvement.
- **Customers and customer groups.** One of the key beneficiaries of the ACE project will be the residential customer who will be presented with a no-obligation opportunity to access the benefits of DSR (see Section 8: Customer Impacts). It is important that the concept of DSR, the reasons for its development and the benefits to customers is clearly, carefully and unambiguously communicated through all relevant channels to customers and customer groups to facilitate take up of the trials and to ensure that customer attitudes towards DSR and media coverage are positive during and after the trials. The customer groups engaged on the Project will include bodies such as:
  - Consumer Futures;
  - National Energy Action;
  - local community groups;
  - local authorities and social housing providers; and
  - the local and national media.
- **Policy and regulation.** An important part of the project will be to ensure learning on the development of wide-scale DSR provision from residential customers and from local authorities is reviewed by a wide range of stakeholders (particularly Ofgem and DECC) and, if considered a viable proposition, that any commercial or regulatory barriers are identified and resolved. The policy and regulation community will include:
  - Government and regulators including DECC, Ofgem, Smart Grid Forum, etc.;
  - industry groups including other LCN Fund projects (especially those working in the same space), the Energy Networks Association (ENA), Energy UK and Sustainability First; and
  - local groups including Local Enterprise Partnerships, Chamber of Commerce, Local Government Association and CO2 Sense.
- **Others in the value chain.** A range of other parties have an interest in DSR. We will engage with:
  - suppliers, including through Energy UK;
  - National Grid; and
  - other industry stakeholders such as Elexon.
- **Research community.** Engaging with the research and academic community will ensure that the ACE Project builds on existing and new learning and can feed into wider growth of knowledge in this area. The research community will include our University Partners at Newcastle, Durham and Exeter, as well as a wide range of European and International

partners they are linked with through smart grid and DSR research groups. Any university that shows an interest in our research will be welcome to attend the knowledge sharing events and have access to project outputs.

Effective communication and knowledge dissemination will be achieved on the ACE project by assigning clear responsibility within the project for:

- the marketing of the DSR products to be put on offer;
- on-going communication with the project's trial participants;
- the communication of project progress and the learning achieved along the way to relevant interested parties; and
- the formal dissemination of knowledge and learning at appropriate times, aligned with the key project output milestones.

There will be single point Executive responsibility for the management of all the communication aspects of the project and a communication manager will be appointed and be responsible for planning, establishing and implementing effective and high quality knowledge management processes, strategies and systems for information gathering, documentation management and dissemination of project learning. Optimum dissemination will be achieved through the use of a wide variety of communication channels.

The key focal point for access to the learning outcomes will be the ACE project website, which will be linked to the ENA Smarter Network portal. This website will include papers, data, photographs, videos, presentations, as appropriate, to ensure that learning is delivered in ways tailored to the different audiences. This will be supplemented by:

- two face-to-face ACE knowledge sharing workshops per year timed to align with accumulation of a number of key output deliverables, supplemented by webinars throughout the year hosted by the ACE Project to communicate key findings as they emerge;
- the Project will participate in the LCN fund annual conference each year the project is live;
- regular newsfeeds and six monthly bulletins will provide all subscribers with updates and direct readers to the ACE website;
- learning will be published in relevant journals;
- social networks (such as Twitter, Facebook and LinkedIn) may be used to spread the DSR offerings to a wider audience;
- press releases will be issued targeting various media to inform about the intentions and on-going achievements of the Project;
- promotional material will be produced including leaflets for further distribution through partners' communication channels and networks;
- a common project brand will be created for use by partners, such as a project logo and project presentation material, ensuring uniformity of the ACE Project to third parties; and
- formal six monthly progress reports and the project close down report will be produced for Ofgem, which will be publically available for any other interested parties.

Northern Powergrid will also seek to actively engage DNOs in internal application of the trials to develop understanding of the interventions and their outcomes, fostering knowledge dissemination. Northern Powergrid will also be interested in the progress of other DNO projects that are trialling customer engagement techniques.

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Knowledge dissemination continued

DNO employees will also be invited to participate in the direct control and profile balancing proposals based upon the Gen Game platform, which will assist DNOs in their understanding of the online game techniques. Each DNO will be provided with six sets of equipment required for the Gen Game and the same information provided to residential customers that participate in these interventions. As in the residential version of the game, results for each of the DNOs will be published on a website league table and employees will be able to compete with each other and group together to form competitions between DNOs. DNOs will also be emailed their results and ranking for circulation among DNO employees. Final results of the DNO Gen Game and rankings of DNOs will be announced at DNO conferences and workshops. We would also be happy to involve Ofgem employees in this competition in the same way.

For internal project communication, a collaborative shared workspace will be used as a means of sharing information, managing documents and publishing reports between Project partners. The Northern Powergrid website and internal communication systems will be used to communicate relevant learning to Northern Powergrid employees.

Northern Powergrid has also established a series of expert advisory panels to help us develop our thinking and evaluate our proposals for innovative business improvements as part of the business planning process for the RIIO-ED1 period.

Our intention is that these panels will continue into the RIIO-ED1 period and the ACE Project will make use of them by keeping them informed on proposals and progress and seeking their advice where required.

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Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%):
0%

Requested level of protection against Direct Benefits that they wish to apply for (%):
None – not applicable

By leveraging the experience gained from the CLNR project, using tried and tested internal governance frameworks and partnering with world class organisations, we believe we can successfully deliver this project.

6.1 Why the project can start in a timely manner

Northern Powergrid can ensure the ACE project starts in a timely manner by bringing together the following components:

- ensuring there is strong executive support from Northern Powergrid and from each partner with a clear commitment to ensure the ACE project successfully delivers the aims of the project and delivers the key milestones and outputs;
- trialling a technology that has already been tested on a small scale;
- working with project partners who can provide ready access to the customers and premises required for the project to succeed; and
- undertaking pre-project authorisation activity to ensure a fast start.
- establishing a Technical Assurance Co-ordination group to ensure technical consistency and alignment across all workstreams.

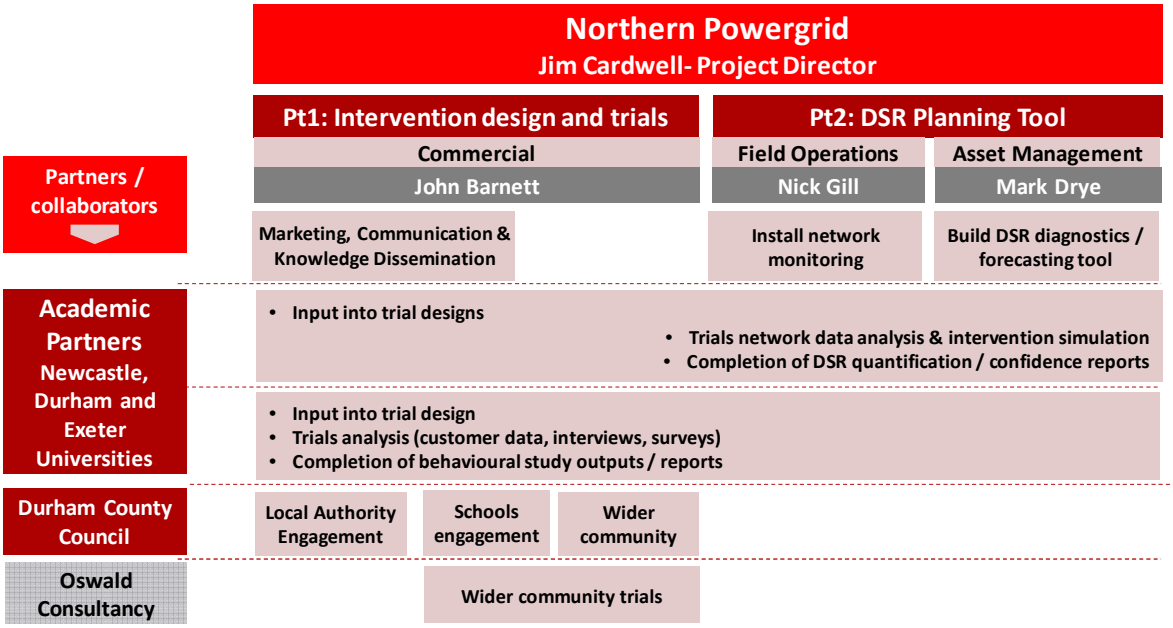
Executive sponsorship from Northern Powergrid and partners/collaborators

The ACE project has strong Executive support from within Northern Powergrid across three Directorates to ensure effective cross-business working and collaboration and the efficient mobilization of resources. Clearly the same level of leadership is required and is provided from our partners, Newcastle University, Durham University and Durham County Council, all of which are committed to the success of this project.

There will be an Executive Board consisting of the Northern Powergrid Directors and equivalent level membership from the project partners. The Executive Board will demonstrate an unambiguous signal of support for the project from each organisation by its senior management. The Executive Board will provide project direction advice and can mobilise the necessary resources to ensure the project delivers the planned outputs. Its first priority will be to complete the collaboration agreements between parties and to allocate resources to the project structure. The level of Executive oversight from Northern Powergrid and the contribution from partners and collaborators is illustrated in Figure 6.1.

The bid production process was a collective exercise with all the project partners / collaborators. This approach ensures that the project aims, scope, deliverables and plans are collectively understood. This understanding ensures a high degree of confidence can be ascribed to the project plans and the roles and responsibilities of each partner. The project readiness planning will continue prior to the LCN fund award to ensure the project is positioned to mobilise in Q1 2014 as planned.

Figure 6.1: Executive oversight / partners and collaborators



Trialling a technology that has already been successfully tested on a small scale

In addition to the project partners the ACE project will be supported by a project collaborator, Oswald Consultancy Ltd, who will develop their Gen Game to trial direct control, and profile balancing. The Gen Game has already undergone highly successful initial development trials in the Midlands as part of the TSB's 'Smart Power Distribution and Demand' competition. We believe that it can be easily modified to deliver the aims of the ACE project and scaled up to manage the required customer numbers. One of the reasons that this collaborator's technology has been chosen is that it has already been proven in a small scale trial.

Working with project partners who can provide ready access to the customers and premises required for the project to succeed

An important partner on the project is Durham County Council who can provide the project with immediate access to the following resources:

- access to 750 local authority premises, such as offices, depots, leisure centres, residential homes, libraries, etc., and to their historical electricity consumption data and a willingness to engage in behavioural studies to encourage employees to reduce energy consumption and move consumption where this has value;
- access to all the schools in County Durham for facilitation of the educational programme to be run through a selection of schools located in the trial areas; and
- access to and engagement with community groups for the wider communication of the ACE programme and the recruitment of participants for the online community DSR trials.

Pre-project authorisation foundation activity

Project readiness preparation will continue after the bid submission in August 2013 through to the decision point in November 2013. By the decision point in November 2013, we are aiming for all partners / collaborators to be signatories to a Memorandum of Understanding which will ensure explicit recognition and commitment to the project deliverables. The key

project readiness activities will involve 1) the identification of named resources by all partners, 2) the identification of potential suppliers for the competitively tendered elements of the bid, and 3) internal communications with key stakeholders e.g. the Northern Powergrid procurement and legal teams. It is intended that the collaboration agreement between Northern Powergrid and the partners/collaborators will be signed by the end of Q1 2014.

Technical Assurance Co-ordination
A technical assurance co-ordination group will be established, led by Northern Powergrid, to ensure technical co-ordination and alignment across all workstreams and ensure that the trials in part 1 are designed to deliver the requirements of the diagnostic tool in part 2.

6.2 Estimation of costs and benefits
The project costs have been constructed by Northern Powergrid with input from project partners and collaborators based upon estimated labour, contract and equipment costs for network monitoring at 20 substations and DSR participation at 40 premises on the local authority trials, 2,000 premises for the wider community trials and 500 for the school trials (with the possibility of expansion if EU funding is received). Benefits have been estimated using the Transform model. More details on this estimation are set out in Section 3 and Appendix 10.

6.3 Measures in place to minimise cost overrun
Great care has been taken to build a cost model that aligns with the project structure, the work breakdown structure and the phasing of the project over project timescales. This will enable close management of costs across these dimensions of the project. All partners have committed to work within their allocated budgets.

Specific contingency items have been built into the cost model to protect against cost increases. The total contingency is 8% of the total cost budget. In addition, the project assumption is that any cost savings delivered on particular aspects of the project will be added to contingency for use in the event of additional cost overruns or returned to customers at the end of the project. The cost model has been reviewed by Frontier Economics and by Northern Powergrid's finance team.

The ACE project budget will be managed by Northern Powergrid's finance function and the management of project costs will be a standard agenda item for the ACE Project Board. The project management methodologies will ensure these processes are embedded in the daily operations of the project. The rigorous approach to project governance should ensure that total costs will not overrun the estimate in the bid.

6.4 Verification of information in the proposal
All information included in the bid is accurate to the best of our knowledge. Cost estimates have been provided by project partners and collaborators and budget costs have been provided from a number of potential suppliers for the elements of the project that will be competitively tendered. We have used external consultants and Newcastle and Durham University to help set the required parameters of the trial and to set the customer numbers at a level that is not excessive but which will guarantee the statistical results that the project is seeking in terms of the cost and reliability of DSR from a range of customer types and user profiles which are required for input into the proposed diagnostics tool. We have also used external consultants to estimate the net financial benefits (Section 3 and Appendix 10). Throughout, we have identified clearly where we have had to rely on assumptions in the absence of accurate information or evidence.

6.5 Risks around LCT take up
The project is reliant to some extent on the take up of LCTs to date and will be seeking

some trial areas that have clusters of heat pumps or PV to provide suitable load profile for modification by the DSR offerings being trialled. We know that it will not be a problem to find such clusters in the Durham County Council area. In addition, the ACE project will, where appropriate, draw on customers that already have LCTs being monitored by the CLNR project. This project will not engage with customers that have already been part of the CLNR flexibility trials as this group will not, as a result of that prior engagement, be typical of the UK customers as a whole. It will, however, consider the use of these customers as a control group. Project learning is thus robust to the take up rate of LCTs within the trial.

6.6 Processes to end the project

Processes are in place to identify circumstances where the most appropriate course of action will be to suspend the project, pending permission from Ofgem that it can be halted. The key process will be to use the principle of stage planning and formal project board approval for the commencement of each stage. In addition, small scale pilots will be run with focus groups to test out the approach and applications for the online community gaming DSR solution before it is rolled out to the wider trial population. While we are confident that the results of the pilot will not result in the abandonment of the trial, it is a useful check-point for the design of the trials to ensure a higher probability of success for the full scale trials.

The Project Board will take responsibility for assessing the project on an on-going basis and approving each stage to ensure our distribution customers receive value for money. Any decision to suspend the project would be presented to Ofgem for final approval. The project will draw on the experience from the CLNR project to ensure project issues, risks and decisions are addressed on a timely basis and by the right people to ensure the project delivers its key aims and outputs as set out within this bid.

6.7 Project governance and project management methodologies

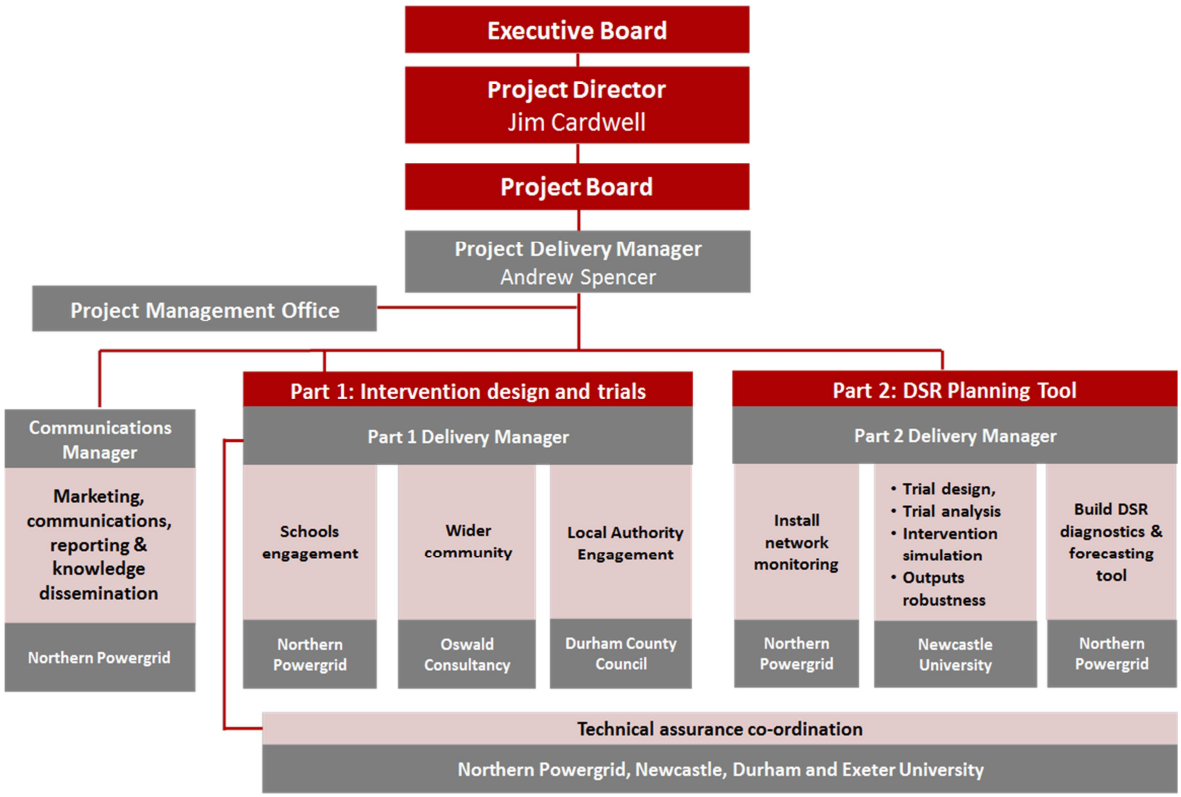
A clear project management and governance structure will ensure that the project is managed to deliver the key milestones and SDRCs, and maximise learning for distribution customers and all project participants. The Project Director, Jim Cardwell, Head of Regulation and Strategy, will take primary responsibility for project direction. The Project Director will be supported by:

- an Executive Board comprising senior management representation from each partner;
- a Project Board comprising each partner/collaborator with project delivery responsibility;
- the Northern Powergrid advisory panels for social issues, customer service, and technology and industry experts;
- a Project Delivery Manager, Andrew Spencer, and project management team comprising both Northern Powergrid and partner colleagues; and
- a Communications Manager.

The groups will be coordinated by the Project Director and Project Delivery Manager. The communications manager will co-ordinate all aspects of internal and external communication, promotion and reporting.

The bringing together of companies with different ways of working and different cultures requires the application of common project management and behavioural principles to ensure that the project is mobilised efficiently and achieves its required outcomes in respect of timing, cost and quality. The project structure is shown in Figure 6.2.

Figure 6.2: ACE Project Structure



Project values and behaviours

The key themes for the values and behaviours applied throughout this project will be the following.

Understanding the project goals

- *Project vision* - All project team members will be made aware of the project vision and have a view of what the vision means to customers and to the partner organisations.
- *Learning outcomes* - All project team members will be made aware of all the learning outcome expectations and how their particular workstream(s) contribute to the big picture.
- *Products* – the key project products will be described by product descriptions and signed off prior to the commencement of their production.

Planning to succeed

- *Create and communicate the high-level plan* - The high-level project plan will be communicated to all project participants by the project delivery manager.
- *Adopt a stage planning approach* - Planning by stages allows the Project Board to more effectively control the time cost and quality requirements of discrete elements of the project relative to the overall goals, to assess project success at pre-determined intervals and to ensure that key decisions are made prior to the detailed work needed to implement them and, in the extreme, to halt aspects of the project if required. The Workstream Managers will plan project stages for Project Board approval.
- *Manage the dependencies and critical path* - The Workstream Managers will fully

understand the critical path for their workstream stages and for the whole project and work with the Project Delivery Manager and Technical Assurance Co-ordinators to actively manage the dependencies between workstreams.

- *Understand project tolerances* - All project team members will understand the tolerances within which they are working and the extent to which a potential deviation from plan could affect the quality of the learning outcomes, the achievement of SDRCs or the cost of the project. The tolerance frameworks will be created by the project delivery manager and signed off by the technical assurance co-ordinators and then the Project Board.
- *Understand roles and responsibilities* - All Workstream Managers will ensure that all their team members understand how the achievement of their tasks contributes towards the overall learning outcome of their workstream and the project overall.

Keep focus on the outcomes

- *Monitor and control* - The Workstream Managers will monitor and control activities to remain on target to achieve the overall time, cost and quality requirements of their workstream.
- *Report on progress* - The Workstream Managers will report on progress in sufficient detail to enable the Project Delivery Manager to manage the dependencies between workstreams and to manage and report to the Project Director and the Project Board on progress against the overall project goals.
- *Managing issues, change and risks* - The Workstream Managers will assess the impact of any issues and risks and any proposed changes to the timing, scope or cost of planned project activity and escalate these to the appropriate project level.

Make decisions at the right level

- *Clearly defined criteria for reporting and escalation* - Changes, issues or risk that result in impacts within the tolerance agreed by the Project Board will be made at workstream or project level but changes that have the potential to threaten the achievement of the project direction will be escalated to the Project Board.
- *Clearly defined criteria for technical assurance* – Key technical decision points will be identified by the Technical Assurance Co-ordinators for Project Board review and approval. The Project Board will use the Advisory Groups, as appropriate, if a wider perspective or additional expertise is required.
- *Seek and apply project learning* - The ACE project team will operate as a learning organisation to encourage and foster a culture of mutual learning and continuous improvement by promoting a process that captures all lessons learned during and at the closure of each project stage in addition to learning from other LCN Fund projects.
- *Communicate to the team* - Actions, decisions and learning from whatever source they arise will be effectively communicated to all relevant participants via a shared workspace.

Stage planning

The Project Director will direct the project, report to the Executive Board and chair the Project Board. Day-to-day control on a stage-by-stage basis will be delegated to the Workstream Managers via the Project Board and the Project Delivery Manager. The Workstream Managers will be given clear parameters of the delegations for each project stage and will convert the high-level requirements into detailed stage plans for approval by the Project Board. The stage planning documentation will consist of the following:

- a stage plan in the form of either a Gantt Chart or similar displaying the timings and the tasks associated with this stage;
- an overview of any impact on the overall project plan and confirmation, or otherwise, of the key project milestones and the overall SDRC milestones;

- an update to the issues register with any issues currently affecting delivery of the stage;
- an update to the risk register with any risks foreseen for this stage;
- a stage initiation document containing: a list of the products to be delivered during the stage; the quality requirements and tolerances for each product and a description of how quality will be assured; details of any customer engagement involved in the stage and the plans in place to appropriately protect customer data; the stage costs and resource requirements; limits of delegated authority on time, cost and quality; identification of any dependencies between the products to be delivered in this stage and products in other workstreams or stages; a description of how the stage will be managed and controlled including how any lessons learned from elsewhere in the project can be applied in this stage; a plan for recording and disseminating learning, whether gained formally (e.g. as products) or informally (e.g. in the process of delivering the products); the issues currently affecting the stage delivery and how these will be addressed; and the risks that have been foreseen for this stage and how these may be mitigated including proposals for contingency.

Once all the products have been delivered and all tasks completed, it is essential that the stage is authorised to close. To gain approval for the closure of the stage, the Workstream Manager must present to the Project Board for approval a Stage End Report including the following: a completed stage plan; an update to the overall associated workstream plans and confirmation, or otherwise, of the future key project SDRC milestones; evidence that the stage has been delivered to cost and all products for the stage have been delivered within the required quality tolerances; evidence that product records have been updated and the products and associated documents have been correctly filed; evidence of effective dissemination; an update to the risk and issues registers for all entries relating to this stage ensuring that these registers include the impact that any departure from plan in this stage may have on adjacent stages/workstreams; and an update to the Lessons Learned Log to report on new lessons learned throughout the stage for future learning for the project team.

The management of decision points, risks, issues and changes

For the ACE project, the distinction between decision points, risks, issues and changes is as follows.

- A decision point is a point in the project where future direction cannot be given until earlier pieces of work have been completed and signed off.
- A risk is an uncertain event or set of events that, should it occur, will have an effect on the achievement of the project objectives.
- An issue is an event that has happened, was not planned or foreseen, and requires management action to resolve if the project is to achieve the project objectives.
- A change is a product deviation outside the predetermined parameters for time cost and quality.

Issues, risk and changes will be documented and managed through the use of registers. Appendix 4 shows the risk register for the ACE project.

Decision Points

The individual Workstreams within the project are structured into stages and each stage will contain identifiable decision points where outcomes from that stage influence the direction and plans for subsequent stages. These dependencies between stages and the relevant decision will be clearly identified in the stage plans.

Risks

The approach to risk management to be taken on the ACE project is to ensure that:

a) project risks are notified as soon as they are identified;

b) the risks enter a formal risk management process;
c) the risk level, in terms of potential impact and impact consequence and the mitigation approach to be taken is approved at level commensurate with the level of risk; and
d) the risks and their associated mitigation plans are reviewed at the appropriate level and at appropriate intervals.

The Project Board is responsible for providing guidance and clarity on new RED and AMBER risks and on risks that remain at this status after mitigation. Where risks transpire to be an issue or actual event which may exceed project tolerances, the Project Board is responsible for escalating such issues and potential solutions to the Executive Board. The Project Director in conjunction with the Project Delivery Manager will agree the budget identified for individual risks which will directly affect the usage of any contingency budget.
The Executive Board are responsible for providing guidance and clarity on RED risks including those risks which have transpired into an issue or event and the mitigation plan would exceed project tolerances.
The initial risk register can be found in Appendix 4.

Issues
The issues management process ensures that any emerging project issues that have the potential to impact on the project outcomes and associated time, cost and quality criteria are identified early, appropriately impact assessed and the contingency plan is escalated to the appropriate level within the project hierarchy for review and approval. It operates with a similar notification process and register as the risk management process.

Changes
The change management process ensures that all material changes to scope, cost or timing of particular project products that fall outside pre-determined parameters agreed with the Project Board are reviewed and approved after a comprehensive review of their impact on the relevant project criteria including the learning outcomes of the project. It operates with a similar notification process and register as the risk management process and the change register therefore keeps track of all approved project changes, the reasons for the change and their impact on the project.

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Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

We have assessed the regulatory implications associated with the delivery of the ACE project. Specifically, we have assessed whether the project may require a derogation, licence consent, licence exemption or change to the current regulatory arrangements to implement the project and have concluded that no such measures are required.

The regulatory areas considered include:

- existing industry DSR frameworks;
- ER P2/6 Security of Supply; and
- Interruptions Incentive Scheme.

Existing industry DSR frameworks

We do not consider that any derogations due to the interactions with any other DSR frameworks will be required.

ER P2 Security of Supply

We intend to base the ACE trial, where practical, on substations that are forecast to reach their firm capacity the soonest due to the growth of LCTs. However, it should be noted that these are forecasts and not actual loads at the moment and we therefore see no issue regarding operating within the requirements of ER P2/6 for the duration of the trial. However, the project will be making post-trial recommendations for input into the consultation process on the development of ERP2/6 into ER P2/7 to take into account the role of DSR, particularly in respect of the confidence that strategic planners and technical designers can assume for the availability and reliability of DSR from residential and local authority resources.

Interruptions Incentive Scheme

In the longer term, there is the risk that the use of flexibility resources to provide security of supply on selected parts of the network could result in delayed post fault restoration times which result in CML penalties under the Interruption Incentive Scheme (IIS). However, we do not see that being an issue for the duration of the ACE trials and will not be seeking any adjustment to the Northern Powergrid IIS targets.

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Section 8: Customer impacts

This section should be between 2 and 4 pages.

This section identifies key customer impact issues that have been identified by community groups and industry participants and then goes on to explain how we think that the principles being trialled on the ACE Project can address these issues and concerns.

A paper published by Consumer Futures on 2 July 2013, entitled "Smart grids: Future-proofed for consumers", concluded that, for DSR to be successful, ways need to be found to ensure that all sectors have the opportunity to participate and customers are not discriminated against in any way. It made four main recommendations.

- Further trials should focus more closely on the effect that socioeconomic and lifestyle factors have on households' ability to shift demand, as well as on the effectiveness of different consumer engagement strategies.
- Trials should also focus on what sorts of behaviour consumers are engaging in to shift usage (rather than simply the extent of the shift).
- Further work should be conducted to investigate the consumer impact of, and consumer reactions to, remote automation of devices.
- Legislation and/or regulation must ensure that consumers are compensated fairly and appropriately for provision of DSR services including where these are mandated at an EU level.

In addition, the Smart Grid Forum is currently working on options for DSR and has drafted a set of principles that state that customers should not be adversely affected by any of the DSR options, as follows:

- *Customer comfort* - Customers should not be unreasonably inconvenienced through pricing which incentivises them to change their electricity usage, or measures which automatically restrict their usage.
- *Clarity of information* – Customers must be able to understand the arrangements they are entering into and these will need to be communicated in a simple way to customers.
- *Pass through of benefit to customer* – Customers must receive appropriate value for the response that they are providing.
- *Ease of use* – Options for customer engagement must not be overly difficult to employ and must be simple enough to implement for all customers.
- *Impact on public attitudes* – The option must not trigger an adverse reaction from customers and must be seen as an opportunity for them to engage and save money.
- *Avoidance of lock in* – Customers must have some rights to leave the DSR arrangement if they want to, particularly if an arrangement with another party could provide better value to them.
- *Strength of signal* – The DSR signal must be strong enough to elicit a reliable response from customers in order to change behaviour.

The DSR measures to be trialled on the ACE project will, if successful, go a long way to address the Consumer Futures recommendations and the Smart Grid Forum criteria, as follows:

For the residential trials (via schools and the wider community).

- The customer is always in control and does not have to participate if they do not wish.
- There are benefits from participation but no penalties for not participating.
- For the direct control trials the customer chooses the load that they wish to offer and can withdraw from the trial or swap to another load if they find that the arrangements are not convenient.

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Customer impacts continued

- The arrangements will be simple to operate and simple to communicate and customers will get continual feedback on how they are doing via the ACE website.
- The value to a DNO from an individual residential DSR response is likely to be small but, in aggregate, the value will multiply depending on the number of people involved.
- Trial participants will benefit through engaging in a fun game with regular opportunities to win prizes, and all customers will benefit from lower future bills as a result of reduced DNO reinforcement costs.
- The arrangements will create a win/win situation for the DNOs and the customer and so it is felt that, despite DSR being a hot topic in the media at the moment, the principles of customer choice and customer benefits with no penalties and no risk will assist the achievement of positive media coverage.
- There are no costs to the customer for participation and there are no lock-in arrangements. The customer can therefore withdraw from the trial at any time. This principle would carry forward into wider scale roll out.
- To amplify the strength of the signal the trials will look for ways to release a proportion of the aggregate value of the DSR provided by the community to individuals and /or by aggregating the value and channelling it into the community in ways that the DSR participants care about.
- Customers will see a) a short-term benefit not reflected in their electricity bill, e.g. prizes or community grants, for participating; and b) a long-term benefit in electricity bills lower than they might otherwise have been, because of efficiently deferred investment. Customers are also likely to see a reduction in their electricity bill due to their increased awareness of how they use electricity.

For the local authority trials

The customer in this case is the local authority, but it is important to recognise that the success of the DSR proposition will be as a direct result of interactions with the management of the local authority and the attitudes and motivations of its many thousands of employees. It is clear to us that sustainability is high on the Durham County Council agenda and we will engage with the Council employees via their sustainability programmes.

Key principles for the residential customer interactions

The aim of the residential trials is to establish whether:

1. residential customers can be attracted by the DSR benefits that are likely to be on offer in the long-term;
2. sufficient participants can be recruited in a specific target area to make a difference to address a local network constraint;
3. participants respond to the signals after they have signed up;
4. customers continue to be engaged and maybe even enthused by involvement in DSR; and
5. different customer groups require different engagement strategies to achieve the required response.

The number of geographic areas targeted will be sufficient to give robust results across a range of at least 86% of the GB demographic mix (Appendix 9). All residential customers within the specific targeted areas will be eligible to participate, irrespective of energy supplier.

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Customer impacts continued

Outline of the engagement with customers

The trials being undertaken will include:

1. direct control trials where customers offer appliances of their choice for direct control at peak times; and
2. peak shifting / profile balancing where customers are incentivised to reduce load at identified peak times and to relocate load to times where the network might need more load to address voltage issues at times of low load / high generation.

Residential customers will be invited to participate via two main routes:

- using schools as a community hub and engaging children in exciting learning opportunities and engaging parents via their children; and
- targeting the wider community via various means to sign up to the on-line game

Customers will not require an interruption of supply for the installation of monitoring equipment. However, customers taking part in the direct control trials will experience occasional interruption to the appliances of their choosing as part of their agreement to participate. No other trial groups will experience any direct curtailment of their energy use.

The ACE project will return the value of the DSR provided by participating individuals back into the community using a number of different approaches. For example in the short-term participants can benefit from the opportunity to win prizes, and in the longer-term customers will benefit from lower bills as a result of improved efficiency in managing network constraints by DNOs.

Participants will have the freedom to group together to channel the benefits of DSR to particular community projects.

The mechanics of the engagement means that the project will need to collect customer data and the only obligation for a participant is that they must agree to allow their load profile data to be analysed by the project team and be identified against their username within the administration of the scheme and so that their individual performance can be fed back to them, relative to various comparators.

Anonymised league tables will be published with the consent of each participant using the username that they have selected. Only the project administrators of the trial and the partners/collaborators involved with one-to-one interviews will have access to the link between the usernames and a customer's full identity. Customers will have the option to decline from participation in surveys and interviews if they wish as we do not want this additional obligation, which might not be present in a wider roll-out, to skew the results of the trials. Large drop-out rates due to this requirement for consent has been a problem on other trials, so we are taking steps to mitigate this risk on this project.

Using schools as a community hub

This trial will include a programme of engagement measures aimed at using schools to act as a community hub and engender action by children's households to adjust their energy use. The responses will be monitored at the household level using smart meters, or smart plugs with whole house monitoring, and progress fed back to the school and made available for parents. The data collected and the visualisations that will be fed back to the schools will allow competitions and comparisons between pupils. This will then foster co-operation among pupils, to encourage competition between classes and ultimately between schools. The motivations for the school to participate will be the engagement of its pupils in a topical area as well as engagement across the local schools community. Prizes will also be offered.

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Customer impacts continued

Targeting the wider community

The Gen Game platform will be used as the basis for customers to provide a DSR response on the wider customer trials. In its simplest form, on the Direct Control trials, customers are awarded points for making their loads available to the Gen Game for direct control and they earn a place in a league table, dependent on the level of loads they offer. Financial rewards are also distributed amongst the players based on their placement in the league, winners are chosen, with more chances given to those who offer more load for curtailment (each unit of weekly energy consumption through the appliances offered for direct control represents one chance at winning the prize for contestant / household). Customers can club together to increase their chances of winning, say to raise funds for a community cause, and such behaviours have been found to spread the level of enthusiasm for wanting to take part.

The Gen Game provides the householder with a self-install smart energy kit, capable of monitoring their energy use and controlling appliances instantaneously and remotely from a centralised Gen Game control system. We would provide support for vulnerable customers who wanted to join the trial but felt unable to install the equipment.

We intend to extend the functionality of the Gen Game to apply it, not only to direct control of appliances, but to also see if a proposition can be created where customers are rewarded for shifting load themselves from a peak period to a time where the network needs more load connected, for instance at midday when there could be low load but a lot of PV generation.

Control Groups

We will also employ a number of control groups against which the impact of these interventions will be compared. We intend to include up to 2000 customers in these control groups. Their energy use will be monitored via smart meters.

Implementing the project with reduced customer interruptions

There is much theory about the potential take-up of DSR but the only way that the potential response can be truly tested in most cases is though field trials involving the level of incentives that are likely to be affordable in practice.

A key aim of the project is to test the effectiveness of the types of DSR being deployed in addressing thermal constraints and voltage constraints using techniques that involve customers participating in direct control and load shifting.

We believe that the principle of whether the load shifting incentives have potential for addressing phase imbalance can be simulated from the results of the general profile balancing trials and so the project does not propose to test phase balancing in the field.

We also intend to run simulations that feed in the results from the trials to network models that include real-time thermal rating devices, energy storage and voltage control to determine how these can be optimised with the type of DSR being trialled by ACE.

Appendix 11 provides an overview of how the customer engagement and retention activities will be managed and resourced.

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

9.1: Select trial areas: 30 September 2014

Criterion:

- Confirm the trial areas to enable the installation of network monitoring and the commencement of the customer engagement process.

Evidence:

- Trial areas selected to enable the engagement of up to 500 customers on school trials, up to 2000 customers on the wider community trials and up to 40 local authority buildings.
- The trial areas will include networks with the types of load/generation profiles that the project aims to address. (i.e. peak loads and intermittent peak generation).
- The trials areas will represent, between them, a broad range of demographics.
- The trial areas will be sufficient in number to allow independent trials to be run (i.e. direct control in one area, peak shifting in another, etc.).

9.2: Complete trial designs: 30 September 2014

Criterion:

- Complete trial designs to allow the commencement of network monitoring equipment and the start of customer engagement.

Evidence:

- Trial / proposition design completed for all trials.

9.3: Complete all customer protection arrangements: 31 October 2014

Criterion:

- Approval of Data Protection Strategy (DPS) and Customer Engagement Plans (CEP).

Evidence:

- Submit DPS and CEP for Ofgem approval by 31 August 2014.
- Ofgem approval of DPS and CEP by 31 October 2014.

9.4: Commence installation of all network monitoring: 31 October 2014

Criterion:

- Commence installation of network monitoring in trial areas.

Evidence:

- Network monitoring commissioned at first substation.

9.5: Complete installation of all network monitoring: 31 March 2015

Criterion:

- Complete installation of network monitoring in all relevant trial areas.

Evidence:

- Complete installation of network monitoring at up to 20 distribution substations to allow the monitoring of the trial areas.

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Successful Delivery Reward Criteria continued

9.6: Commence monitoring of trials – 1 June 2015

Criterion:

- Commence monitoring of customer data in response to the trial signals.

Evidence:

- Engagement / recruitment complete.
- Customer monitoring equipment installed.
- Commencement of interventions / monitoring.

9.7: Knowledge dissemination – trial designs: 28 February 2015

Criterion:

- Trial designs disseminated to DNOs.

Evidence:

- Trial design report published – 31 January 2015.
- DNO knowledge sharing event – 28 February 2015.

9.8: Knowledge dissemination – customer engagement: 30 November 2015

Criterion:

- Customer engagement experience disseminated to DNOs & other stakeholders.

Evidence:

- Customer engagement report published – 31 August 2015.
- DNO knowledge sharing event – 31 October 2015.
- Regional stakeholder event – 30 November 2015.

9.9: Knowledge dissemination – customer interventions: 28 February 2016

Criterion:

- Customer intervention results disseminated to DNOs after one year of monitoring.

Evidence:

- Summer 2015 results published – 31 January 2016.
- Winter 2015/16 results published – 30 June 2016.
- DNO knowledge sharing event – 31 August 2016.
- Regional stakeholder event – 30 September 2016.

9.10: Knowledge dissemination – DSR diagnostics tool: 31 January 2016

Criterion:

Issue DSR diagnostics tool functional specification for DNO review.

Evidence:

- DSR planning tool functional specification issued for review/comment– 31 January 2016.

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Successful Delivery Reward Criteria continued

9.11: Knowledge dissemination – final reports: 31 October 2017

Criterion:

- Final dissemination of learning after two year's monitoring.

Evidence:

- Final reports published – 31 October 2017.
- DSR planning tool made available to other DNOs – 31 October 2017.
- DNO Knowledge sharing event – 31 October 2017.
- Project Close Down Report – 31 October 2017.

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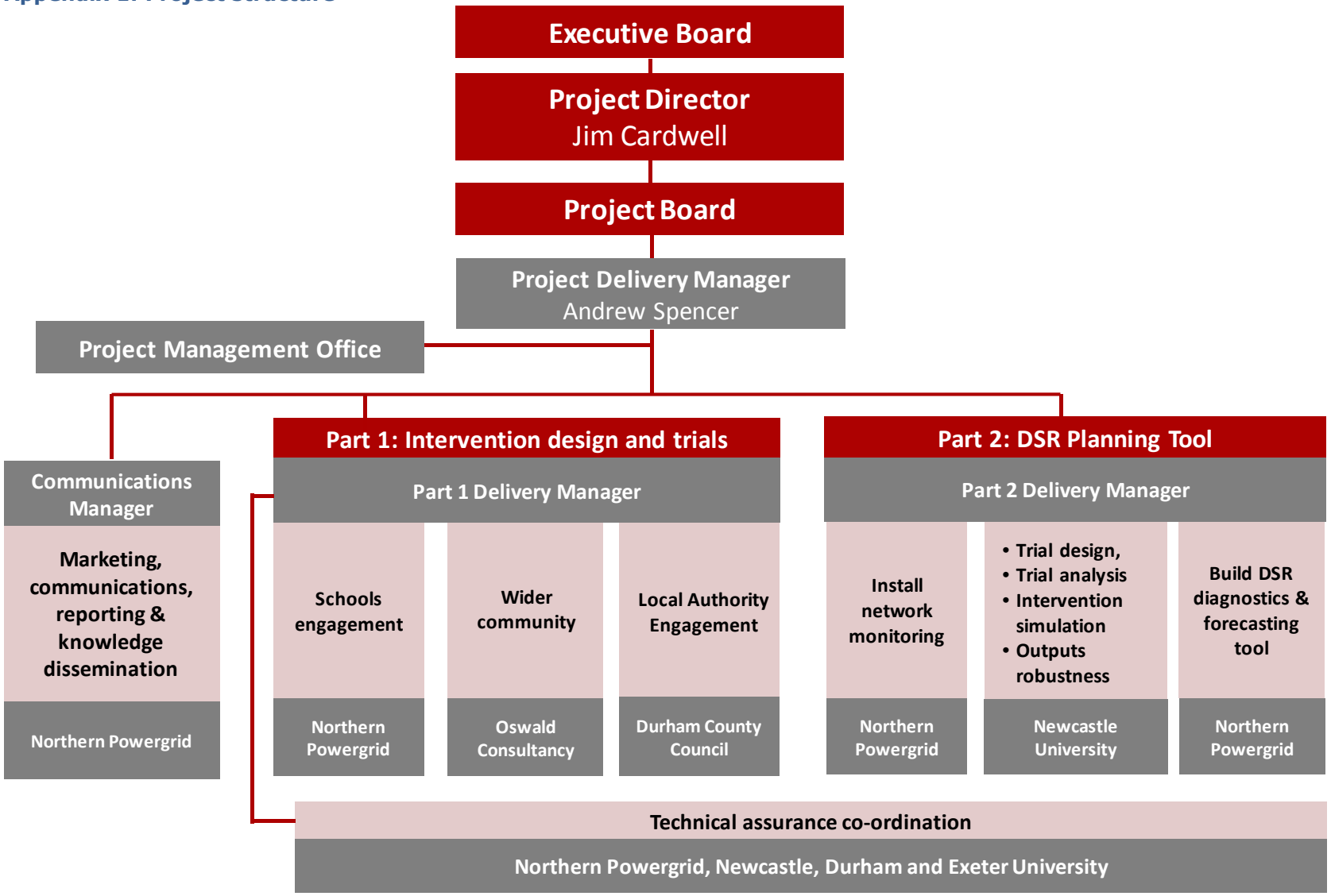
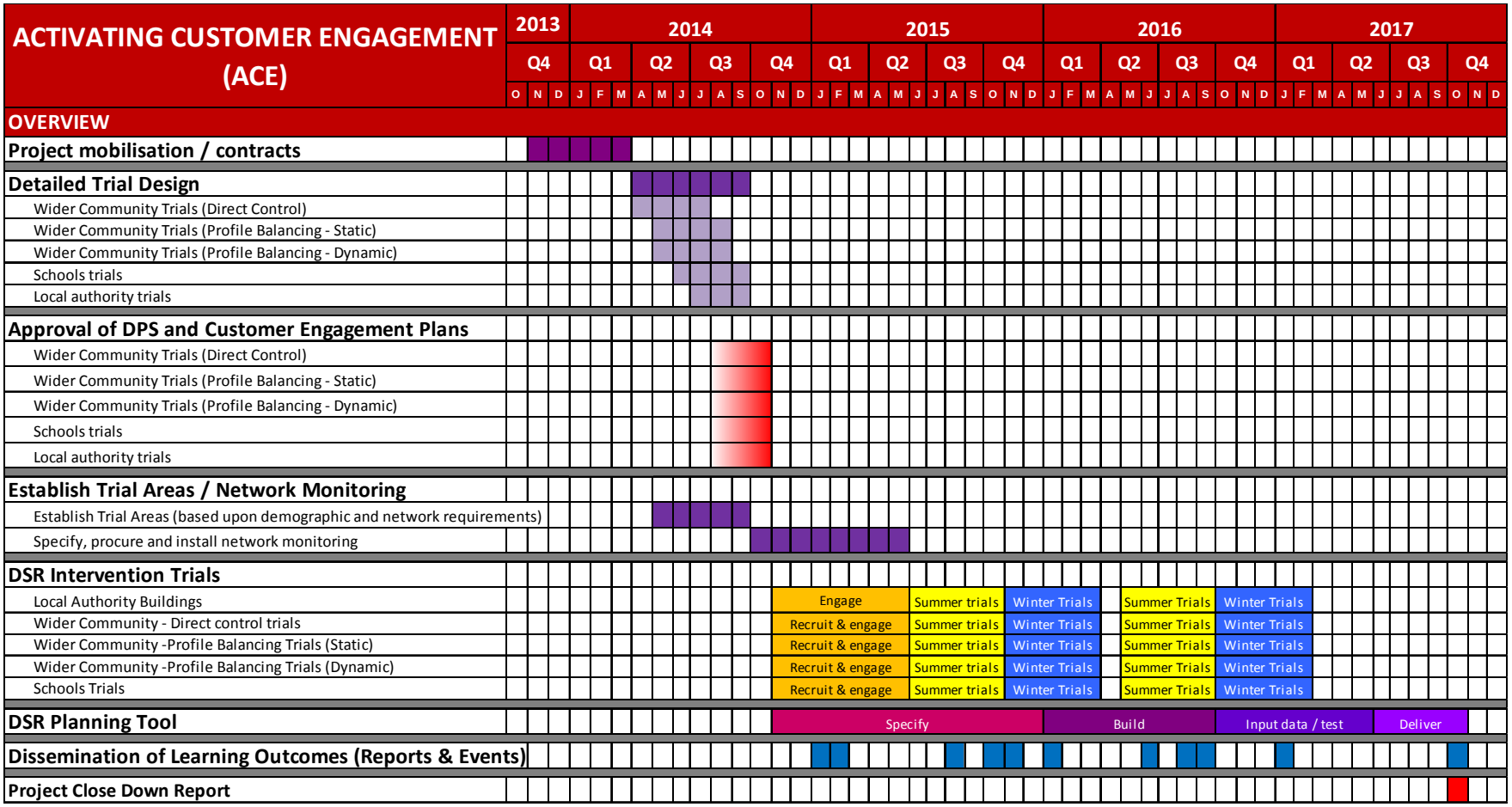
Section 10: List of Appendices

1. Project structure
2. Project plan
3. Maps
4. Risk register
5. Review of trials of non-tariff interventions
6. Emerging social science evidence from CLNR
7. Statistical design of the trials
8. Smart Grid Forum criteria
9. Demographic analysis
10. Further details on the benefits case
11. Recruiting and retaining customers
12. Second Tier Funding Request

Appendix 1: Project structure



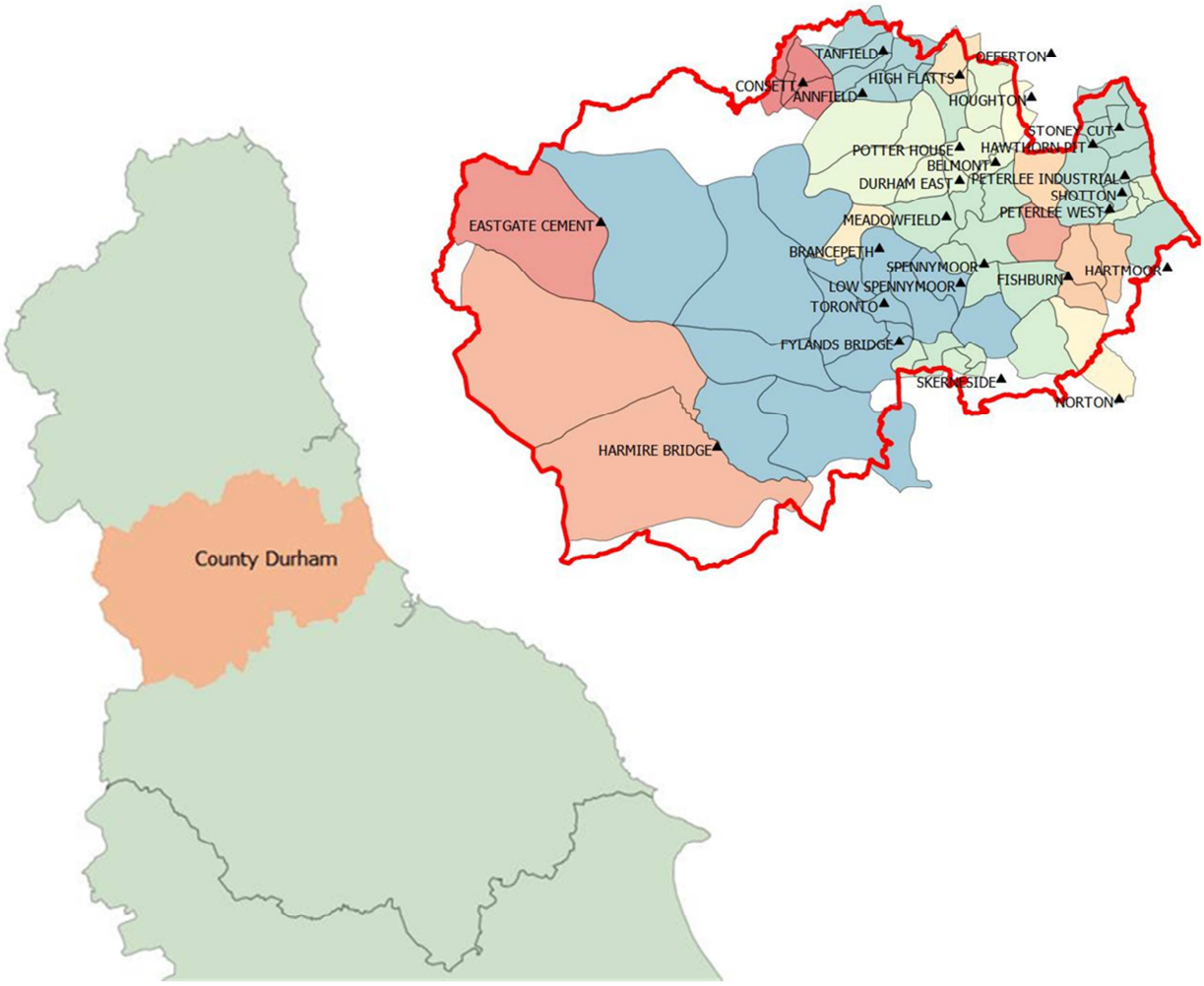
Appendix 2: Project plan



Appendix 3: Maps

The project will be predominantly undertaken in County Durham where there are 30 primary substations supplying over 234,000 residential customers from a wide range of demographics (See Appendix 9). This means that a range of test areas can be selected to test the response to interventions from a range of customers that form a good representation of the GB population as a whole.

We are also working with Durham County Council which has 750 half-hourly metered premises under its control and can provide access to over 230 schools.



Appendix 4: Risk Register

No	Description	Prob.	Impact	Mitigation
Project management risks				
1	Key personnel not available to deliver the project or leave during the project	Low	Medium	• Identify resource requirements during Q3 2013 and Q4 2013 in readiness for the project initiation. • Ensure individuals share and document knowledge.
2	Poor project management threatens the learning outcomes and/or results in cost and time overruns	Low	High	• Leverage learning from the CLNR project to implement robust governance frameworks. • Appoint skilled project management resources.
3	Project partners and/or collaboration partners are no longer willing or able to support the project	Low	High	• Ensure Memorandum of Understanding agreements are in place before the start of the project. • Ensure that a collaboration agreement is in place before the end of Q1 2014. • Partner with organisations participating in the CLNR project or with other highly regarded organisations.
Technology and systems risks				
4	The costs of delivering the technical aspects of the project are higher than expected	Low	High	• Network monitoring: install network monitoring equipment that has been installed on CLNR, where the costs are known. • Customer monitoring: utilise equipment used for the Gen Game, where the costs are known. • Undertake small pilot trials for any further developments of the Gen Game to identify issues and reduce the risk of subsequent rework. • Tender for the technology provision for the Gen Game hardware and computing infrastructure.
5	The delivery of the technical aspects of the project takes longer than expected	Low	High	• Network monitoring: install network monitoring equipment that has been installed on CLNR, where the installation requirements are known. • Draw on learning from the initial trial of the Gen Game. • Undertake small pilot trials for any further developments of the Gen Game to identify issues and reduce the risk of subsequent rework.

No	Description	Prob.	Impact	Mitigation
6	The technical aspects of the project do not work	Low	High	• Network monitoring: install network monitoring equipment that has been installed on CLNR, where the data transfer protocols are known. • Customer monitoring: utilise equipment used for the Gen Game, which has been proven to work for direct control. • Undertake small pilot trials for any further developments of the Gen Game to identify and resolve issues prior to full scale roll out.
Customer recruitment risks				
7	Customer interest in the trials is low	Medium	Medium	• Test reactions with focus groups before rolling out the wide scale trial. • Design interventions based on learning from previous trials, including the CLNR and the Gen Game. • Draw on Durham County Council for links to schools and local authority buildings and also the Council's own employees. • Low uptake of measures will provide learning in itself.
8	Customers in the trial are not representative of GB as a whole	Medium	Medium	• Interventions will be tested on representative customer groups predominantly within the Durham County Council area, which has been analysed to contain 86% of UK demographics. • The project will identify other locations if there is a shortfall of the customer types in County Durham. • Low uptake of interventions among certain customer groups will provide learning in itself.
Effectiveness of interventions				
9	Interventions do not reduce peak demand or address voltage issues	Low	Low	• Allow time for detailed intervention design, drawing on academic and practical learning from CLNR and other LCNF projects. • Where interventions have low effectiveness, this will provide learning in itself.

No	Description	Prob.	Impact	Mitigation
Learning & Dissemination				
10	Results are not statistically robust	Low	High	• Trial design has been reviewed by Newcastle University to ensure statistical robustness. • Use of complementary data from other trials (including the CLNR) to provide cross checks. • Qualitative analysis where certain customer types are too rare to ensure statistical significance (e.g. EV owners)
11	Results are not applicable to DNOs across GB	Low	High	• Locate trial in County Durham area where population is representative. • Undertake upfront analysis on the potential for replication. • Deploy model-based simulation to allow testing of different conditions to those actually experienced in the trial periods. • Ongoing engagement with all DNOs to ensure ACE's wider relevance.
12	Project learning is not captured by partners	Medium	Medium	• Include sufficient time in each project partner's plan to capture learning. • Durham and Exeter Universities will be supporting the project to capture learning robustly.

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Mitigation and contingency planning

Mitigation actions have been undertaken or are planned to reduce the probability of the above risks occurring.

We are confident that these mitigations are sufficient but have included a 8% contingency provision to cover the cost of any contingency actions.

Section 6 describes the approach to project governance, including risk management and sets out the stage planning approach which re-examines the risks at each stage of the project to ensure that it remains on track to deliver the committed learning outcomes. The objective of the project governance framework is to clearly communicate the project vision to all participants, identify relevant and timely project milestones and deliver these through robust planning and timely and effective decision making, resolution of issues, control of changes, mitigation of risks and contingency planning.

The project has the advantage of building on the working relationships developed during the CLNR project, which reduces the project management and delivery risks associated with multi-partner projects.

Lower levels of LCT and renewable energy take up in trial areas than anticipated

The project is reliant to some extent on the take up of LCTs to date and will be seeking some trial areas that have clusters of heat pumps or PV to provide suitable load profile for modification by the DSR offerings being trialled. We know that it will not be a problem to find such clusters in the Durham County Council area. In addition, the ACE project will, where appropriate, draw on customers that already have LCTs being monitored by the CLNR project. This project will not engage with customers that have already been part of the CLNR flexibility trails as this group will not, as a result of this engagement, be typical of GB customers as a whole. It will, however, consider the use of these customers as a control group. Prior to the roll out of the method, take up numbers have been confirmed as sufficient, to ensure statistically robust results to inform learning.

Appendix 5: Review of trials of non-tariff interventions

There is an increasing awareness of the role of customer involvement in supporting network needs. For example, a recent report by Consumer Futures[1] focuses on how the smart grid may impact on domestic customers and their energy behaviours. The report highlights the need for further behavioural change studies to see how best to encourage DSR, particularly in a GB context.

The ACE project aims to secure access for DNOs to cost-effective DSR to address specific localised network constraints. To do this it will design and trial non-tariff based interventions to encourage DSR from a range of residential customer types representative of most of the GB population and from local authority employees working in a range of public building types.

The choice of interventions has been based on a review of evidence from trials that use non-tariff interventions to influence customers' patterns of energy consumption[2]. Our aim from this review was to understand what has been learnt from previous trials to identify gaps in the research that ACE could best address and areas of best practice in previous interventions that we could build upon.

This Annex provides the results of this review and supports the ACE trials.

- A number of trials have looked to encourage changes in electricity customers' behaviour.
- Community groups and public commitments foster a sense of team involvement and can increase incentives to act differently. Community involvement can be deepened when combined with public commitments: individuals and corporations are more likely to honour a commitment if it is made publically and before an action is undertaken.[3]
- Introducing a competitive element to social norms, and extending information through gamification have been shown to play a role in encouraging behavioural change.
- There is evidence that children can act as messengers to provoke behaviour change in households.

Gaps in research

The ACE project can add value by addressing a number of gaps in current research.

- Most trials of non-tariff interventions have focused on energy efficiency rather than on addressing network constraints using DSR. While we can draw useful learning from the energy efficiency trials (e.g. on the types of interventions which engage customers), ACE can deliver additional learning by focusing on trials which concentrate particularly on reducing peak demand.
- Where the impact of non-tariff interventions on DSR has been examined, limited customer types have been represented in the trials. For example, some of the community trials undertaken to date by DNOs are focused in affluent and

1 Smart grids: Future-proofed for consumers (2013).

2 A comprehensive review of **tariff based** interventions has been published by DECC: Frontier Economics and Sustainability First (2012), *Demand side response in the domestic sector*. Emerging results are also now available from the tariff trials carried out in the CLNR, e.g. British Gas (2013) *Initial time of use trial analysis* and Northern Powergrid (2013), *Initial report on industrial and commercial demand side response trials*. Although not directly relevant to non-tariff interventions, the ACE project can still learn from these earlier projects. For example, findings demonstrate that customers are largely not aware of DSR and may require prior educational and information engagement in advance of eliciting a response.

3 Pallak *et al* 1980; British Gas, Green Streets; Pallak *et al.* 1980.

environmentally motivated rural areas[4]. Trials on I&C customers have focused on customers from the private sector[5]. The ACE trials will target customer groups which can be found in every DNO area with interventions designed to have a wide appeal.

- A number of trials in place in the UK have not been structured to produce statistically robust and representative results. A lot of research in this area has involved small samples, and it is not yet known if these interventions are scalable.[6] We are working with statisticians from Newcastle University in the design of the ACE trials ensure the ACE trials can produce robust results which network planners can use in GB.

Best practice

We first outline how best practice in previous trials has informed the design of the ACE measures. We then look specifically at best practice in engaging and retaining customers, and in working with school children and I&C customers and in using serious games.

The ACE trial will build on best practice from UK and international trials, and emulate these interventions.

- Providing feedback on behavior and social norm information[7] to domestic customers has been found to reduce energy consumption, particularly when combined with information on how to change behaviour and when comparisons are provided against a peer group rather than across a general customer base[8]. The ACE trial will build upon this learning to address network peaks and will provide feedback information, and information on how to change behavior in the schools trail through the teaching and information materials provided, and through competitions. Social norm information will be provided in the wider community trial, through the Gen Game league tables. The ACE project will provide rewards at the community level to encourage co-operation. The competitions included in each of the ACE trials, include an element of public commitment, as participation of households, and public sector I&C will be ranked in the league tables and customers can encourage each other to change behaviours as they use the opportunity presented by ACE for them to work towards raising money for a common cause.
- Results from trials demonstrate changes in energy behaviour when games which provide insight into energy use and consumption are combined with information to customers on how to change their behavior[9]. All three ACE trials include a competitive element, building on the increasing use of games and competitions to encourage behavioural change and introduce customers to new products[10]. The ACE schools' trial incorporates competitions between classes and schools, the wider community trial will allow households and communities to compete (and co-operate), and the local authority I&C trial will incorporate league tables and competitions for internal company awards. Trials have demonstrated that parents learn from their children in energy and environmental

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4 For example, Ashton Hayes Smart Village 2011; Smart Hooky.

5 For example, New Thames Valley Vision project.

6 Transition Streets Totnes, EcoTeams, PlugIn.

7 Social norms use information to normalise a customer's experience within a cohort of other relatable customers, to nudge their behaviour towards a positive outcome.

8 Allcott 2011; Behavioural Insights Team 2012; Costa and Kahn 2012; Dolan and Metcalfe 2011; 2013; Peschiera *et al.* 2010.

9 Froehlich *et al.* 2009; Geelen *et al.* 2010; Gnauk *et al.* 2010; Gustafsson and Bang 2008;Leonard 2010; Petkov *et al.* 2011; Reeves and Armel 2010; Shiraishi *et al.* 2009; The Gen Game 2012.

10 Petkov *et al*. 2011; Shiraishi *et al.* 2009
Please refer to Table A5.3 for an outline of high profile games in the financial, retail and commercial sectors.

issues[11]. The schools trial is specifically targeted at conveying messages to households through children's education.

Best practice: Engaging and retaining customers

Our review of previous research has identified a number of general principles for engaging and retaining customers during the trial. The ACE trial will incorporate these principles in its rollout.

- Evidence demonstrates that the importance of regular feedback of information to customers is central to ensuring that customers remain engaged. Regular feedback information on energy use allows customers to connect their behavioural change to changes in their energy use and bills. This supports understanding of how individual behaviours can make an impact, and fosters long term behavioural shifts. All three of the ACE trials will involve regular feedback to participants.
- Providing customers with simple and easy to understand information and including clear advice on actions that can be taken for participation, have also been highlighted as central factors in positive customer engagement. This ensures customers understand why their actions are important, and what it is they can do to provide DSR and participate in the trials. However, this information must be simple to ensure that participants are not overburdened with technical detail, which might put them off participating. All three of the ACE trials will provide clear information and advice on possible actions to participants.
- The importance of having clear roles for participants, and clarity on the variety of organisations managing the trials, has also been demonstrated in long-term successful customer engagement. Participants need to have a clear understanding of how they can participate and what they can expect from the organisations involved in the interventions. This ensures that participants know where they can find out further information about the interventions themselves, the organisations involved and seek assistance while they participate. Through the websites and public forums for engagement, the ACE trials will provide information and clarity on roles, ensuring that participants can engage with the interventions with ease.

Best practice: schools

Our review of the literature has identified several elements of best practice in schools' interventions aimed at changing energy behaviour and engaging school children. The ACE schools trial will build on this learning, for example, through the following:

- use of participative and interactive approaches;
- use of humour, fun and playing;
- balancing the need to make teaching resources available, while leaving teachers enough autonomy to adapt to their own style; and
- involving teaching staff to develop the message, to ensure the teaching materials include an appropriate level of complexity.

[11] Damerell *et al*. 2013; Heijne 2003; Leeming *et al*. 2009; Legault and Pelletier 2000; Uzzell *et al*. 1994; Vaughan *et al*. 2003.

Best practice: serious games

There is a wide literature on serious games and there is an increasing use of games to encourage customer response and behavioural change[12]. Our review has identified the following elements of best practice for the design of serious games' trials that engage customers successfully over a period of time, and The Gen Game design incorporates these elements:

- allowing players to have a unique identity within the game;
- inclusion of interactive aspects of play with feedback on behaviour;
- ability to engage with the game on a simple or more complex level depending on participant preference; and
- ensuring that game interface and feedback site are simple with semi-automatic capabilities for easy engagement.

Table A5.3 provides examples of where serious games have been used successfully in other sectors; Halifax and Metro bank use games to encourage savings behaviour, Nike and Mindbloom have developed games to encourage healthy behaviours and competitions are becoming increasingly popular for marketing activities and across the retail sector.

Best practice I&C customers

There are a core number of best practice activities for engaging public sector I&C customers in changing energy behaviours which the ACE trial will adopt:

- the role of public accreditation for company-wide motivation;
- the role of public commitments through social and environmental responsibilities and policies; and
- the importance of centralised management of schemes for cohesive rollout.

Conclusions on focus for the ACE trial

The ACE trials can build on existing learning to focus on the most promising interventions types, while addressing gaps in the current literature.

- **Schools.** There is promising evidence on children's role as messengers**.** While school interventions have been trialed internationally, these have not yet been explored in detail in the UK energy sector. Education programmes rely on school children to pass the message onto the wider household and influence parents. The ACE trials will explore the effectiveness of children acting as messengers to engender behavioural change within their households and possibly their neighbours.
- **Wider community games.** While games have been shown to be highly effective internationally, their application in the GB energy sector has not been explored in statistically representative trials. We are therefore including a trial of community-based games in the ACE project.
- **Local Authority I&C.** The New Thames Valley Vision project has found valuable results for non-tariff interventions for private sector I&C customers. However, public sector I&C customers may respond differently, given their different motivations. We are therefore focusing on public sector customers in the ACE I&C trial.

[12] *Please refer to Table A5.3 for an outline of high profile games in the financial, retail and commercial sectors.*

Summary of literature

Table A5.1 summarises the literature reviewed.

Table A5.1: Summary of literature

Publication	**Trial location and date**	**Questions addressed**	**Results**
Allcott, 2011, *Journal of Public Economics*, Social norms and energy conservation	USA, 2009	Can social norms and information provision encourage energy efficiency?	On average the interventions lead to a decrease in energy consumption of 2%. Without repeated communications the impact of the interventions diminishes. Households with higher levels of consumption decrease their usage by more than households with lower levels of consumption. Robust quantitative analysis was undertaken.
Ashton Hayes Smart Village, 2011, SP Energy Networks, http://www.spenergynetworks.co.uk/innovation/documents/Flyer_AshtonHayes.pdf	UK, on-going	Can reports providing information on collective electricity usage, and usage of typical village properties, promote energy efficiency through comparison and community engagement?	No formal results have yet been published. Given the focus of the trial in an affluent rural location, the customer base under analysis, results obtained would not be suitable to scale to the UK national basis.
Behavioural Insights Team, 2012, Behaviour Change and Energy Use https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48123/2135-behaviour-change-and-energy-use.pdf	UK, on-going	Can social norms and information provision encourage energy efficiency? Do community interventions and public commitments impact on energy behaviours? How does time discounting impact on energy decisions?	Results have not yet been published, but are anticipated to inform the upcoming Green Deal. Given the quantitative analysis and consideration for a representative base the findings of these studies will be suitable for application in the UK context.

Publication	Trial location and date	Questions addressed	Results
California State-wide Pricing Pilot, 2003, *Charles River Associates*, Impact Evaluation of the California Statewide Pricing Pilot http://sites.energetics.com/MADRI/toolbox/pdfs/pricing/cra_2005_impact_eval_ca_pricing_pilot.pdf	USA, 2003	Can mass media be used to elicit demand side response?	The study used an information only intervention drawing on mass media to encourage customers to reduce their electricity consumption on critical days. Customers were provided with educational material on how to reduce their loads when required. Robust quantitative analysis reported that the information-only campaign did not have any statistically significant impact on peak demand reduction.
Centre for Sustainable Energy, Smart and Happy Meters http://www.cse.org.uk/projects/view/1192	UK, on-going	Can use of social norms facilitate customer engagement with new technologies? How do customers prefer rewards to be offered to them?	Although no robust analysis of this trial has yet been undertaken, high level learning from user groups demonstrate the importance of considering how social norm information is distilled. Customers also reported a preference for a personal choice in reward structure provided to them and had a general preference for financial over non-financial rewards, finding them easier to understand.
Costa and Kahn, 2010, *NBER Working Paper Series*, Energy Conservation "Nudges" and Environmentalist Ideology: Evidence from a randomized residential electricity field experiment	USA, 2008	Does the impact of behavioural interventions differ based on customer type?	Results indicate that political inclination matters for responsiveness to behavioural nudges. A democratic household that engages with energy awareness programmes reduces its consumption by 3% in response to an information provision and social norm intervention while a Republican household that does not pay for electricity from renewable sources and that does not donate to environmental groups increases its consumption by 1%.

Publication	Trial location and date	Questions addressed	Results
Crossley, D. (2010): International Best Practice in using Efficiency and Demand Management to Support Electricity Networks, *Australian Alliance to Save Energy Research Project*, Report No.4	Australia, 2001-2003	Are customers open to remote control of technologies to elicit demand side response?	Customers were found to be open to allowing their air conditioners to be controlled. Results show a 1.03kW reduction on average in demand for each controlled residential air-conditioner during a curtailment event. The percentage of overridden units during the curtailment event from 2-6pm increased from 6.7% at the hour ending 3pm in August 2002 to 20.8% at the hour ending 6pm.
Damerell, P., Howe, C. and Milner-Gulland, J. (2013): Child-orientated environmental education influences adult knowledge and household behaviour, *Environmental Research Letters*, Vol.8, No.1.	The Republic of the Seychelles, 2009	Can children's education influence household behaviours?	Analysis found that parents of children included in the trial obtained significantly more knowledge about ecosystem service provision and conservation of wetlands than did the control parents. Parents receiving environmental education from their children improved their score on a test by 29%.
Dolan and Metcalfe, 2011, Working Paper, Better neighbours and basic knowledge: a field experiment on the role of non-pecuniary incentives on energy consumption Dolan and Metcalfe, 2013, CEP Discussion Paper No 1222, Neighbours, Knowledge, and Nuggets: Two Natural Field Experiments on the Role of Incentives on Energy Conservation	UK, 2010	Can social norms, information on how to change and financial incentives encourage energy efficiency? How do different behavioural interventions interact with each other?	Descriptive social norms reduce energy consumption by 6% and combined with information on how to change behaviour, by 9%. Financial incentives led to an 8% reduction in energy consumption, but this disappeared if incentives were combined with social norm information. The effects of social norms also differ over time (norms have the biggest effect on the day that they are received, the impact then decreasing over time), across customer groups (asset poor and young heads of households are most responsive to social norm information), and the manner in which social norms are distilled is important (online social norms did not impact as much as hard copy information).

Publication	Trial location and date	Questions addressed	Results
EcoTeams http://ecoteams.org.uk/about-us	UK, on-going	Can community engagement encourage energy efficiency and behavioural change?	Self-reported results indicate that participants reduced their energy consumption by 21%. Given the important role this scheme plays in encouraging community responses, learning could have benefit at the national level.
EcoWatt, 2011, Réseau de transport d'électricité, Generation Adequacy Report, on the electricity supply-demand balance in France	France, 2008/2009	Can mass media be used to elicit demand side response?	Conclusive results are not available for this intervention.
Froehlich, Dillahunt, Klasnja, Mankoff, Consolvo, UBIGreen: Investigating a Mobile Tool for Tracking and Supporting Green Transportation Habits	USA 2007	Can mobile phones be used to provide feedback and change transport habits?	Results demonstrate that a mobile phone application which automatically senses and feeds back information on movement can influence how consumers think about their energy use.
Heijne, 2003, *Centre for Sustainable Energy*, Energy Education Hitting Home Monitoring the Impact of Energy Matters	UK, 2003	Can children's education influence household behaviours?	Qualitative results from 148 interviews reported three-quarters of parents as adopting some behavioural changes to save energy as a result of their children's involvement in the programme. Parents rated their children as being almost twice as influential on their behaviour as other sources of information. Pupil and staff participants also reported personal changes in behaviours to reduce energy consumption and the majority of the schools involved reported undertaking an energy saving investment, as either a direct or indirect result of participation.

Publication	Trial location and date	Questions addressed	Results
Flex Alert, 2008, Summit Blue Consulting, Flex Alert Campaign Evaluation Report, *Demand Response Measurement and Evaluation Committee (DRMEC*) http://www.calmac.org/publications/2008_Flex_Alert_Final_Report_12-18-08.pdf	USA, 2008	Can mass media be used to elicit demand side response?	Qualitative self-assessments reported that 37% of all survey respondents reported taking conservation actions in response to the Flex Alert message. Evidence also indicated that customers found it difficult to recall the hours within which they should alter their behaviour – the results of this study suggest the importance of frequency, as well as manner, of communications.
Geelen, Brezet, Keyson, Boess, 2010, Knowledge Collaboration & Learning for Sustainable Innovation*, ERSCP-EMSY conference,* Gaming For Energy Conservation in Households	The Netherlands, 2010	Can customers be motivated to change their energy use, other than through financial means?	User trial results demonstrate the potential for combining gamification with other interventions to encourage changes in energy behaviour. During the course of the trial, households reduced their energy consumption by 24% but qualitative evidence reported that few of the behaviours adopted during the game persisted. Results suggest that use of the game allowed for an explicit conversation within households about the need to address energy consumption.
Generation Green http://www.generationgreen.co.uk/	UK, on-going	Can children's education influence household behaviours?	No systematic assessment of the scheme has been published.
Gnauk, Dannecker and Hahmann, 2012, EnDm, Leveraging Gamification in Demand Dispatch Systems	Germany, 2012	Can customers be motivated to change their energy use, other than through financial means?	The trial included the impact of social norms in a game setting, as well as testing customer responses to different network needs. Results suggest non-financial incentives can be important.

Publication	Trial location and date	Questions addressed	Results
Green Streets, 2009, IPPR, Final Report to British Gas	UK, 2008/2009 2010/2011	Can community engagement encourage energy efficiency and behavioural change?	Results found that the average energy saving across all Green Streets households was just over 25%, and average street reduction in energy use ranged from 15% to 35%. Results were qualitatively gathered and assessed. Findings demonstrated the role technology provision and access can play in energy savings, and the support that community groups can give in the success of technological installations.
Gustafsson and Bang, 2008, Advances in Computer Entertainment Technology, Evaluation of a pervasive game for domestic energy engagement among teenagers	Sweden, 2008	Can games motivate customers to change their energy use?	High level learnings suggest that games can be efficient in motivating and engaging consumers and households, to change behaviours. Results suggest that households respond well to the competitive and play elements, and indicated positive customer engagement with the intervention.
Leeming F.C., Porter B.E., Dwyer, W.O., Cobern M.K. and Oliver, D.P. (1997): Effects of Participation in Class Activities on Children's Environmental Attitudes and Knowledge, *The Journal of Environmental Education,* Vol.28, No.2	USA, 2009	Can children's education influence household behaviours and parental attitudes?	Quantitative data was collected via surveys; 348 survey responses were returned from parents of experimental children whereas only 138 results were returned from parents of control children, indicating a less pro-active role among control parents. Furthermore, the surveys reported a greater increase in concern for the environment and pro-environmental behaviours among the parents of the experimental group relative to the parents of the control group.
Legault, L. and Pelletier, L.G. (2000): Impact of an Environmental Education Program on Students' and Parents' Attitudes, Motivation, and Behaviours, *Canadian Journal of Behavioural Science*, Vol. 32, No.4	Canada, 1999	Can children's education influence parental knowledge?	A total of 184 children and 131 parents completed the two waves of data collection at the beginning and end of the project. Parents in the experimental group reported lower levels of ecological satisfaction compared to parents of children in the control group, indicating a higher level of awareness in terms of possible improvements.

Publication	Trial location and date	Questions addressed	Results
Leonard, 2010, The "I's" Have It: A Framework for Serious Educational Game Design	USA, 2010	Best practice in game design	Outline of lessons learned and framework for design of educational games, drawn from a number of studies on game design and development in the American educational system.
DECC, 2012, Low Carbon Communities Challenge Evaluation Report	UK, 2012	Can community engagement and information provision encourage energy efficiency and behavioural change?	Results are not yet available.
New Thames Valley Vision - Scottish and Southern Energy, 2012, Power Distribution, LCNF Tier 1 Close-down Report, Honeywell I&C ADR: Demonstrating the functionality of automated demand response	UK, 2011	Can team commitments and information provision impact on I&C customer energy efficiency and behaviours, with a view to understanding network demand and balancing?	Results are not yet available.
Newsham, G. and Birt, B. (2010): Demand-responsive Lighting – A Field Study, National Research Council Institute for Research in Construction	Canada, 2008	Can technological interventions encourage DSR?	Two afternoon demand response trials were conducted in the afternoon, which dimmed lights by up to 35% over 15-30 minutes. The trial achieved a power reduction of 24% and 23% respectively. Building-by-building analysis showed that each campus building contributed to a total load reduction which varied between 8-39%, depending on the space types and occupancy of the various building areas. Furthermore, qualitative data showed that there were no lighting-related complaints throughout the afternoons of the trials.
di Oliveira, Nina, 2012, *EU CIP-ICT-PSP Grant Agreement,* Save Energy Manual	UK, 2009	Can games motivate non-residential customers to change their energy use?	Results across serious games, staff involvement and energy monitoring interventions, reported a 25% reduction in energy consumption across the different pilot projects and across different areas of use within the buildings (e.g. catering, lighting etc.).

Publication	Trial location and date	Questions addressed	Results
Pallak, M.S., D.A. Cook and J.J. Sullivan, 1980*, Applied Social Psychology Annual*, Commitment and Energy Conservation	USA, 1980	Do public commitments impact on residential customers' energy use?	Households who received a home visit by an energy auditor, and made a public commitment on their energy use, reduced their natural gas and electricity consumption by between 10% and 20% and these effects were persistent after the end of the public commitment. People who made a private commitment did not change their behaviour.
Peschiera, Taylor and Sigel, 2010, Energy and Buildings, Response–relapse patterns of building occupant electricity consumption following exposure to personal, contextualized and occupant peer network utilization data	USA, 2009	Can information provision and social norm comparisons in a group building setting encourage energy efficiency and behavioural change?	One group was provided with information on their own electricity use, a second, their use and average building occupant use and the third, their usage, average building occupant use and use of their peer network within the building. The only group that significantly reduced their electricity use was those that could compare peer network use. The test group which just had access to information on their use, showed no significant reduction in their electricity use.
Petkov, Kobler, Foth, Krcmar, 2011, Motivating domestic energy conservation through comparative, community-based feedback in mobile and social media. 5th International Conference on Communities & Technologies, Brisbane	Australia, 2010	Best practice on design of energy-related comparative feedback games.	Development of, EnergyWiz, a mobile application that enables users to compare personal and past performance and compete with neighbours and contacts from social networking sites.
PlugIn http://pluginmidlands.wordpress.com/	UK, on-going	Can community engagement encourage energy efficiency and behavioural change?	No assessment has been undertaken of the interventions.

Publication	Trial location and date	Questions addressed	Results
Reeves and Armel, 2010, *Precourt Energy Efficiency Center*, Serious Games and Energy Use Behaviour	USA, 2010	Can games motivate customers to change their energy use?	User group research assesses a multiplayer computer game which promotes changes in energy consumption with community participation. The work suggests combined individual and community goals can lead to sustainable behaviour change. However, no robustly assessed results have been published.
Scottish Government Social Research, 2011, *Brook Lyndhurst and Econometrica* Review of the Climate Challenge Fund	UK, 2011	Can community engagement and information provision encourage energy efficiency and behavioural change?	Self-reported results indicated that 94% of households would reduce their energy use after borrowing an energy monitor. Individuals reported that the interventions galvanised otherwise latent intentions to improve energy efficiencies, disrupted engrained habits and facilitated changed through provision of information on how to change.
Shiraishi, Washio, Takayama, Lehdonvirta, Kimura, Nakajima, 2009, Using Individual, Social and Economic Persuasion Techniques to Reduce CO2 Emissions in a Family Setting	USA	Best practice on design of interactive games and types of behavioural techniques to use, for eco-friendly behaviours.	Proposal of EcoIsland, an online game using a variety of behavioural science techniques to encourage behavioural changes to reduce household CO2 emissions.
Smart Hooky http://www.hn-lc.org.uk/what-were-doing/smart-hooky	UK, 2012	Can social norms and provision of information encourage energy efficiency and behavioural change?	No systematic assessment has been published. Furthermore, given the specificity of the customer base under analysis, results obtained would not be suitable to scale to the UK national basis.
The Gen Game http://www.thegengame.com/Pages/default.aspx	UK, on-going	Can games motivate customers to change their energy use?	Initial results indicate that people respond well to the competitive elements.
Transition Streets/Transition Towns http://www.ashden.org/winners/tttotnes11	UK, on-going	Can community engagement and information provision encourage energy efficiency and behavioural change?	No systematic quantitative analysis has been undertaken. However, the project reports a range of positive qualitative results on household financial and carbon savings made along with positive social benefits.

Publication	Trial location and date	Questions addressed	Results
Uzzell, D. and European Commission Directorate General for Science Research and Development Joint Research Centre (1994): Children as Catalysts of Environmental Change, Research on Economic and Social Aspects of the Environment, DGXII/D-5.	Denmark, 1993 UK, 1994	Can educational programmes in schools strengthen community participation in environmental projects?	Feedback was collected through interviews and questionnaires, where parents reported a strong interest in their children's' school projects. Qualitative data suggests that the QUARK project affected parent cooperation in a positive way. Interviews and questionnaires were carried out to investigate whether children may act as catalysts. 84% of all the parents said they had discussed this topic with their children. Parents of experimental group children were over twice as likely to identify causes of and actions to address water pollution, than parents of the control group.
Vaughan, C., Gack, J., Solorazano, H. and Ray, R. (2003): The Effect of Environmental Education on Schoolchildren, Their Parents, and Community Members: A Study of Intergenerational and Intercommunity Learning, *The Journal of Environmental Education,* Vol. 34, No. 3	Costa Rica, 2001	Can children's education influence and parental knowledge?	A high level of information transfer between children and their parents was detected; with parents performing better on questions after their children had attended conservation activities. Intercommunity transfers were detected 8 months later.

Impacts of Trials

Table A5.2 summarises the findings of the trials relating to energy reductions.

Table A5.2: Trial findings on energy reductions.

Publication	**Trial location and date**	**Method of Engagement**	**Reduction in Energy Consumption**
Dolan and Metcalfe, 2011, Working Paper, Better neighbours and basic knowledge: a field experiment on the role of non-pecuniary incentives on energy consumption Dolan and Metcalfe, 2013, CEP Discussion Paper No 1222, Neighbours, Knowledge, and Nuggets: Two Natural Field Experiments on the Role of Incentives on Energy Conservation Paul Dolan and Robert Metcalfe	UK, 2010	social norms	6%
		social norms and information on how to change	9%
		financial incentives	8%
Generation Green http://www.generationgreen.co.uk/	UK, on-going	community focused competitions, technological interventions and specialist advisor support	25%
Geelen, Brezet, Keyson, Boess, 2010, Knowledge Collaboration & Learning for Sustainable Innovation*, ERSCP-EMSY conference,* Gaming For Energy Conservation in Households	The Netherlands, 2010	games	24%
Pallak, M.S., D.A. Cook and J.J. Sullivan, 1980*, Applied Social Psychology Annual*, Commitment and Energy Conservation	USA, 1980	public commitments	15%
di Oliveira, Nina, 2012, *EU CIP-ICT-PSP Grant Agreement,* Save Energy Manual	UK, 2009	serious games	25%

Further evidence on serious games

Table A5.3 outlines case studies on the prevalence of serious games.

Table A5.3: Case studies on serious games.

Industry	**Game**	**Behaviour targeted**	**Reference**
Financial sector	Halifax runs a monthly draw for customers registered to save, with 1,103 prizes of up to £100,000 to be won. The competitive nature of the lottery is heightened with information provided on an interactive "Winners near me" site. This draws from behavioural science on loss aversion, signalling and social norms.	Encourage customer savings	http://www.halifax.co.uk/savings/savers-prize-draw/
	Metro Bank uses in store "Magic Money Machines" directed primarily at younger customers, to encourage saving. The games introduce a play element to saving, as well as a competitive opportunity for customers to win a prize by participating in an interactive game through the machines.		https://www.metrobankonline.co.uk/Discover-Metro-Bank/More-Convenient-Services/Magic-Money-Machine/
Retail sector	Nike's FuelBand smart technology game calculates player's exercise and calorie consumption, feeding back information through a band worn around the player's wrist. Users set targets, and can connect through social networking sites to compete with friends. Results indicate likely increases in exercise, and ultimately Nike sales.	Encourage increase in exercise	http://mashable.com/2013/02/22/nike-fuelband-stats/
Healthcare	The Mindbloom online social game is available to employees and healthcare customers. It is aimed at improving health and wellness, through engaging users in a game where they take actions to keep a tree healthy and great. Initial results report progress in achieving health goals	Encourage health awareness and healthy behaviours	https://www.mindbloom.com/
Marketing	Volt Stockholm held a competition in Sweden where visitors to a special Peugeot website were challenged to click and hold their mouse button on a car they wanted, with the person holding the longest winning the chance to drive the car for a week. People were willing to play these games (with minimal chance of personal benefit) for up to 15 hours	Use of competitions to engage customers	http://www.adweek.com/adfreak/endurance-advertising-peugeots-click-and-hold-online-car-game-132883

Industry	Game	Behaviour targeted	Reference
	Mercedes- Benz used an online interactive game in a 2011 digital marketing campaign. Players were required to navigate out of a Streetview map, with the chance to win the launch car.		http://news.mercedes-benz.co.uk/innovations/escape-the-map-with-marie-and-mercedes-benz.html
	Walkers crisps used a competition in 2012 to launch new flavours, with significant direct impact on sales and considerable marketing impact. Customers were required to guess three mystery flavours with three prizes of £50,000 on offer. There were nearly 800,000 entries, and the company secured a 13% stake in the six-pack bagged snacks market category in a single seven-day period of the campaign, in early 2012		http://www.thegrocer.co.uk/fmcg/ambient/crisps-nuts-and-snacks/walkers-reveals-its-three-mystery-flavours/227165.article

Appendix 6: Emerging social science evidence from CLNR

This appendix describes the social science evidence emerging from Durham Energy Institute's (DEI) work on the CLNR project. This evidence has informed the design of the ACE project.

As the detailed design of the trials proceeds during the project, we will build on this learning further.

Evidence from domestic customer research

The CLNR research has found that three types of flexibility are important for domestic customers.

- *Fuel switching.* Those with duel fuels (e.g. wood burning stoves, gas cooking) are more flexible.
- *Changing timing of energy use.* Where there is a TOU tariff, customers can shift demand to before or after the evening peak (or sometimes to the next morning). Where there is PV, customers can shift demand to when the panels are generating.
- *Energy Reduction* We observed customers reducing total demand for those forms of energy use that happen in the peak. There is an opportunity to use peak demand management to achieve energy use / carbon emissions reduction targets.

Research shows that flexibility is achieved in a number of ways.

- Flexibility is produced through the interaction of 'things' (e.g. dishwashers), 'time-structures' (e.g. leaving to go work, coming home from school), 'home economies' (ways in which household resources and assets are managed), and 'practices' (established ways of e.g. doing the washing, cooking a meal). This means that individuals can't always choose to radically change their demand and that changing individual levels of knowledge or 'emotional engagement' with peak energy demand use is only likely to work where technology, routines, home economies and practices 'fit'. Where they do not, frustration, helplessness, and increasing feelings of alienation from energy companies and government are likely. This in turn suggests that any 'information' or 'emotional' intervention needs to be accompanied by intervention in at least one of these other four elements.
- 'Valuable' flexibility is produced through the interaction of these entities as well as a regime of measurement and validation. Some practices (e.g. washing) are more flexible than others (e.g. cooking), and achieving valuable flexibility may require specific engagement around these practices.
- One basis for a more demographic focus is that initial evidence from CLNR (draft, not yet peer reviewed) suggests that those on the highest incomes use the most electricity, and have highest peaks. Price is even less likely to work as a motivation for this cohort, and this could provide a strong rationale for trialing alternative interventions with high income earners. We also find variations in flexibility according to home/work routines (e.g. picking up children from school, shift work) which could also provide the basis for targeting specific socio-demographic groups.
- Because of the importance of routines between home/school/work in shaping flexibility, interventions should be designed with this in mind. This could involve targeting specific sorts of routine (e.g. those who collect kids or work shifts).
- Those customers with domestic LCT can have very high levels of awareness and engagement where they have 'ownership' of the LCT and its configuration (e.g. solar PV owners) but equally may have very low levels of capacity where this has been imposed (e.g. local authority housing air source heat pumps). This suggests that enhancing domestic control and 'ownership' (whether literal or emotional) over energy provision

can provide a strong motivation for higher levels of engagement in managing peak demand.

- Flexibility is associated with what has traditionally been women's work in the home, but men often have the contractual relationship with the energy supplier. Engaging women will be critical to realising flexibility through ACE. This will involve not falling into stereotypes, but properly engaging with issues of gender in the design of energy interventions.

Households give a range of reasons for engaging with interventions, including:

- an interest in 'doing their bit' for the grid – 'keeping the lights on';
- an awareness and acceptance of the need to decarbonise and secure energy provision;
- a broad concern with energy costs (rising prices);
- a sense of being able to better manage their 'resource use' over the household budget;
- using managing peak demand as a means of managing 'excess' energy use by other household members (e.g. teenage children); and
- 'gaming' the system – wanting to beat their personal 'best' in terms of reducing energy use and cost.

Building trust is likely to be critical to successful engagement. There remains a persistent concern that energy companies are profiteering while asking customers to be 'flexible', sometimes seen as a euphemism for unwanted compromise. Furthermore there may be little distinction made between DNOs and retailers by customers. In this context, trusted third parties may be key to realising flexibility.

Evidence from SME and I&C customers

There is a low level of interest in and capacity for DSR across the SME sector in general. There is a perception that there is limited scope for flexibility that would not affect core business priorities. This may mask hidden potential (e.g. reducing power use by switching to computer batteries in office environments between 4-7 pm, other potential sources of storage or fuel switching).

While small businesses are mostly already relatively energy efficient for cost reasons, large organisations are actively pursuing energy conservation to meet carbon reduction and CSR targets (e.g. Universities, local authorities, hospitals, supermarkets, large commerce). Such organisations often have active energy reduction programmes but lack social and technical know-how to achieve targets and are also unaware of the synergistic ways in which actions to achieve these targets could be integrated with DSM / smart grid projects. Evidence from the CLNR suggests there is the potential to work with these to achieve win-win outcomes.

Some such organisations have 'community' and 'champion' based schemes working within them already – it will be important to understand how/why these are/not working and how they frame energy challenges (as being about CO_2, cost, energy, power, network capacity).

Workplaces could also provide a key means for reaching a wide 'domestic' community (e.g. University students tend to cluster in particular urban areas, employees of large organisations within a particular radius could be engaged through work).

Early CLNR work on Customer Engagement (2011)

Early review work by the DEI social science team for CLNR found that engaging customers in smart grid projects would need to address:

- *trust* – evidence suggests customers can doubt the motivations of the actors involved and where this occurs engagement suffers;

- *individual benefits* – direct benefits to households or businesses;
- *shared benefits* – at a local community level or more broadly (national grids, global climate); and
- *accessibility* – members of the community who cannot access an intervention cannot be engaged. This relates to factors such as ownership of smartphones, internet connections, disability, mobility, and so on.

This work also identified different mechanisms for engagement, the most relevant of which to ACE are:

- *practice based initiatives* – measures or mechanisms which provide new technology, visualisations, skills or other means of affecting how energy demanded by everyday practices;
- *personal incentives* – measures that seek to provide a direct benefit to those participating, often in the form of financial or other direct rewards;
- *shared incentives* – incentives that are aimed at creating some form of collective or other non-personal benefit, either for a 'community of interest' (e.g. a sports club) or an area-based community (e.g. a village hall project); and
- *inducements* – measures that seek to persuade individuals of the benefits of participating by highlighting the indirect benefits they and / or others would gain from participation. These may include performance in a game or league table or collection of tokens or other alternative currencies.

Appendix 7: Statistical design of the trials

It is very important that the ACE trial produces statistically robust results that can be of practical use to DNOs. We have therefore paid careful attention to the statistical design of the trials.

This appendix sets out the analysis carried out in this area. This analysis was undertaken by Professor Richard Boys at Newcastle University.

The exact design of the trials will be reviewed during the project itself.

Control groups

The impact of each trial will be measured against a control group who do not receive the intervention.

Sample sizes

The calculations are made on the basis of individual household data which will be provided via smart meters or in-house monitoring/smart plugs.
Sample sizes have been calculated assuming that the differences between the control group and the intervention group will be assessed using a 5% two sample t test. This test is commonly used for assessing such differences as it is fairly insensitive to deviations from normality in the population distributions and has a simple formula for determining sample sizes. For statistical reliability (out of sample assessment) we will choose our samples sizes so that the 5% test has 80% statistical power of detecting a difference of Δ between the control group and intervention group mean values, when the groups vary with standard deviation σ. Note that the sample size needed to reliably detect a difference Δ increases as standard deviation of the populations increase due to it being harder to distinguish between real differences between groups and natural variability within groups. The sample size *n* required for both control and for intervention groups must satisfy:

$$\Phi\left(-1.96-\sqrt{\frac{n}{2}}\frac{\Delta}{\sigma}\right)+\Phi\left(-1.96+\sqrt{\frac{n}{2}}\frac{\Delta}{\sigma}\right)=0.2$$

Φ (*z*) is the distribution function of the standard normal distribution. This can be simplified enormously if, as is the case in our calculations:

$$1.96+\sqrt{\tfrac{n}{2}}\tfrac{\Delta}{\sigma}>3$$

To give

$$n\simeq 15.70\,\sigma^2/\Delta^2.$$

A summary of the required sample sizes in both control and intervention groups are given in the following table. The details underlying these calculations then follow.

Table A7.1: Number of households required to reliably detect a change of a given size.

10% Change	5% Change
120	480

Data provided by the CLNR project (half-hourly electricity consumption for 5000 test cell 1a customers on 16th January 2012) indicate that mean level is around 1kW and standard

deviation is also around 1kW. In order to detect a 10% change, that is Δ=0.1kW, the sample size required is n $\simeq$ 1570. The CLNR data for individual households shows that typically the correlation between usage 14 days apart is quite low, and so we may treat fortnightly data as being uncorrelated. Thus we can repeatedly sample each household 13 times within a 6 month period and use all this data in our analysis.

Therefore the number of households needed (in both control group and in the intervention group) is n $\simeq$ 1570/13 $\simeq$ 120. Thus for a trial that runs for 6 months the number of households needed is 120. Note that if we wanted to reliably detect a 5% change, that is Δ=0.05kW, then we would need n $\simeq$ 6280/13 $\simeq$ 480 households in both control group and in the intervention group.

ACE is aiming to trial over a larger range of socio-demographic groups than other trials so the sample sizes need to be sufficiently large to detect changes for individual customer types. This will make the results applicable to DNOs in areas with a different customer and user mix and is a key example of how ACE will add valuable learning. In order to reliably detect such changes the sample sizes quoted will be needed for each such customer type/demographic group. It is difficult to estimate at this stage exactly how large the sample sizes need to be because we do not expect all demographic groups to participate in each trial. For example, in the schools trial we would only expect responses from demographic groups with children, and in the community trial it might be reasonable to assume that the Gengame might not appeal to all demographic groups. This will need to be investigated further as the trial is developed. Our current understanding is that take-up of up to 500 households in each of schools trial should be sufficient to detect a 10% change in peak demand. The community trial is likely to appeal to a wider range of customer types so we propose a slightly higher sample size of up to 650 in each of the trials.

We believe that sample sizes less than those proposed here increases the risk of not producing robust and transferable results on completion of ACE. For example a smaller sample size of 500 per wider community trial instead of our proposed 650 could impact the results in two ways:

- the statistical confidence of our results would decline if we have less than 120 households per customer type; or,
- we would only be able to obtain robust results for a smaller number of customer types (in this example from 5 down to 4).

The benefits of ACE will be reduced if network planners and designers are less able to rely on the demand reduction from ACE measures.

Appendix 8: Smart Grid Forum criteria

This appendix describes how the ACE project meets the criteria developed by the Smart Grid Forum's Workstream 6 on DSR.

	DSR assessment criteria	ACE project
DNO impact	The DNO will want a high level of certainty that the option will change customer behaviour. If the DSR is unable to do so, then it could lead to involuntary power cuts for which the DNO is penalised under Ofgem's incentive scheme. The DNO will also want to ensure that options suit their specific needs which will be time and location specific.	The interventions being trialled in ACE are being tested rigorously to ensure that a high level of certainty can be associated with them. Because the interventions do not rely on tariffs, they are particularly flexible and they can be tailored to suit specific time and location needs.
Market impact	This assesses the impact that options may have on other participants in the market. For instance, does it cut across the role that another industry party has traditionally played or would the TSO, suppliers and generators need sight of the DSR arrangements in order to factor them into their business decisions.	The interventions being trialled in ACE are novel and therefore will not cut across the role that another industry party has traditionally played. As with all DSR, there may be implications for the TSO, suppliers and generators. However, it will be possible to signal these implications in advance.
Customer impact	This assesses the impact the option will have on the customer. Customers should not be adversely affected by any of the options. The following sub criteria make up the Customer Impact criterion: • Customer comfort - Customers should not be unreasonably inconvenienced through pricing which incentivises them to change their electricity usage, or measures which automatically restrict their usage. • Clarity of information – Customers must be able to understand the arrangements they are entering into and these will need to be communicated in a simple way to consumers. • Pass through of benefit to customer – Customers must receive appropriate value for the response that they are providing. • Ease of use – Options for customer engagement must not be overtly difficult for consumers to employ and must be simple enough to implement for all customers. • Impact on public attitudes – The option must not trigger an adverse reaction from customers and must be seen	Customers will choose how to respond to the ACE interventions and therefore will not be unreasonably inconvenienced by them. Information on the interventions will be clear, the interventions will be designed to be easy for customers to engage with. Benefits will be passed through to consumers in the form of incentives for participation in the interventions (e.g. prizes), and ultimately lower bills. Because of this the impact on public attitudes should be positive, and consumers will see the interventions as an opportunity to save money. Customers will not be locked into participation. The interventions will be designed to ensure the signal is strong enough to elicit a response.

	DSR assessment criteria	ACE project
	as an opportunity for them to engage and save money. • Avoidance of lock in – Customers must have some rights to leave the DSR arrangement if they want to, particularly if an arrangement with another party could provide better value to them. • Strength of signal – The DSR signal must be strong enough to elicit a reliable response from customers in order to change behaviour.	
Viability	This criterion will assess the options in terms of their viability and their feasibility for wide-scale use and employment: • Suitability - Does the option fit the purpose it has been designed for, i.e. will the option solve the specific problem. • Sustainability – The option will need to be able to deliver long term benefits. • Compatibility with other options – can the option work alongside and complement others. • Technical, commercial and economic viability – Is the option ready for implementation, is the technology available and affordable. What barriers exist and what would need to be done to make this option feasible?	Previous trials of non-tariff interventions such as those being trialled in ACE suggest that these interventions are viable. Viability will be tested further during the ACE project.

Appendix 9: Demographic analysis

We compared the demographic profile from Experian customer classifications on ACE customer types against population customer types, to assess representativeness of ACE trials across the GB Distribution System. We control for the number of residential connections around Northern Powergrid's 32 primary substations to get a full representative sample of ACE customer base.

Table A11.1 below shows the Mosaic Experian Customer group breakdown, against a weighted average of residential connections by postcode, for ACE customer type breakdown.

Table A9.1 ACE customer base as representative of the UK customer base

		Mosaic	Durham Weighted Average
A	**Alpha Territory**	3.54%	1.30%
B	**Professional Rewards**	8.23%	6.09%
C	**Rural Solitude**	4.40%	3.85%
D	**Small Town Diversity**	8.75%	8.90%
E	**Active Retirement**	4.34%	2.32%
F	**Suburban Mindsets**	11.18%	7.83%
G	**Careers and Kids**	5.78%	5.73%
H	**New Homemakers**	5.91%	2.90%
I	**Ex-Council Community**	8.67%	23.61%
J	**Claimant Cultures**	5.16%	10.60%
K	**Upper Floor Living**	5.18%	0.82%
L	**Elderly Needs**	5.96%	8.10%
M	**Industrial Heritage**	7.40%	8.69%
N	**Terraced Melting Pot**	7.02%	7.72%
O	**Liberal Opinions**	8.48%	1.33%

Excluding those groups that are under-represented in Durham[13], establishes that ACE's customer base is representative of 86% of the GB population. However, this under-representation is not a cause for concern and the Durham customer base can be considered generally representative of the UK population.

We will consider during the trial design phase if it is appropriate to seek representation from the under-represented groups from outside County Durham.

[13] We have taken this to be groups where Durham has a population of less than 65% of the Mosaic figures. This covers groups K and O.

Appendix 10: Further details on the benefits case

This Appendix presents further details on our methodology and assumptions for calculating the net benefit of the ACE measures.

We cover the following:

- estimation of the base case at GB scale;
- sensitivity analysis using an alternative scenario for LCT uptake; and
- calculation of the net benefits of ACE at project scale.

The Base Case at GB scale

The Base Case describes the assumed most efficient alternative methods for releasing capacity on the GB Distribution System (without ACE), against which we compare the benefits of the ACE DSR planning tool and DSR propositions.

It is important to note that, in our Base Case, we assume that DNOs are able to undertake a range of conventional *and* smart network reinforcement options, such as storage, enhanced voltage control, and RTTR. We then make two further assumptions on the availability and use of DSR, in order to establish a range-estimate.

- For the upper boundary of our range-estimate, we assume that DNOs can access and use the full range of smart options, apart from DSR. This is a reasonable assumption, as without the tool being developed in Method Part 2, DNOs may not be able to integrate DSR into their planning and design decisions with the required level of confidence.
- For the lower boundary, we assume the smart options available in the Base Case will include DSR, with the most likely source being bilateral contracts with I&C customers. We also assume that this Base Case DSR is already associated with a 5% reduction in electricity use. This is highly conservative, as energy savings associated with DSR from I&C customers are likely to be more limited than the savings associated with DSR from households. This is because the DSR may be supplied from sources such as back-up diesel generators, rather than through changes in energy behaviour. We therefore present a less conservative sensitivity below, where we reduce the energy saving assumed to be already achieved in the Base Case by 50%.

Determining the Base Case within Transform

To quantify the Base Case at GB-scale, we used the Transform model.

Transform was developed in Workstream 3 of the Smart Grid Forum. It contains a parameter-based representation of the GB distribution network system. By looking at levels and patterns of demand, and considering options to invest in 'conventional' solutions (such as new cables and transformers) and 'smart' solutions (such as energy storage, enhanced voltage control, real-time thermal ratings, and DSR), it allows DNOs to determine the best investments to make out to 2050 under various LCT growth scenarios.

The advantage of using the Transform model to determine the Base Case is that it allows us to assume that in the future, DNOs will have the options to implement the learning from CLNR and other research projects by taking account of the fact that there will be cost-effective alternatives to traditional reinforcement available to free up network capacity. We have therefore assumed that there will be a wide range of technologies that

can be used to release capacity on networks and that these may be the most cost-effective solutions in some situations. This, however, results in conservative benefits estimates because it means that our Base Case assumes that the potentially cost-effective technologies included in the Transform model, which are not yet part of DNO business plans, will be commercially available to release headroom.

This produces a benefits case with a range-estimate for the potential benefits of ACE. Our headline numbers of £3.4bn to 2050, and £114m a year (in Section 3) are based on the midpoint of this range.

To produce the upper boundary of our range-estimate, we ran the Transform model assuming that there was no cost-effective DSR available to DNOs.

To determine the lower boundary of our range estimate, we ran the model with DSR priced at £43/kW/year. This represents the cost to DNOs of bilaterally contracting for DSR with I&C customers. To contract with I&C customers, DNOs would have to compete with National Grid and so it is unlikely that they could access this DSR at a cost below the cost of STOR. Our cost of DSR in this part of the Base Case is therefore based on the current average cost of STOR, including both availability and utilisation, adjusted to take account of the transaction costs associated with bilateral contracting. We estimate that the transaction costs of setting up bilateral contracts for flexibility consist of:

- legal costs, commercial resources and engineering input required to setup flexibility contracts; and
- commercial and administration costs associated with settlement.

Additional costs of bilateral trading might include higher levels of disputes compared to trading through a market. We do not have an estimate for these costs, so they are not included in the quantitative analysis (including them would increase our net benefits estimates). We assume that contracts are for 0.5MW of flexibility on average, and last one year.

Under the Base Case for the upper boundary, no DSR is used. Total reinforcement costs are £33.1bn at GB scale. Under the Base Case for the lower boundary, 11.2GW of DSR is used until 2050, an average of 374MW per year. Total reinforcement costs are £30.4bn at GB-scale, a difference of £2.7bn.

To determine the benefits of the ACE method, we look at the incremental savings associated with the ACE measures relative to these costs.

Sensitivity analysis

In this section we assess the impact of two sensitivities on the range of benefits. These make less conservative assumptions regarding energy savings and the roll-out of low carbon technologies.

In our benefits case we have assumed that the energy savings associated with the DSR in the Base Case and ACE are the same. Given it is most likely that, without the facilitation provided by the ACE tool, DNOs would have to rely on bilateral contracts with I&C customers instead of with residential households, the energy savings are likely to be lower. As explained above, this is highly conservative, as energy savings associated with DSR from I&C customers are likely to be more limited than the savings associated with DSR from households. An assumption that DSR in the Base Case delivers only half

of the energy savings that would be delivered by ACE, increases the lower boundary of our range to **£2,041m or £68m-£201m per annum**.

Our headline estimates are based on roll out of LCTs consistent with Workstream 3, Scenario 1. If we re-estimate the base case (both upper and lower boundaries) using Workstream 3, Scenario 3, where there is a higher take-up of electric vehicles and solar PV, the net benefits increase to £3,196m-£7,408m (2030-2050) or £107m-£247m per annum. Under this scenario the Transform model estimates that an average of 518MW of DSR in each year out to 2050 is taken up under these cost assumptions (106-518MW of additional DSR relative to the Base Case).

Table 10.1: Breakdown of the GB-scale annual benefits in the alternative higher Workstream 3 Scenario 3.

ACE benefits	Benefits to all DNO customers	Additional benefits to ACE households	Additional benefits to ACE I&C customers	Benefits to other parties	**Carbon Benefits**	**Total net benefits**
Lower boundary	£39m	£62m	£3m	£0m	£2.1m	**£107m**
Mid-point	£87m	£83m	£4m	£0m	£2.8m	**£177m**
Upper boundary	£134m	£104m	£5m	£0m	£3.4m	**£247m**

The same table for Scenario 1 is shown in Section 3 of this document.

Calculation of net benefits at project scale

We have also estimated the benefits at project scale, as required by the Ofgem Governance Document. However, project scale benefits do not represent an appropriate means of assessing this project's potential. This is because the trials have been sized to deliver statistically significant results while being no larger or more complex than required. We are not trialling these interventions at a size that would be optimal for implementation. In reality, because of the associated fixed costs, the ACE interventions would be implemented at a much larger scale, increasing cost-effectiveness and overall net benefits.

To estimate the project scale costs, we undertook a bottom-up calculation based on the size of the trials and, in the same way as our GB-scale benefits, we have produced a range with an upper and lower boundary. Our headline estimate is based on the mid-point of this range. In these calculations, we took account of the fact that measures are more expensive at project scale relative to the alternatives, due the presence of fixed costs spread over a very small number of customers (Table 3.3). Without these fixed costs, the cost-effectiveness of the ACE measures would be comparable to those at GB scale.

- For the upper boundary of the range estimate we assumed that DSR is not available to DNOs and compared the cost of ACE to an estimate of the average cost of network reinforcement, which we estimate to be £45/kW.

- For the lower boundary of the range estimate we have assumed that the DNO can access DSR at a cost of £43/kW, based upon the cost of STOR.

We have also included an estimate of the energy savings. For the upper boundary of the range estimate there is no DSR in the Base Case so the energy savings from ACE are entirely additional. At the lower end of the range estimate, we assume there are energy savings associated with the DSR in the Base Case. At this scale it is highly unlikely that DNOs will be able to contract directly with households and therefore the main option for achieving DSR is likely to be contracting with I&C customers. The energy savings associated with this kind of DSR are likely to be limited and therefore we assume that Base Case energy savings of 5% are associated with only half of the DSR contracted.

This yields a headline estimate of the benefits at project scale of £3.6m to 2050, or £119k per annum. This is the mid-point of a range of benefits from £2m-5.1m, which equates to £68k-£169k per annum.

Appendix 11: Recruiting and retaining customers

The recruitment and retention of participants is a central part of the ACE project:

- it is crucial that the ACE project delivers learning on the best ways to recruit and retain customers through the trial of intervention design and delivery options;
- sufficient participant numbers are required to robustly demonstrate the effectiveness of the individual interventions being trialled; and
- recruitment must be economical, to demonstrate the potential long-term viability of the trials when scaled up to GB level.

ACE will draw on a range of in-house and stakeholder expertise to ensure positive recruitment and retention of trial participants. It will focus on this through good trial design and best practice customer engagement channels throughout the course of the project, with both in-house and external stakeholder support:

- Northern Powergrid employees will manage the project centrally and draw on extensive in-house expertise in long-term sustainable customer engagement. Northern Powergrid staff will:
  - make design decisions and carry out day–to–day engagement with intermediaries, community champions and trial participants;
  - fill the roles of the ACE DSR trials project manager, the ACE communications manager and the ACE trials recruitment co-ordinator; and
  - draw on the support and expertise of the in-house stakeholder engagement people in the Northern Powergrid Commercial Directorate.
- Durham University, Exeter University and a social marketing specialist will together shape customer engagement channels through:
  - designing the information provided in the schools and local authority trials, drawing on in-house expertise on best practice for retaining customers to ensure behavioural change;
  - advising on the appropriate channels of customer engagement, e.g. community groups, on an individual household level, direct conversation and provision of hard and soft copy publicity and information materials; and
  - targeting local community groups to connect with customers as both households and local small businesses.
- Oswald Consultancy will design the digital customer interface for the DSR propositions drawing on best practice for retaining customer engagement through games and competitions.[14]
- Durham County Council will provide support for recruiting and retaining participants for all three trials:
  - facilitating the engagement of local schools in the schools trial areas;
  - facilitating the engagement of local authority buildings for the local authority trial;
  - providing publicity in public buildings and newsletters and contacts for community groups for the wider community trials;
  - promoting the project and any competitions or other actions through the relevant Area Action Partnerships, and through relevant Parish and Town Councils, to reach a wide cross section of the geographical area;

[14] Please see Annex 5 for further information on best practice on games and competitions for customer engagement.

- working closely with Durham Rural Community Council (DRCC), supporting several hundred community organisations, leading community training schemes and running the One Voice network that speaks for all voluntary organisations in the County.

- The Voluntary Organisations Network Northeast (VONNE) will also provide support in recruiting participants across all three ACE interventions by:
  - Helping the ACE project recruit target clusters of communities who might be interested in being involved;
  - assisting with the identification and selection of local good causes to support;
  - identifying and communicating with grass roots community organisations and acting as intermediaries to mobilise within their communities to ensure we maximise every opportunity;
  - providing a forum for local projects to consider a "good causes fund" for participating individuals to donate rewards to the local community in each cluster;
  - promoting the initiative widely through their e-bulletin, sent to 1500 subscribers across the North East;
  - sending out direct mailings to the targeted groups, endorsing the idea from VONNE; and
  - using their social media channels, in particular Twitter to promote the propositions.

Appendix 12: Second Tier Funding Request

Second Tier Funding Request

		2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	Total
Cost	*From Project Cost Summary sheet*							
	Labour	106	597	537	551	343	-	2,134
	Equipment & contractor	10	1,391	1,227	1,078	769	-	4,475
Payments to users & Contingency		9	158	142	163	117	-	588
	Other	7	99	37	37	28	-	208
	Total	132	2,245	1,944	1,828	1,256	-	7,405
External funding	*Any funding that will be received from Project Partners and/or External Funders - from Project Cost Su*							
	Labour	-	18	-	-	-	-	18
	Equipment & contractor	9	256	169	295	182	-	910
Payments to users & Contingency		-	-	4	8	4	-	16
	Other	-	-	-	-	-	-	-
	Total	9	274	173	303	186	-	944
DNO extra contribution	*Any funding from the DNO which is in excess of the DNO Compulsory Contribution - from Project Cost*							
	Labour	-	-	-	-	-	-	-
	Equipment & contractor	-	-	-	-	-	-	-
Payments to users & Contingency		-	-	-	-	-	-	-
	Other	-	-	-	-	-	-	-
	Total	-	-	-	-	-	-	-
Initial Net Funding Required	*calculated from the tables above*							
	Labour	106	579	537	551	343	-	2,116
	Equipment & contractor	2	1,135	1,059	783	587	-	3,565
Payments to users & Contingency		9	158	138	154	112	-	572
	Other	7	99	37	37	28	-	208
	Total	124	1,971	1,771	1,525	1,070	-	6,461
Direct Benefits	*from Direct Benefits sheet*							
	Total	-	-	-	-	-	-	-
DNO Compulsory Contribution / Direct Benefit	*from Project Cost Summary sheet*							
	Labour	11	58	54	55	34	-	212
	Equipment & contractor	0	114	106	78	59	-	357
Payments to users & Contingency		1	16	14	15	11	-	57
	Other	1	10	4	4	3	-	21
	Total	12	197	177	152	107	-	646
Outstanding Funding required	*calculated from the tables above*							
	Labour	95	521	483	495	309	-	1,904
	Equipment & contractor	2	1,022	953	705	528	-	3,209
Payments to users & Contingency		8	142	125	139	101	-	515
	Other	6	89	33	33	26	-	187
	Total	112	1,774	1,594	1,372	963	-	5,815
balance	5,621	-	3,736	2,235	923	(9)	0	5,621
interest		-	94	60	32	9	(0)	194
								5,815

SECOND TIER FUNDING REQUEST £ **5,621**

Project Direction

Cost Category	Cost
Labour	
Project Management	1,131
Technical Engineer	319
Comms, recruitment, engagement, dissemination	455
Equipment & Contractors	
Equipment & Contractors	3,674
Payments to users	
Community DSR Award	40
Schools DSR Award	10
Other Costs	
Other costs	187
Total	**5,815**