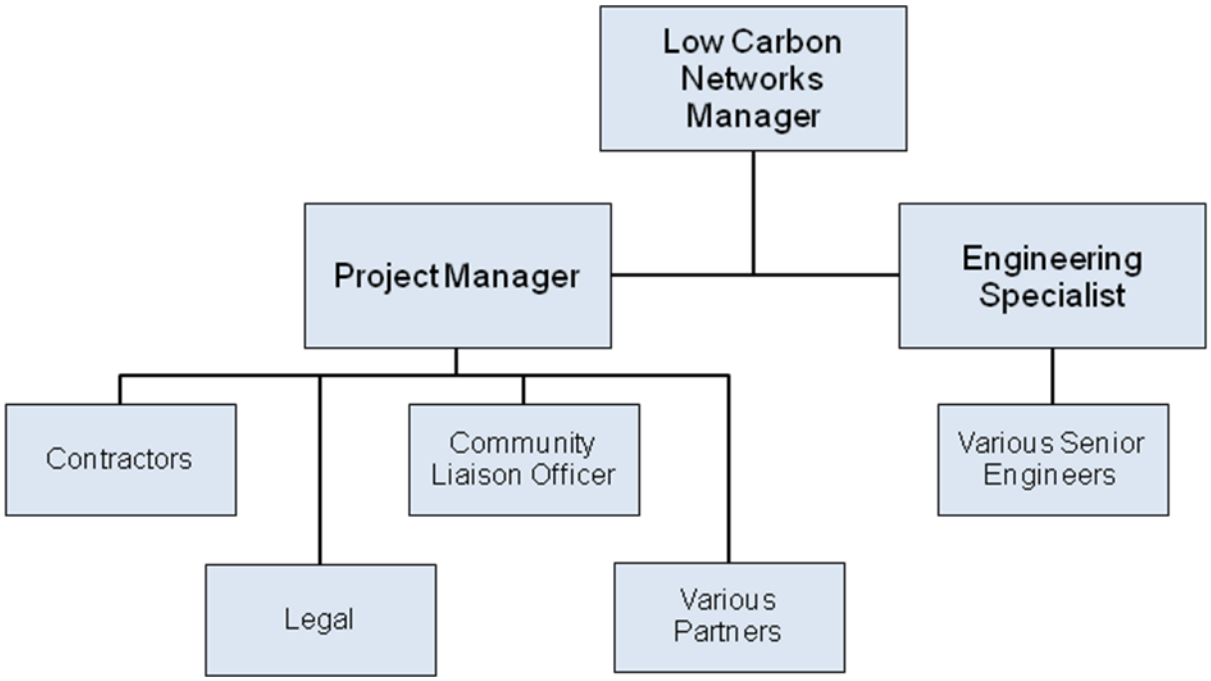
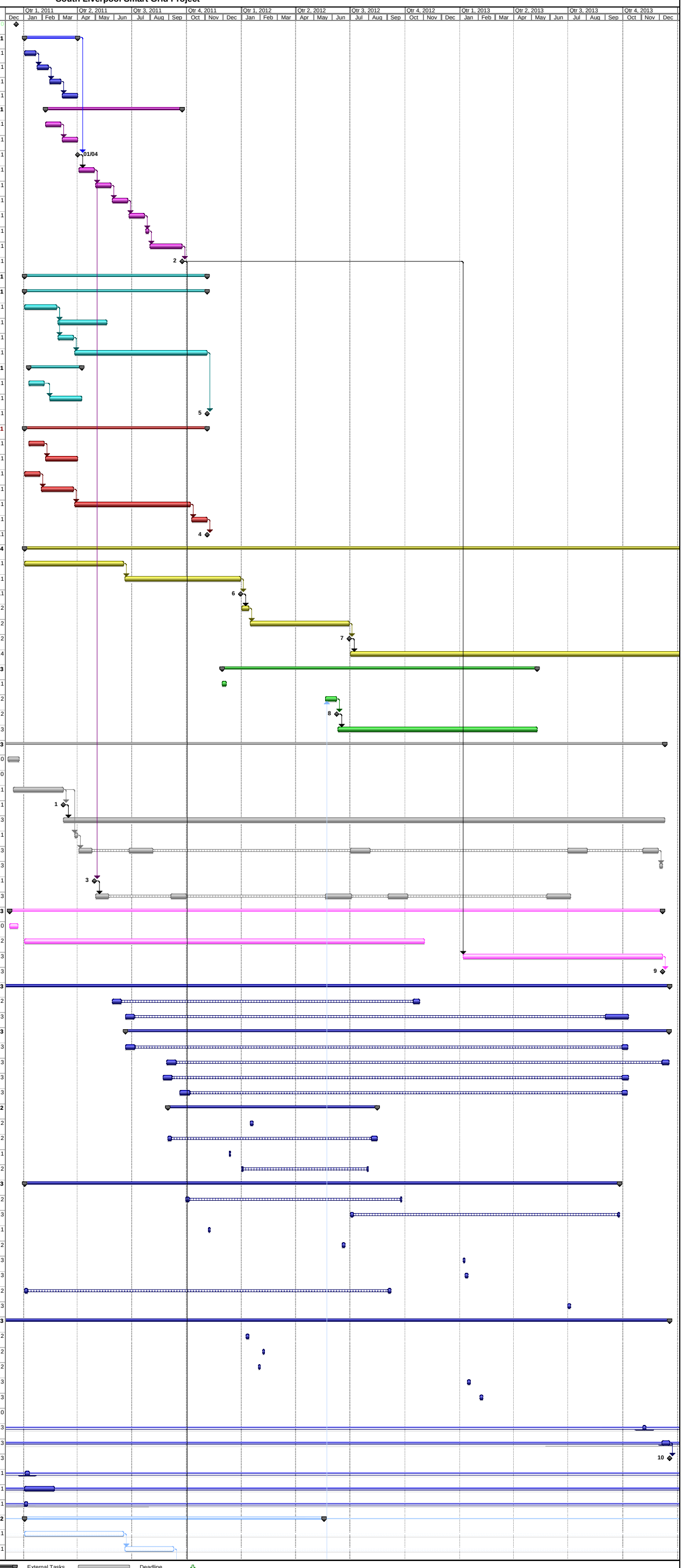
Appendix C
Organogram



Appendix D
Project Plan

Appendix D.1
South Liverpool Smart Grid Project

ID	Task Name	Duration	Start	Finish
1	SPEN Project Team established	0 days	Mon 20/12/10	Mon 20/12/10
2	**Procure Network Monitoring Devices**	**65 days**	**Mon 03/01/11**	**Fri 01/04/11**
3	Finalise specification	3 wks	Mon 03/01/11	Fri 21/01/11
4	Agree collaboration agreement	3 wks	Mon 24/01/11	Fri 11/02/11
5	Agree procurement contract	3 wks	Mon 14/02/11	Fri 04/03/11
6	Lead time / shipping	1 mon	Mon 07/03/11	Fri 01/04/11
7	**Install Network Monitoring Devices**	**165 days**	**Mon 07/02/11**	**Fri 23/09/11**
8	Procure contract fitting team	1 mon	Mon 07/02/11	Fri 04/03/11
9	Train contract fitting team	1 mon	Mon 07/03/11	Fri 01/04/11
10	Monitoring installation starts	0 days	Fri 01/04/11	Fri 01/04/11
11	Install schools monitors	1 mon	Mon 04/04/11	Fri 29/04/11
12	Install Primary substation monitors	1 mon	Mon 02/05/11	Fri 27/05/11
13	Install monitors in engagement areas	1 mon	Mon 30/05/11	Fri 24/06/11
14	Install monitors in non-engagement control areas	1 mon	Mon 27/06/11	Fri 22/07/11
15	Install monitors in areas with storage	1 wk	Mon 25/07/11	Fri 29/07/11
16	Install monitors in remaining Substations	2 mons	Mon 01/08/11	Fri 23/09/11
17	Monitoring installation complete	0 days	Fri 23/09/11	Fri 23/09/11
18	**Smart Grid Software**	**220 days**	**Mon 03/01/11**	**Fri 04/11/11**
19	**ESRI**	**220 days**	**Mon 03/01/11**	**Fri 04/11/11**
20	Finalise ESRI Specification	2 mons	Mon 03/01/11	Fri 25/02/11
21	ESRI Upgrade Development Activities	3 mons	Mon 28/02/11	Fri 20/05/11
22	Procure, install and config additional hardware	1 mon	Mon 28/02/11	Fri 25/03/11
23	Install, Configure & test ESRI analytical software	8 mons	Mon 28/03/11	Fri 04/11/11
24	**PI**	**65 days**	**Mon 10/01/11**	**Fri 08/04/11**
25	Procure, install & config PI server hardware	1 mon	Mon 10/01/11	Fri 04/02/11
26	PI config & development activities	2 mons	Mon 14/02/11	Fri 08/04/11
27	Software installation complete	0 days	Fri 04/11/11	Fri 04/11/11
28	**Smart Grid Communication Channel**	**220 days**	**Mon 03/01/11**	**Fri 04/11/11**
29	Procure additional data bundle	1 mon	Mon 10/01/11	Fri 04/02/11
30	Upgrade current VPN	2 mons	Mon 07/02/11	Fri 01/04/11
31	Procure APN Sim Cards	1 mon	Mon 03/01/11	Fri 28/01/11
32	Procure GPRS modems	2 mons	Mon 31/01/11	Fri 25/03/11
33	Commission comms system to PI	7 mons	Mon 28/03/11	Fri 07/10/11
34	Commission control centre systems	1 mon	Mon 10/10/11	Fri 04/11/11
35	Established Communication Channel with Monitoring	0 days	Fri 04/11/11	Fri 04/11/11
36	**Storage**	**790 days**	**Mon 03/01/11**	**Fri 10/01/14**
37	Approve Storage Units	6 mons	Mon 03/01/11	Fri 17/06/11
38	Procure Storage Units	7 mons	Mon 20/06/11	Fri 30/12/11
39	Storage Procurement Complete	0 days	Fri 30/12/11	Fri 30/12/11
40	Analyse & devise different control strategies for storage	10 days	Mon 02/01/12	Fri 13/01/12
41	Install and commission Storage Units	6 mons	Mon 16/01/12	Fri 29/06/12
42	Storage Installation Complete	0 days	Fri 29/06/12	Fri 29/06/12
43	Implement Load Shift Strategies	20 mons	Mon 02/07/12	Fri 10/01/14
44	**Voltage Control**	**378 days**	**Wed 30/11/11**	**Fri 10/05/13**
45	Analysis & recommendations of when 2% V drop can be implemented	5 days	Wed 30/11/11	Tue 06/12/11
46	Install advanced Automatic Voltage Controllers (AVCs)	3 wks	Mon 21/05/12	Fri 08/06/12
47	AVCs installed	0 days	Fri 08/06/12	Fri 08/06/12
48	Implement voltage control strategy	12 mons	Mon 11/06/12	Fri 10/05/13
49	**Customer Initial Engagement**	**864 days?**	**Thu 19/08/10**	**Tue 10/12/13**
50	Initial media briefing event	15 days	Mon 06/12/10	Fri 24/12/10
51	Ongoing media liaison	1 day?	Thu 19/08/10	Thu 19/08/10
52	Smart Grid web portal commissioned	3 mons	Wed 15/12/10	Tue 08/03/11
53	Smart Grid website live	0 days	Tue 08/03/11	Tue 08/03/11
54	Smart Grid website live	36 mons	Wed 09/03/11	Tue 10/12/13
55	Initial Community Event	5 days	Mon 28/03/11	Fri 01/04/11
56	Community programme	5.8 mons	Mon 04/04/11	Fri 29/11/13
57	Community dissemination event	5 days	Mon 02/12/13	Fri 06/12/13
58	Start of schools programme	0 mons	Fri 29/04/11	Fri 29/04/11
59	Schools programme	6.15 mons	Mon 02/05/11	Fri 05/07/13
60	**Network Policy Changes**	**782 days**	**Thu 09/12/10**	**Fri 06/12/13**
61	Analysis recommendation for DG connection policy	10 days	Thu 09/12/10	Wed 22/12/10
62	Review policy & project Learning's	24 mons	Mon 03/01/11	Fri 02/11/12
63	Draw up policy relaxations for smart grid	12 mons	Mon 07/01/13	Fri 06/12/13
64	Review of data aquired from project & quantification of benefits	0 days	Fri 06/12/13	Fri 06/12/13
65	**Learning capture and project evaluation programme**	**863 days**	**Mon 30/08/10**	**Wed 18/12/13**
66	Collect and analyse schools data	20 days	Mon 30/05/11	Thu 25/10/12
67	Collect and analyse primary sub data	40 days	Tue 21/06/11	Thu 10/10/13
68	**Collect and analyse secondary substation data**	**651 days**	**Tue 21/06/11**	**Tue 17/12/13**
69	engagement areas	20 days	Tue 21/06/11	Wed 09/10/13
70	non engagement areas	20 days	Mon 29/08/11	Tue 17/12/13
71	Storage areas	20 days	Tue 23/08/11	Thu 10/10/13
72	non storage areas	20 days	Tue 20/09/11	Tue 08/10/13
73	**Customer feedback analysis**	**251 days**	**Wed 31/08/11**	**Wed 15/08/12**
74	Analyse customer engagement initial survey	1 wk	Mon 16/01/12	Fri 20/01/12
75	Customer engagement feedback analysis	12 days	Wed 31/08/11	Wed 15/08/12
76	Prepare Customer PV survey	2 days	Mon 12/12/11	Tue 13/12/11
77	Analyse PV customers behaviour	4 days	Mon 02/01/12	Tue 31/07/12
78	**Other data collection and analysis**	**713 days**	**Mon 03/01/11**	**Wed 25/09/13**
79	Adjacent group primary data - ripple effect analysis	6 days	Fri 30/09/11	Tue 25/09/12
80	Advanced voltage control effects analysis	8 days	Mon 02/07/12	Wed 25/09/13
81	EV connection impact analysis	3 days	Mon 07/11/11	Wed 09/11/11
82	Data in support of policy review	5 days	Mon 18/06/12	Fri 22/06/12
83	Impact of policy change on DG connection	3 days	Mon 07/01/13	Wed 09/01/13
84	Impact analysis of other DG facilitation	3 days	Thu 10/01/13	Mon 14/01/13
85	Evaluate reduced travel due to monitoring	10 days	Mon 03/01/11	Fri 07/09/12
86	Customer post-engagement awareness survey	5 days	Mon 01/07/13	Fri 05/07/13
87	**Reports and dissemination events**	**863 days**	**Mon 30/08/10**	**Wed 18/12/13**
88	First year report	5 days	Mon 09/01/12	Fri 13/01/12
89	First year technical dissemination event	3 days	Mon 06/02/12	Wed 08/02/12
90	First year community dissemination event	3 days	Mon 30/01/12	Wed 01/02/12
91	Second year report	5 days	Mon 14/01/13	Fri 18/01/13
92	Second year technical dissemination event	5 days	Mon 04/02/13	Fri 08/02/13
93	Second year community dissemination event	2 days	Mon 30/08/10	Tue 31/08/10
94	Final year report	5 days	Mon 04/11/13	Fri 08/11/13
95	Final year dissemination events	9 days	Fri 06/12/13	Wed 18/12/13
96	Final dissmenation of learning	0 days	Wed 18/12/13	Wed 18/12/13
97	Establish for measures that will facilitate DG connections	5 days	Tue 04/01/11	Mon 10/01/11
98	Liaison with manufactures and stakeholders to co-ordinate implementation of	36 days	Mon 03/01/11	Mon 21/02/11
99	Ensure safety and environmental policies and procedures are followed by inst	5 days	Mon 03/01/11	Fri 07/01/11
100	**3rd Party Distributed Generation Procurement**	**360 days**	**Mon 03/01/11**	**Fri 18/05/12**
101	Initial PV generation procurement	6 mons	Mon 03/01/11	Fri 17/06/11
102	Install initial PV generation	3 mons	Mon 20/06/11	Fri 09/09/11

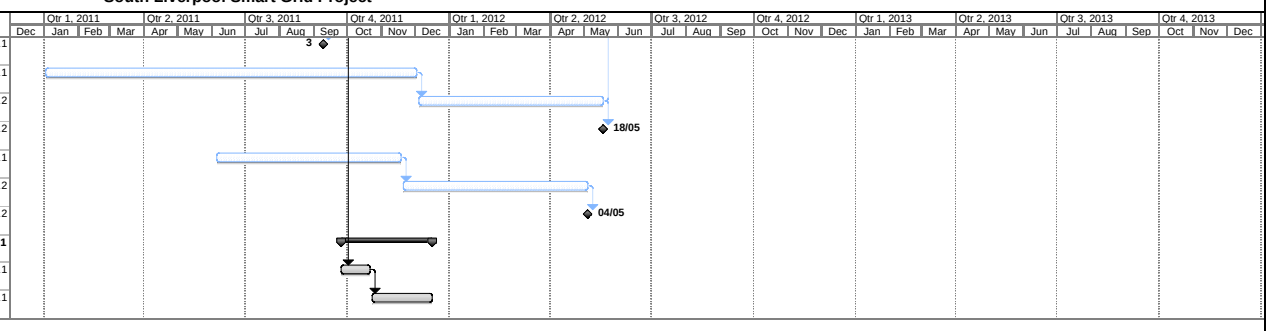


Project: Appendix D.1
Date: Thu 02/09/10

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Appendix D.1
South Liverpool Smart Grid Project

ID	Task Name	Duration	Start	Finish
103	Installation of initial PV Generation Complete	0 days	Fri 09/09/11	Fri 09/09/11
104	Urban wind generation procurement	12 mons	Mon 03/01/11	Fri 02/12/11
105	Install urban wind generation	6 mons	Mon 05/12/11	Fri 18/05/12
106	Install urban wind generation Complete	0 days	Fri 18/05/12	Fri 18/05/12
107	Initial mCHP generation procurement	6 mons	Mon 06/06/11	Fri 18/11/11
108	Install initial mCHP generation	6 mons	Mon 21/11/11	Fri 04/05/12
109	Installation of initial mCHP generation Complete	0 days	Fri 04/05/12	Fri 04/05/12
110	**Low carbon load integration**	**60 days**	**Mon 26/09/11**	**Fri 16/12/11**
111	Designate EV charging points	1 mon	Mon 26/09/11	Fri 21/10/11
112	EV connections using SG connection policy	2 mons	Mon 24/10/11	Fri 16/12/11



Project: Appendix D.1
Date: Thu 02/09/10

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Appendix E
Information Sources referenced in Box 14/15 and details

1. CARBON REDUCTION EVALUATION

The carbon reductions anticipated as a result of the Smart Grid trial in South Liverpool may come from a number of different sources:

- Reductions in network losses
- Increase in renewable generation that can be connected.
- Reduction in demand or demand shifting to reduce the carbon intensity of the power consumed.
- Reduction in transport or use of electric vehicles

The savings may not be very great within the limited project area but if replicated across the UK LV network the savings are estimated to be significant.

1.1. Baseline and Control Data

In order to establish the level of reductions, it is necessary to estimate the present carbon emissions. The only power flow data in advance of the trial are half-hourly measurements at the three primary substations feeding the area. This is sufficient to estimate the total energy used and the corresponding carbon emissions, assuming the carbon intensity of the power used is equivalent to that emitted using the average national mix of generation types (equivalent to 0.5406kgCO_2/kWh for 2010)[1]. The historic data does not provide enough granularity to understand where power is being consumed or lost (e.g. via network losses).

1.1.1. Additional Monitoring During the Trial

During the trial, each LV feeder will be monitored and therefore a much better understanding of power flow on an interconnected network with generation and storage connected will be possible. This will potentially provide the following:

- Losses through the 6.6kV feeder and transformers can be implied from feeder current measurement and knowledge of the network parameters.
- Carbon reductions due to network losses through the LV cables can be calculated from the readings on the LV side of the secondary substations and if available, reconciled with data from smart meters. If this is not possible, savings can be assessed using control groups (see section 1.1.3).

1.1.2. Variation in Historic Data

Four years of load data from 2006 to 2009 is available. The total annual consumption is given in Table 1 with the standard deviation and mean over the four years. The 95% confidence interval is 3046MWh. That is, if the consumption over a number of years is not changing, 95% of years will have a consumption of 101878MWh+/- 3046. Conversely, an annual consumption outside this range could indicate that the consumption is increasing or

[1] *Elexon* www.**elexon**.co.uk accessed 2nd September

decreasing over time. The 2009 value is outside this range and therefore further investigation is needed as described below.

Table 1 Total consumption for the three primaries feeding the South Liverpool area.

	2006	2007	2008	2009	Standard deviation	Mean
Total consumption	102625	102487	103705	98695	2191	101878
Standard deviation	0.242	0.709	0.286	1.054		

The total consumption each month for the four years is in Table 2 with the mean, standard deviation and the 95% confidence interval for each month. There are only two monthly values outside the 95% confidence interval. These are in October 2008 and in February 2007.

Table 2 Total monthly consumption for the three primaries feeding the South Liverpool area

	2006	2007	2008	2009	Standard deviation	mean	95% confidence intervals
Apr	4,301	3,902	4,445	3,716	339	4,091	472
May	4,101	3,828	3,879	3,731	157	3,885	218
Jun	3,735	3,539	3,694	3,508	112	3,619	156
Jul	3,744	3,603	3,834	3,558	127	3,685	177
Aug	3,795	3,602	3,865	3,440	193	3,676	268
Sep	3,842	3,862	3,992	3,726	109	3,856	151
Oct	4,308	4,343	4,555	4,216	143	4,355	199
Nov	4,593	4,783	4,825	4,432	181	4,658	252
Dec	4,850	5,139	4,994	4,847	139	4,958	193
Jan	4,886	5,148	4,947	5,069	118	5,013	164
Feb	4,444	4,683	4,384	4,486	130	4,499	180
Mar	4,709	4,802	4,432	4,613	158	4,639	220

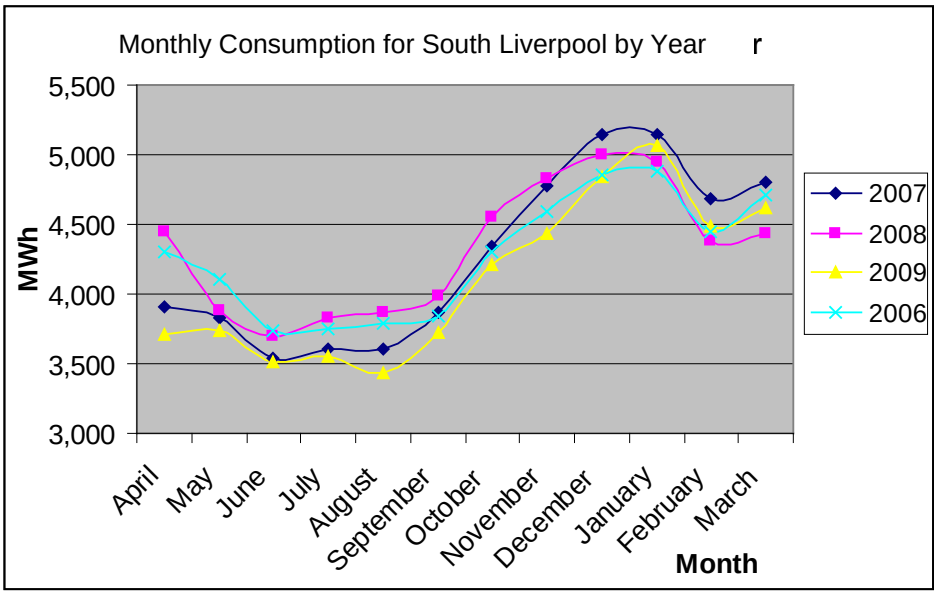


Figure 1 Month Consumption for South Liverpool by Year

Figure 1 shows that the month by month consumption for 2009 is the lowest in spring and summer value of the four years but each month is within the 95% confidence interval for the monthly consumption. Consumption is high compared to the previous three years during the winter of 2009. It is likely that the 2009 consumption may not be significantly lower than previous years and does not represent a downward trend in demand given that each month is within the 95% confidence interval

From the analysis above, for a drop in consumption during the trial to be significant, the annual total consumption and individual monthly consumptions would have to all be above or below the 95% confidence interval. For the annual total consumption from 2006-2009 the confidence interval is +/- 3046MWh but the value of 95% confidence interval will depend on the monthly or yearly consumption in the area and time period considered.

The standard deviation of the half hourly readings is much greater for 2009 compared to the years 2006-2008 (Table 1). This could be interpreted as an increase in the variability of the load. However, the standard deviation for 2007 is greater than 2006 or 2008 and therefore the variability in 2009 is not necessarily a sign of increasing variability in readings.

As the network is interconnected and transformers are electrically similar, the loads on the three substations should be fairly evenly spread. Table 3 shows the yearly consumption, the mean over four years and standard deviation for the three substations. Dingle is consistently slightly less loaded than St James and Granby apart from in 2009 and has a lower standard deviation.

Table 3 Load on the three primary substations over four years.

Substation	2006	2007	2008	2009	mean	standard deviation
St James	34495	37681	36443	34046	35666	1699
Granby	35342	33814	34106	31975	33809	1391
Dingle	32788	30993	33156	32674	32403	962

1.1.3. Control groups

Historic data has insufficient granularity to understand the changes in load on a particular feeder or as a result of implementing a particular solutions. In addition smart meter data may not be available. As a result, it will be necessary to use control groups. To understand the impact of different measures and/or their combined impact, this technique compares data from control areas either within or alongside the project area where solutions are not being implemented to areas where solutions are being implemented. Control areas should be as similar as possible in terms of building types and demography to make a reasonable comparison.

1.2. Embodied Carbon

There is always additional carbon emitted when manufacturing and installing equipment and these are referred to as embodied carbon. If it is replacing existing equipment, then only the additional carbon emissions over and above replacing like for like should be taken into account. If it is additional equipment, the carbon emitted in manufacture and installation should be taken into account. The carbon emitted during various different activities are given by DEFRA to calculate emissions for the Carbon Reduction Commitment and these figures are used.

Generation will also incur carbon emissions during manufacture. For renewable generation these are more than compensated for by the electricity generated with no emissions over their lifetime. One method to take the embodied carbon of renewable generators into account is to convert it into an equivalent carbon emission per kWh that is generated over the expected lifetime of the generation equipment.

1.3. Types of Carbon Reduction

As identified above there are 3 ways that carbon can be reduced with the South Liverpool project.

1.3.1. Network losses

Network losses (per kWh consumed) can be reduced by:

- Minimising reactive power flow
- Minimising the impedance or resistance of the network

Reductions could occur through the transformers, on the 6.6kV cables or the LV feeders.

As the network is interconnected, solutions implemented on the LV network could reduce losses on more than one of the 6.6kV feeders and therefore it may be difficult to evaluate and separate out from the other affects. Losses on the 6.6kV system are, however, expected to be small in comparison with those on distribution transformers and LV cables. Comparison of the overall consumption of the smartgrid area with other similar areas or different parts of the smartgrid are itself could be used to evaluate when there is a reduction in load due to a decrease in losses.

1.3.2. Generation

Renewable generation will reduce fossil fuel generation and thus reducing the carbon instensity of the power consumed. Locally generated power reduces network losses due by reducing the power carried over the transmission and distribution network.

However, connection of generation is possible under present regulatory and network operation arrangements. Only the carbon reduction of the additional generation facilitated by the actions taken under the LCNF project is taken into account.

1.3.3. Energy Efficiency and Shifts in Demand

If customers are provided with energy display devices, smart meters and provided with advice, it is likely that they will reduce their consumption. This has been demonstrated in the energy reduction trials carried out by major licensed suppliers. If the load profile can also be shifted by changing behaviour and/or use of storage, this will reduce the average carbon intensity of the demand.

As with generation, only the carbon benefits that can be attributed to interventions by the DNO under the LCNF trial are taken into account.

1.3.3.1. Carbon Intensity of Demand

Shifting the time of day of demand can reduce its carbon intensity. Ignoring network losses, the average emissions from generation in 2009 were 0.4286kg CO_2/kWh. However, the carbon emissions from generation vary according to the mix of generation being used. Elexon published the percentages of different type of generation used during each half-hour throughout the year. A study of the carbon intensity over 24 hour periods showed that the carbon intensity varied on average from 0.3660[2] kg CO_2/kWh and 0.4660 kg CO_2/kWh (excluding transmission losses). By moving load around it is theoretically possible to reduce the carbon emissions per kWh by 25%. Although a 25% reduction is not possible in practice, the theoretical figure demonstrates the value of load shifting to reduce carbon emissions.

By using these average hourly carbon intensities, the carbon emissions from grid supplied generation can be estimated for past consumption and future consumption where customers are encouraged to shift their load.

[2] *Elexon* www.**elexon**.co.uk accessed 2nd September

2. CARBON BENEFITS AND CONSUMER BENEFITS SPREADSHEET

In order to calculate the carbon saving benefits and net present value calculations, it is necessary to quantify the different possible savings and emissions outlined in section 1. To do this a spreadsheet was constructed covering the following areas:

- Base line electricity consumption and new consumption and conversion to equivalent tonnes of CO_2 emitted.
- Savings in carbon emissions due to renewable energy installed and the percentage increase due to action under LCNF.
- Reduction in consumer consumption and changes in carbon intensity due to load shifting due to consumer behavioural change or use of storage.
- Reduction in carbon emissions due to reductions in network losses. These could be increases in renewable generation used locally or reductions in losses of P and Q on the network.
- The embodied carbon of the solutions used under LCNF.
- Savings emissions from transport due to reduced transport for operations or increases in electric vehicles.
- The overall carbon savings of the project.
- The resultant carbon savings NPV of carbon savings if the solutions are rolled out across the country.
- Savings in electricity bills and income from feed in tariffs as a result of the actions taken under LCNF

2.1.1. Carbon Emission Factors

The carbon emissions factors are from DECC/DEFRA's figures for the Carbon Reduction Commitment reporting[3] with the following exceptions:

- The predicted traded carbon prices published by DECC to 2050[4].
- The hourly carbon intensity for electricity generation are calculated from 2009 half-hourly generation mix reported by Elexon and DBERR's figures for carbon intensity of different generation technologies from 2007/2008[5] as illustrated at Earth Notes [6]
- The embodied carbon of PV, wind and biomasss from Parliamentary Office of Science and Technology postnote 268[7].

2.1.2. Sources of Other Values

The predicted traded carbon prices used are those published by DECC to 2050[8] and the predicted domestic energy prices used are from DECC's published statistics[9]. Feed in Tariffs are the published figures to 2020.

[3] 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting Version 2.0, 20/9/2010. accessed 11th August 2010
[4] Carbon Valuation in UK Policy Appraisal: A Revised Approach, Climate Change Economics, Department of Energy and Climate Change, July 2009.
[5] http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/energy/markets/electricity-markets/fuel-mix/page21629.html accessed 11th August 2010
[6] http://www.earth.org.uk/note-on-UK-grid-CO2-intensity-variations.html accessed 11th August 2010
[7] http://www.parliament.uk/documents/post/postpn268.pdf accessed 11th August 2010
[8] Carbon Valuation in UK Policy Appraisal: A Revised Approach, Climate Change Economics, Department of Energy and Climate Change, July 2009.
[9] Annex F Fossil fuel and retail price assumptions http://www.decc.gov.uk/en/content/cms/statistics/projections/projections.aspx accessed 24th August 2010

2.1.3. Link to the Evaluation Plan

The data can be updated with real data from the monitoring to evaluate the carbon benefits in actuality as described in the evaluation plan.

2.2. Net Present Value Calculation

The total carbon saved over 50 years and the net present value calculations for the carbon and other benefits are based on estimates of the costs of rolling out the solutions to appropriate points on the UK electricity network. The cost of roll out per solution are estimated to be less that the demonstration costs. The carbon benefits may decrease as the carbon intensity of public electricity supplies decreases over the next 40 years. The assumptions for each solution are given below.

2.2.1. NPV of Storage

There are two potential options for the energy storage being trialled at the secondary substations:

- 1 storage unit rated at 100kW and 150kWh with a 68% round trip efficiency.
- The same unit but only utilising one of the two 50kW modules and 50kWh of storage.

If the storage is charged over 4 hours during times of low carbon intensity and discharged during times of high carbon intensity this achieves a carbon benefit. The page ‘changes in carbon intensity’ has average values for each hour of the day. For 1 day the charging is assumed to be either:

- 12.5kWh for 4 hours during early morning and discharging in the afternoon (assuming 50kWh of storage).
- 37.5kWh for 4 hours during early morning and discharging in the afternoon.

The savings is reduced because of the batteries imperfect round trip efficiency. It is assumed that the difference in carbon intensity between different times of day will not change from year to year.

If, the batteries are used to minimise reactive power flow for 15 hours of the day and are assumed to be able to export or import 50kVAr or 100kVAr, the maximum change in current due to power factor correction is 0.06A or 0.12A respectively. If the resistance of the circuits is 1 Ohm and the rating of the transformer is 800kVA, 0.06kWh or 0.22kWh are saved in 15 hours.

It could be assumed that the storage will provide charge for EVs, based on a city EV driving 20km a day, this displaces the carbon emissions that would have been emitted using a petrol fuelled car but requires 5kWh of charging from network electricity. For 50kW, 50kWh, it is assumed that 10 extra EVs charging points are connected and for 100kW, 150kWh, it is assumed that 30 extra EVs points are connected due to the peak lopping capability provided by the storage.

Over the 40 year period considered it is assumed that the embodied carbon on average of the unit is 10780kg for 50kW, 50kWh and 43120kg for 100kWh, 150kWh. This assumes that

the energy costs of manufacturer will reduce considerable overtime as energy is decarbonised and bulk manufacturer is introduced. Therefore as an estimate, the embodied energy is derived from 0.77kg/£ of expenditure but with a cost of £14000 and £56 000 for 50kW and 100kW.

2.2.2. Other benefits

Due to deferral of generation, a further benefit would be gained from the avoided cost of building a new power station for peak demand as the distributed storage would be able to fulfil this purpose. Using the extrapolation of deployment of storage technology, below, and assuming each unit is capable of storing 100kW, by 2030 700MW (peak) of storage would be available across Great Britain. It is unlikely that this will provide a benefit simultaneously across the UK, therefore it is assumed that from 2030 and beyond, 500MW of peak generation will be offset. On the basis of a CCGT capital to be £718.3/kW[10], a capital saving of approximately £359m (2010 prices) in 2030 is recognised.

A further benefit may also be derived from the avoided cost of reinforcement. It has been assumed that energy storage at the LV level will reduce the requirement for reinforcement of the LV network. On the basis that the storage device would reduce peak demand on the LV network, the associate LV transformers will no longer require to be replaced. Assuming that this is the case at half of the sites where a storage device is installed, and a unit cost of £13.2k[11] as per the unit cost agreed under DPCR5.

2.2.3. Extrapolating across the country

It is estimated that there are approximately 140 000 secondary substations in Great Britain and 5% of them could have a storage unit by 2030, resulting in 7000 units. Assume will be rolled out in the following manner:

- 20 units by 2015,
- 100 units by 2020
- 1000 units by 2025
- 7000 units by 2030

Costs take into account reductions over time due to mass production, maintenance and replacement costs. Based on work by EPRI, it is assumed that the price will fall by 30% in the next 10 years and fall a further 10% between 2020 and 2030.[12]

[10] UK Electricity Generation Costs Update, June 2010.Mott Macdonald for DECC: http://www.decc.gov.uk/assets/decc/statistics/projections/71-uk-electricity-generation-costs-update-.pdf Pg 71, total capital costs for CCGT, Medium scenario, Nth of a kind.
[11] Electricity Distribution Price Control Review, Final Proposals - Allowed revenue - Cost assessment appendix 7 December 2009 page 21.
[12] EPRI Vanadium Redox Flow Batteries, An In Depth Analysis http://mydocs.epri.com/docs/public/000000000001014836.pdf

It is assumed that maintenance costs will be £1200 for units already installed beyond 2030 and this cost will be incurred per unit after 2030. It is assumed that after 2030, 2 units will be replaced a year.

2.2.4. Total Savings and Net Present Values

The net present value of the energy storage device, taking into consideration the unit cost, carbon benefit, and other benefits up to 2050 is £606m. This is based on the assumptions outlined above for a 100kW device.

2.3. Customer Engagement

ScottishPower will engage with the community through the community website, schools and other forum. The work will encourage understanding of the distribution network, energy efficiency and microgeneration.

It is assumed as a result of the work that ScottishPower will undertake:

- The customer load will reduce by 5%, half of which is attributable to ScottishPower's actions.
- 40kWp of additional PV will be installed. Each 1kWp of PV provides 780kWh per year on average (an estimate from real life experience).
- 1% of the new load that would previously been used at the 4 most carbon intensive hours of day will be used at the 4 least carbon intensive hours of day.
- Benefits beyond 2040 do not increase but are sustained

The embodied energy or other carbon emissions taken into account are as a result of:

- the manufacture of the PV panels
- the manufacturer of communication equipment estimated at 0.56kg/£ at a cost of £5000.
- 200km of travel in a petrol car necessary for the project.

2.3.1. Other Benefits

Consumer Benefits

Customers will benefit is savings in energy bills due to their 5% reduction in demand. It is assumed that customers will benefit from a saving of 3p/kWh from moving to times of low carbon intensity that are during times of Economy 7 type tariffs.

Customers will also benefit from the electricity generated by the PV and the feed in tariffs. It is assumed that half of what is generated will be used directly and half will be exported. The feed tariffs are used to 2020 and then assumed to be constant.

2.3.2. Extrapolating across the Country

If similar initiatives are taken across the country, this would require 6000 similar project, that is:

Customers in South Liverpool: 10 000

Customers in the UK: 60,000,000
Projects required:

$$\frac{60000000}{10000} = 6000$$

Assume

- 10 projects by 2015
- 1000 projects by 2020
- 6000 projects by 2030

It is assumed that there will be a 10% reduction cost by 2015 and a further 20% by 2030 due to reuse of materials and reduced overheads.
Once the projects are rolled out, it is assumed that cost of maintaining and continuing them will be £10 000 a year.
It is assumed that there will be similar levels of carbon savings, cost savings, avoided reinforcements and additional generation for each project.

2.4. Monitoring and Communications

ScottishPower plan to monitor the whole of the network to understand the power flows and capacity of the network. This should have the following benefits:

- Develop maps of spare capacity to maximise the utilisation of the network and advise those seeking connection.
- Understand the power flows on the network to update design policy.
- Understand the extent to which the network needs monitoring to achieve this level of information.

This should:

- Reduce travel for OPEX. It is estimated that it will remove the need for 4 site visits to each secondary substation per year, that are on average a 14 miles round trip.
- Allow SP to understand when a transformer in a group could be switched out saving 11kW per transformer in copper losses. It is assumed that this could take place 50% of the time.
- Allow an additional 40 kWp of PV to connect, each 1kWp generating 780kWh per year (estimated from real life experience) and 500kW of wind operating at typical 30% capacity factor.

The embodied energy of the PV and wind turbines is taken into account. The embodied energy of the communications equipment is estimated at 0.56kg/£ and each substation costs £14 000.

The benefits are divided by the number of substations in the trial to calculate the benefits per substation.

2.4.1. Extrapolating across the Country

It is assumed that the monitoring will be appropriate for 70 000 substations across the country and the roll out will be:

- 400 by 2015
- 1300 by 2020
- 8000 by 2030
- 70000 by 2040

Once the system is rolled out, it is assume that it will cost £500 per substation for the communication infrastructure and to maintain from 2040. It is assumed that the costs will drop by 90% by 2015 and by 70% by 2021.

2.5. Advanced Voltage Control Relay

ScottishPower will reduce the voltage setpoint of the primary substations by 2% during times of low load using advanced voltage control relays. It is estimated that this can be carried out 70% of the time. This should reduce the total consumption by 1.2%. The 5% reduction in demand is taken into account.

The embodied carbon of the relays is estimated assuming 0.77kg/£ and £4000 per relay. The benefits are divided by 3, the number of primary substations in the trial.

2.5.1. Extrapolating across the Country

It is estimated that there are around 12000 primary substations of which about 70% are in urban areas. It is assumed that there are around 8400 primary substations in urban environments where this voltage drop may be possible. It is assumed:

- 10 are installed by 2015
- 600 are installed by 2020
- 8400 are installed by 2036

It assumed that 3 relays are replaced each year from 2037 to 2050.

3. EVALUATION PLAN

The evaluation plan is split into the evaluation of the different solutions deployed. Each of the feeders will be monitored and as far as possible this information will be the sources for the evaluation. In some circumstances additional data will be required.

3.1. Customer Engagement

There are three measureable aims from this activity:

- Demand Reduction
- Demand Shifting
- Increases renewable generation installation

It will be difficult to distinguish between actions that would be taken anyway and those that occur as a result of SPs activities.

To this end it is proposed that:

- Changes in total demand and shifts in demand during the day are monitored at the three main primaries. Comparisons can be made year on year during the project and with historical data. The degree to which values must change to indicate a statistically significant change are discussed in section 1.1.2.
- If activities are held in schools, the consumption is recorded in 3 primary schools where no action is taken and compared to primaries where action is taken. Likewise, the consumption pattern at a secondary school where action is taken is compared to that where action is taken. The trend over time of schools where action is taken can also be studied. This will require half-hourly monitoring of the consumption at the schools if they do not have their own secondary substation.
- Each time a connection for renewable generation is requested, the customer could be requested to fill in a brief questionnaire asking what influenced their decision to install renewable generation.
- Customers installing generation could also be requested to provide the annual generation to understand the performance and income of the generation. This may be most easily have achieved when the owner is a social landlord or Liverpool Council.
- Assessment of any ripple affect to neighbouring areas from publicity and word of power could be made by studying the trends in load on the power through primary substations neighbouring the area.

3.2. Storage

There will be one site storage but two possible sizes deployed. For each one the aims are to:

- Shift load to reduce the carbon intensity
- Reduce network losses due to reactive power flow
- Facilitate new loads e.g. EVs

The results of the above for the two sizes will be compared to assess the advantages and disadvantages of the two sizes.

As the network is interconnected, savings due to the storage will be hard to quantify. The power flow from the substation where the storage is connected will be compared to a number of other substations (for example around four others) where there is no storage connected. For each of the substations the trends in load profile over each day, overall demand and reactive power flow will be monitored.

If it is demonstrated that the storage provides a peak lopping capability, the potential for connecting new loads such as EVs or heat pumps will be calculated.

3.2.1. Other Benefits

If the storage demonstrates peak lopping capacity, this can be translated into the potential for avoidance of network reinforcements.

3.3. Monitoring and Communication

Monitoring and communication will facilitate the evaluation process above. In addition it should:

- Reduce the cost of connection renewable generation e.g. reduce the need for back up LOM relays or allow more generation to connect to the existing network. This will be reflected in updated design policies.
- Reduce travel for OPEX.
- Allow SP to understand when a transformer in a group could be switched out.

The savings from reduced cost of connection or increased capacity will not be demonstrated from the trial itself but can be extrapolated from the finding and increased understanding. For example

- If the design policies are updated so that the allowable capacity to connect is increased, this can be extrapolated to provide a figure for how much additional generation could be connected across the country.
- If back-up loss of mains relays are not required, the reduction in costs of connection for the likely number of connections where this may apply can be used to estimate a cost reduction.

The reduced travel as a result of the monitoring should be demonstrated in the trial. The number trips to service a similar network in Liverpool will be compared to those in the LCNF area to demonstrate any reduction. One off trips to implement the trial itself that would not occur if LV monitoring became ‘business as usual’ should be excluded from this comparison. The reduction in travel can be translated into reduction in carbon emissions and cost savings.

If the monitoring demonstrates that it is possible to switch out a transformer, the savings in energy could be estimated but such savings would only be demonstrated in a later phase of the project.

To evaluate the benefits of the increased knowledge from monitoring, a comparison could be made of a selected sample of connections designs of distributed generation using the conventional approach and updated design guidance. Comparisons could be made of the difference in:

- Capacity available
- Cost of connections

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3.4. Facilitation of DG

Facilitation of DG should:

- Reduce the time to design connections
- Improve the efficiency and capacity of the network

The impact will be assessed by comparing the impact of the designs where solutions are deployed compared to estimates of 'business as usual' in the following categories:

- Potential savings in network losses.
- Potential increase network capacity.
- Potential increase in network control.
- Potential savings in time for connection design.

3.5. Impact of Using Advanced Voltage Control relays

The Advanced Voltage Control Relays will be used to reduce the voltage set point during times of low demand and/or high generation. This should reduce the demand and can be measured via changes in the power flow through the primary substations. No other measures should be added to the network or altered during the time when the impact of reducing the voltage setpoints is being assessed, as otherwise the impact of the reduction in voltage will not be distinguishable from the impact of other measures. To check that any drops in demand are due to the voltage reduction, month by month, day by day trends in power flow will be compared to historic data and neighbouring primary substations. It is important to check in a number of different ways as the percentage reduction is only expected to be a matter of 1-2 % which could be lost in the 'noise' of the system.

3.6. Data Required

To summarise, the additional data that will be required over and above that provided by the monitoring:

- Consumption at the schools in the area
- Generation data
- Surveys of people motivation for installing generation
- Surveys of how many people have shifted their load and switched to using an economy 7 tariff
- Reduce travel to the substations monitored by SP operations.
- Travel to similar unmonitored substations by SP operations.
- Load flow data from neighbouring primary substations.