Appendix 14.2 - Benefit Analysis of the TVV Project

1 NETWORK SAVINGS

1.1 Background

Assumptions about network savings are based on Imperial College/ENA Study on 'Benefits of Smart Metering for Demand Response Based Control of Distribution Networks', April 2010:

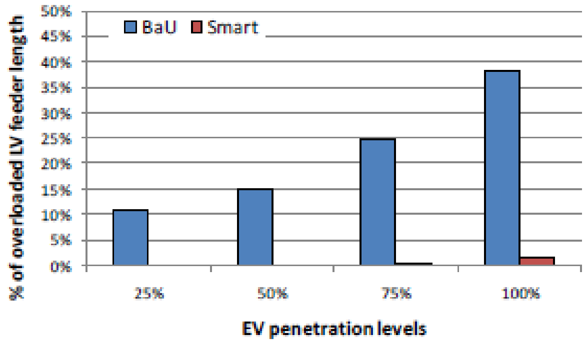
- Assumes steady ramp up to 5% electric vehicle (1.7million) and heat pump penetration by 2020 as per government projection[1] and then examines scenarios for 25%, 50%, 75% and 100% penetration in 2030; with a sensitivity study at 10%,
- Based on three types of LV network load density; urban, semi-urban, rural,
- Initial HV model based on Coventry network,
- Utilises Imperial College proven network model algorithms and scaled up to provide a GB-wide assessment.

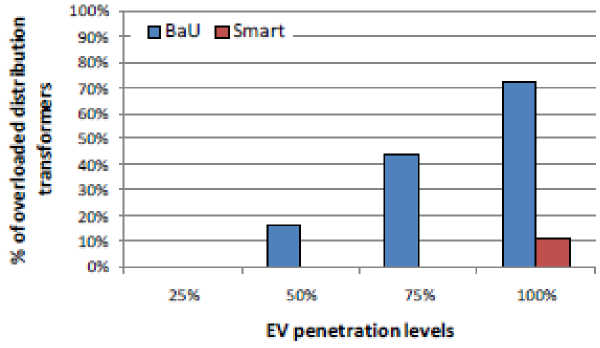
1.2 Electric Vehicle (EV) Only Penetration

The graphs below show likely impact of the Electric Vehicle penetration scenarios on GB-wide LV networks (based on semi-urban load density) in terms of overloaded feeders and transformers for EV only penetration. The blue data items represent the Business as Usual (planning networks to meet forecast reasonable demand) approach and red data items represent the Smart approach utilising Demand Response (DR) to manage and shift peaks.

*The graphs indicate that Smart approach avoids feeder overload until heavy EV penetration (75%) and transformer overload would not occur until 100% penetration – **The TVV approach and technology will enable this enhanced network utilisation.***

[1] Committee on Climate Change, "Meeting carbon budgets – the need for a step change," October 2009. Available online at: http://hmccc.s3.amazonaws.com/21667%20CCC%20Report%20AW%20WEB.pdf

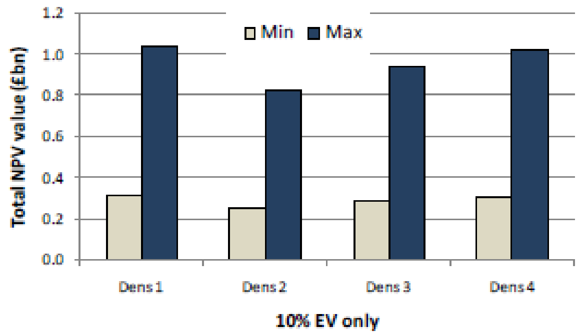


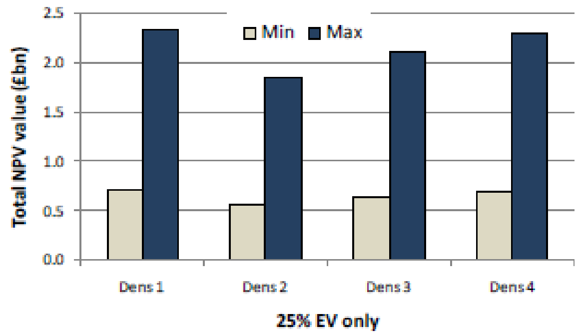


EV only scenarios of 10% and 25% penetration by 2030 were considered to give an indication of the value of (smart meter enabled) DR into real time network operation. The network models considered a mix of four EV densities across a network to attain average network penetrations of 10% and 25% respectively.

From the figures above it is noted that the reinforcement cost anticipated in a Smart operating regime for penetrations up to 25% EV is negligible. Not surprisingly, approximately 11% of LV feeder lengths would require reinforcement in a Business as Usual environment.

The GB-wide net present value (NPV) of active DR control has been estimated to be in the range £0.25bn to £1bn for 10% penetration and ranges from £0.6bn to £2.3bn for 25% EV penetration by 2030, as shown in the graphs below.





This illustrates that even in scenarios of low EV penetration and a complete absence of heat pumps the value of active management of DR is considerable.

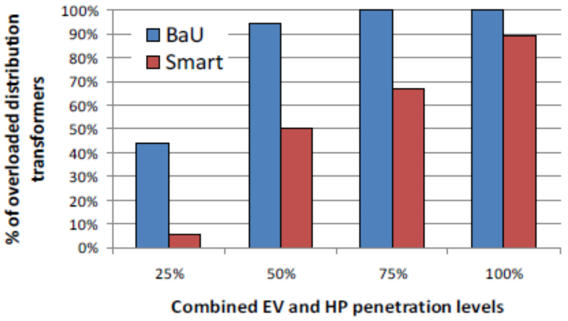
The Study commented that **optimal demand response is highly time and location specific** and if future demand is to be integrated efficiently into networks an appropriate infrastructure is required to facilitate real time and location specific DR.

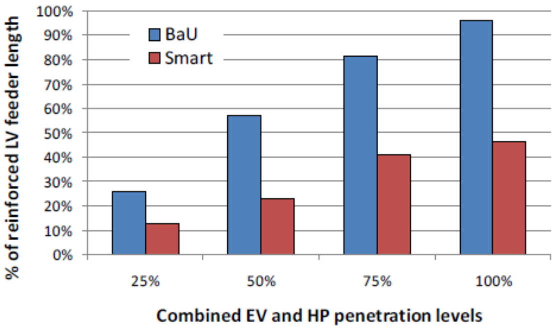
The Study also observed that "**Not recognising the specific conditions on individual LV feeder sections driven by actual locations of loads could compromise the potential for avoided network reinforcement costs.**"

The TVV project will test and inform this observation; and aims to provide the mechanism to inform and respond to such eventualities.

1.3 EV and Heat Pump Penetration

The graphs below indicate the effect on GB-wide networks of both EV and HP penetration (semi-urban results shown), indicating enhanced network utilisation and deferral of plant overload by deployment of Smart DR technologies.





1.4 Network costs and NPV (EV & HP penetration)

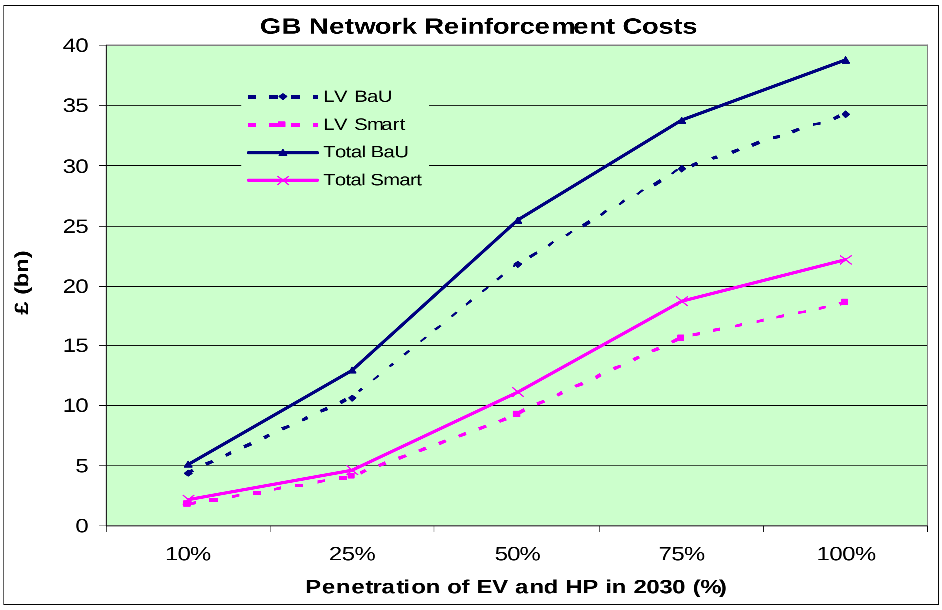
Estimated reinforcement costs from the Study are illustrated graphically below, indicating total network costs taken from Ofgem's DPCR5 Final Proposals[2] - HV in solid lines and LV only costs in dotted for a Business as Usual and Smart approach. The gap provides an indication of the reinforcement costs avoided with the Smart approach;

- at 25% penetration BaU costs are approximately 2.8 times higher than Smart,
- at 75% penetration BaU costs are approximately 1.8 times higher than Smart.

GB related network reinforcement savings from adopting Smart approach over BaU at;

- 25% penetration are approximately £8.3billion, and
- 75% penetration are approximately £15billion.

[2] OFGEM, "Electricity Distribution Price Control Review Final Proposals – Allowed Revenue – Cost assessment appendix," 7 December 2009. Available online at: http://www.ofgem.gov.uk/Networks/ElecDist/PriceCntrls/DPCR5/Documents1/FP_3_Cost%20Assesment%20Network%20Investment_appendix.pdf



The majority of reinforcement costs and subsequent savings associated with the Smart approach occur in the LV network, ***- which aligns with the focus of the TVV project.***

An NPV analysis, based on a smart meter implementation of DR, of avoided network reinforcement costs was positive across all scenarios studied. The analysis results ranged from a minimum of £0.48bn with 10% (combined EV and HP) penetration to a maximum of £10.04bn at 100% penetration.

The study has shown theoretical NPV values from optimisation of Smart DR solutions that contribute positively to establishing a business case for a smart distribution network. **The TVV project will test and monitor flexible technical and commercial DR solutions under several operating regimes that will inform how practical implementation of the theoretical business case can be optimised.**

2 EMISSIONS SAVINGS

2.1 GB basis

KEMA has utilised National Grid data in it's Plexos electricity market model to determine GB demand profiles on four days during the year to represent a typical demand scenario for each season. The model provides the type of generation operating to meet the demand and its output for each half hour period.

To calculate the generation emissions during the peak demand period, generally 15.00 to 20.00, KEMA has taken the Plexos model output and assigned the appropriate carbon equivalent (CO_2e) conversion factors from the Defra/DECC tables[3] to each generation type. It was then possible to determine the emissions differential between the peak and off-peak generation and then examine the effect on emissions production of moving the peak demand to a different time on the demand curve.

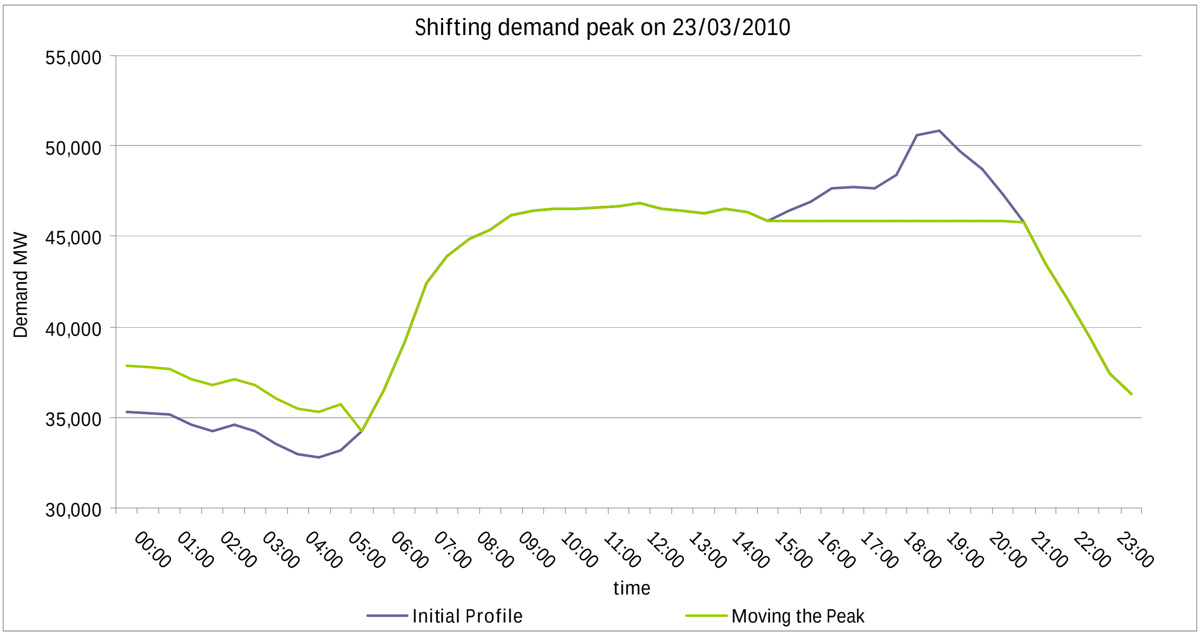
[3] 2009 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting, v2.0, updated 30/09/2009.

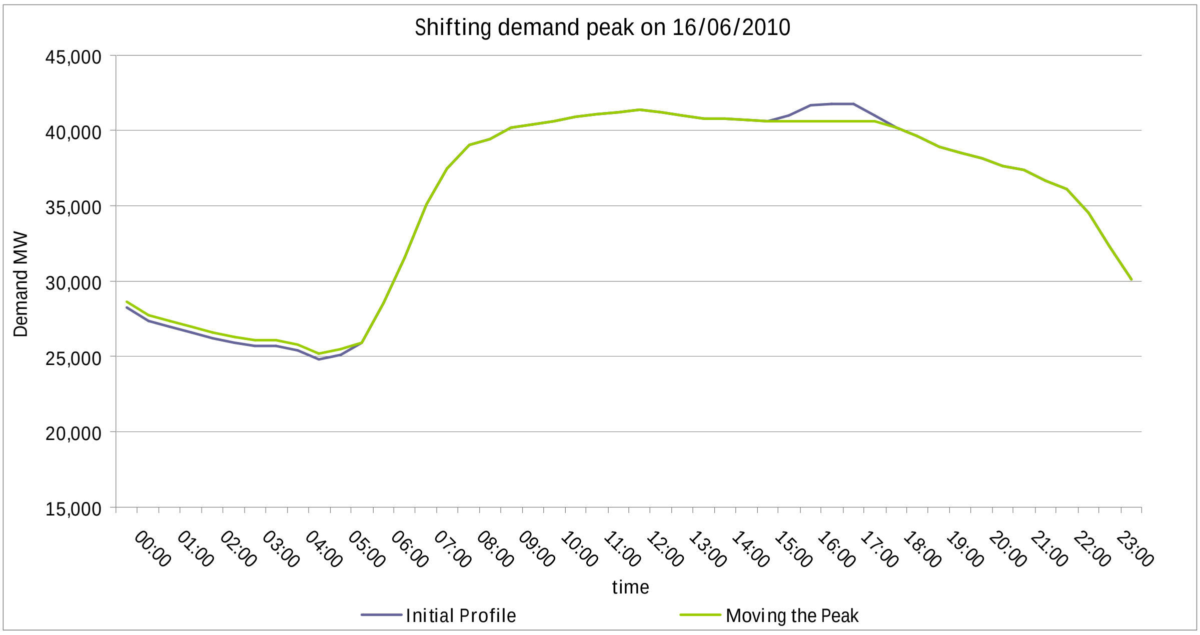
The blue line in the demand curves below indicate the actual profile and the green line the profile with the peak demand over the period 15.00 to 20.00 re-allocated to the off-peak 00.00 to 05.00 period. A considerable variation in the scale of the peak demand is observed throughout the year.

As anticipated, results indicate a decrease in emissions during the peak period and an increase in emissions when the demand is moved to the off-peak. The results are tabulated below and also indicate the net emissions reduction.

	Change in CO_2e Emissions		
	Peak	**Off-peak**	**Net**
March 2010	-8.0%	+6.9%	-2.2%
June 2010	-0.1%	+0.1%	0%
Sept 2010	-7.9%	+5.1%	-3.3%
Dec 2010	-24%	+10.0%	-11.9%

To obtain an accurate annual figure of potential emissions savings would require each day to be modelled and adjusted as outlined above. As time does not permit this degree of modelling perhaps a simple average of the above provides an approximate indication of potential emission savings from DR management; indicating 4.4% CO_2e savings per annum.




Shifting demand peak on 16/06/2010
45,000
40,000
35,000
30,000
25,000
20,000
15,000
Demand MW
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
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16:00
17:00
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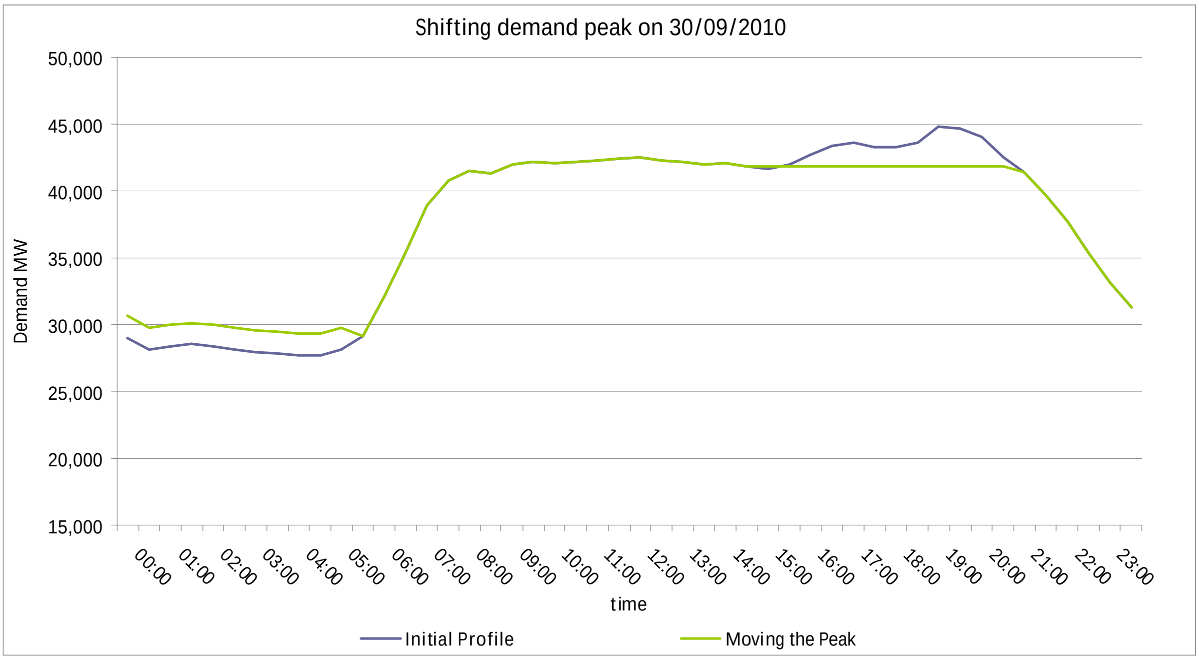
19:00
20:00
21:00
22:00
23:00
time
Initial Profile
Moving the Peak


Shifting demand peak on 30/09/2010
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
Demand MW
00:00
01:00
02:00
03:00
04:00
05:00
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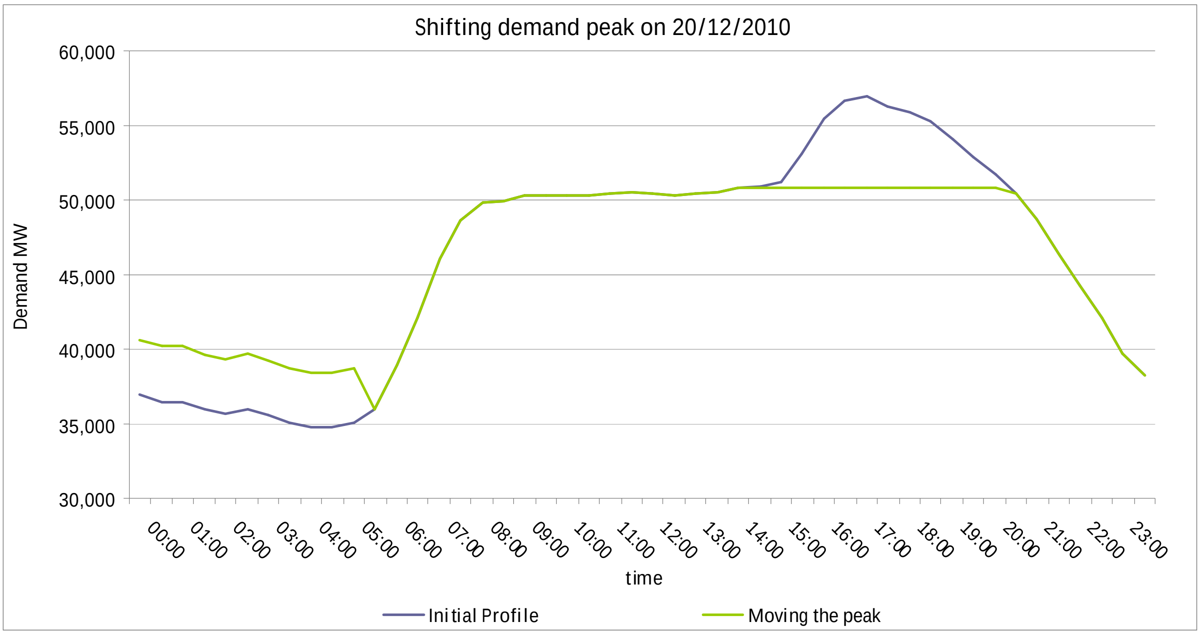


2.2 TVV Basis

If the 4.4% annual CO_2e savings from the deployment of smart DR is applied to the TVV project this would indicate a potential saving of 6794 tonnes CO_2e per annum[4], in the Bracknell area.

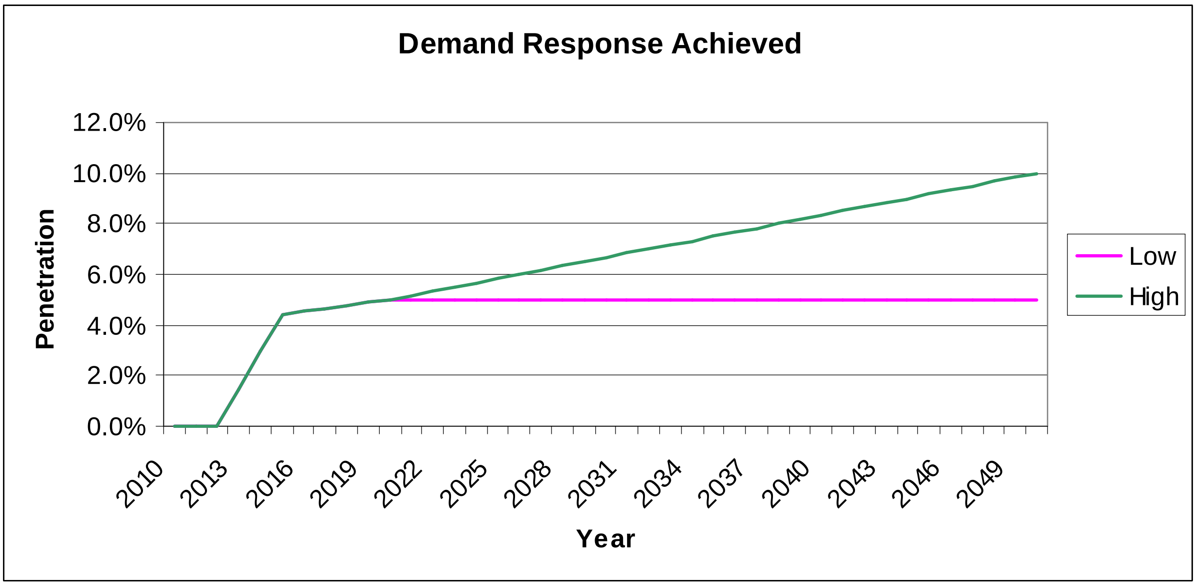
2.3 Carbon savings TVV up to 2050

For the carbon savings by DR for the TVV region up to 2050, two scenarios have been used, with the end targets in line with the Demand Response consultation of Ofgem.

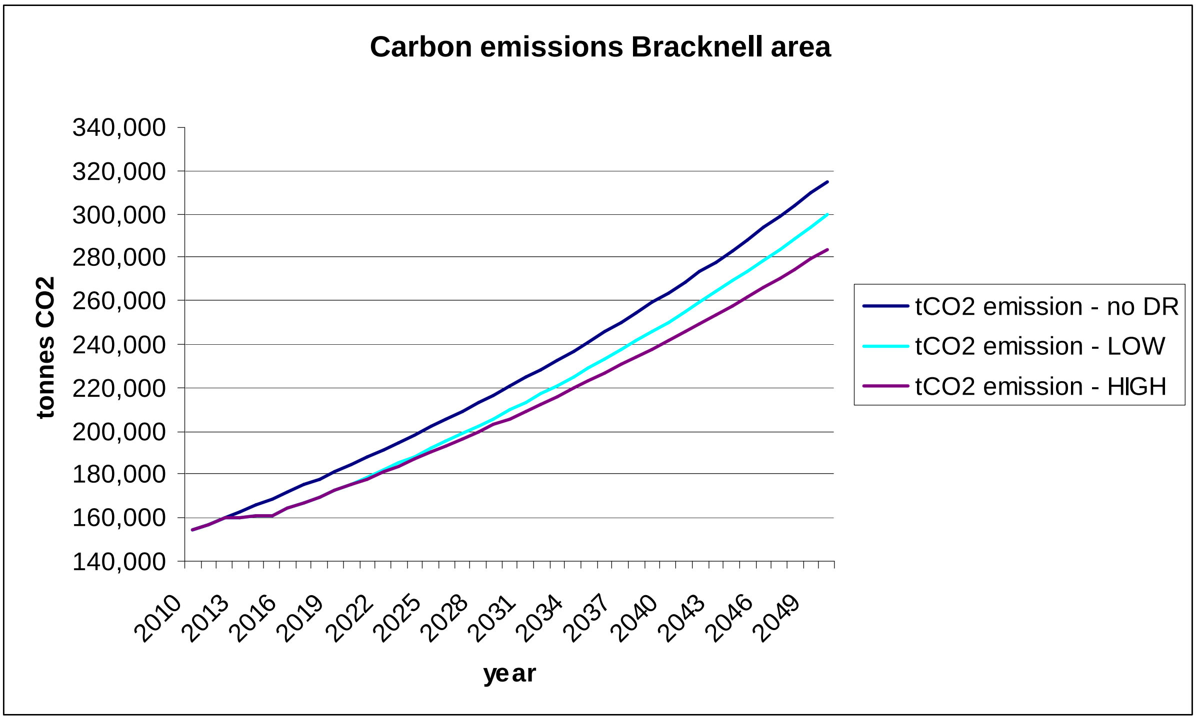
- **LOW**: no DR for the first two years of the LCNF, 4.4% at the end of the LCNF in 2015 with incrementally increasing DR up to 5% in 2050.
- **HIGH**: no DR for the first two years of the LCNF, 4.4% at the end of the LCNF in 2015 with incrementally increasing DR up to 10% in 2050.

The figure below presents both DR scenarios.

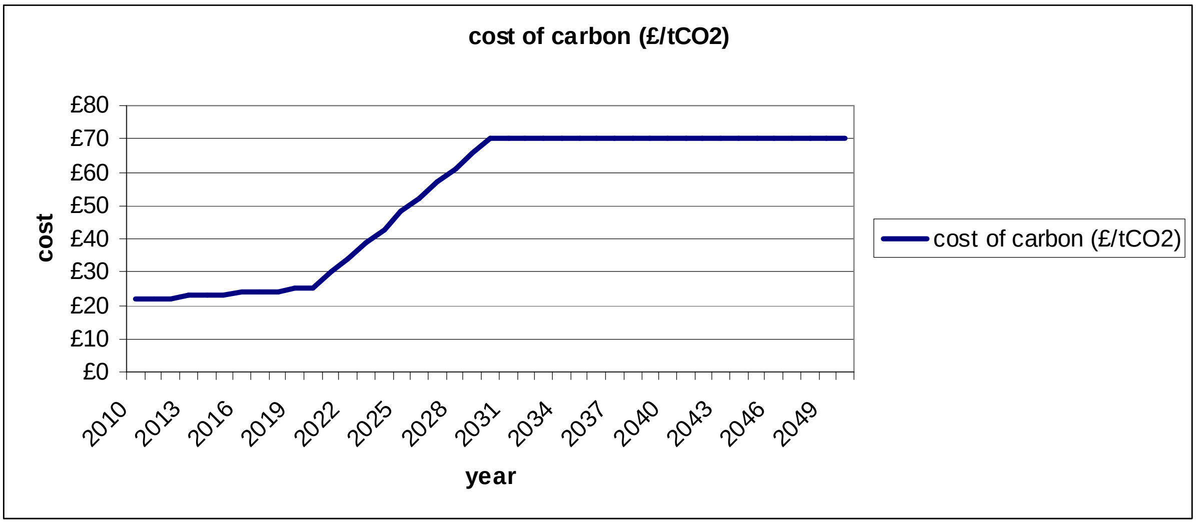
[4] Estimated using: 54MW peak demand at Bracknell grid group, 60% load factor, applying the DEFRA CO2 conversion factor of 0.544 tonnes CO2 per MWh.



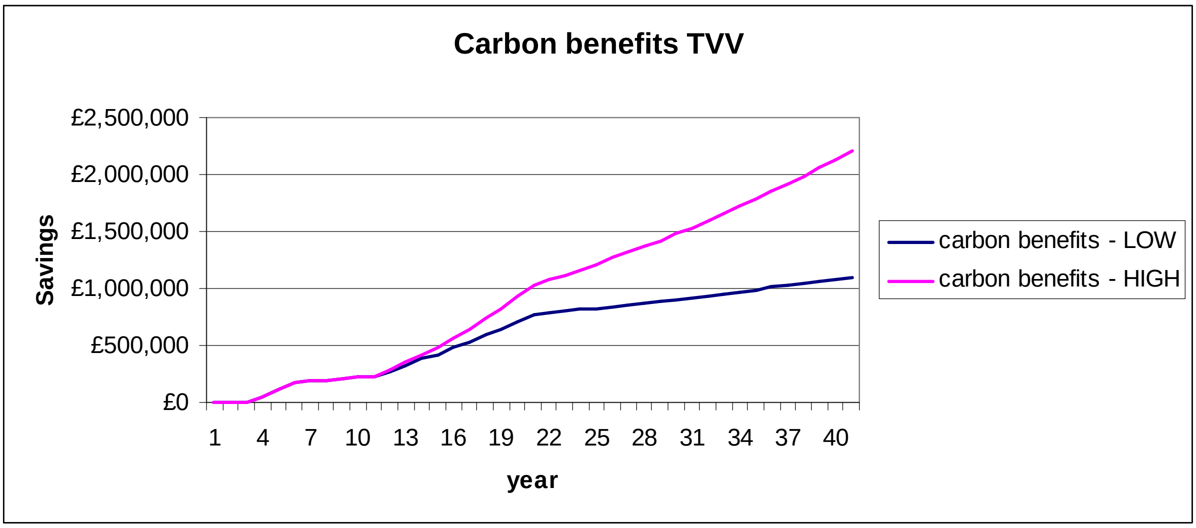
For the calculation of the carbon emissions up to 2050, we have assumed a peak load of 54 MW in 2010 with an **annual load growth of 1.8%** per annum and a **load factor of 60%**. This results in the following carbon emissions over time for NO DR, LOW and HIGH DR scenarios.



For the **carbon price**, we have assumed a starting price of £22 per tonne carbon for 2010, increasing up to £24 in 2020 with a further incremental increase up to £70 in 2030. We have assumed no further price increases after this year as a conservative estimate (see figure below).

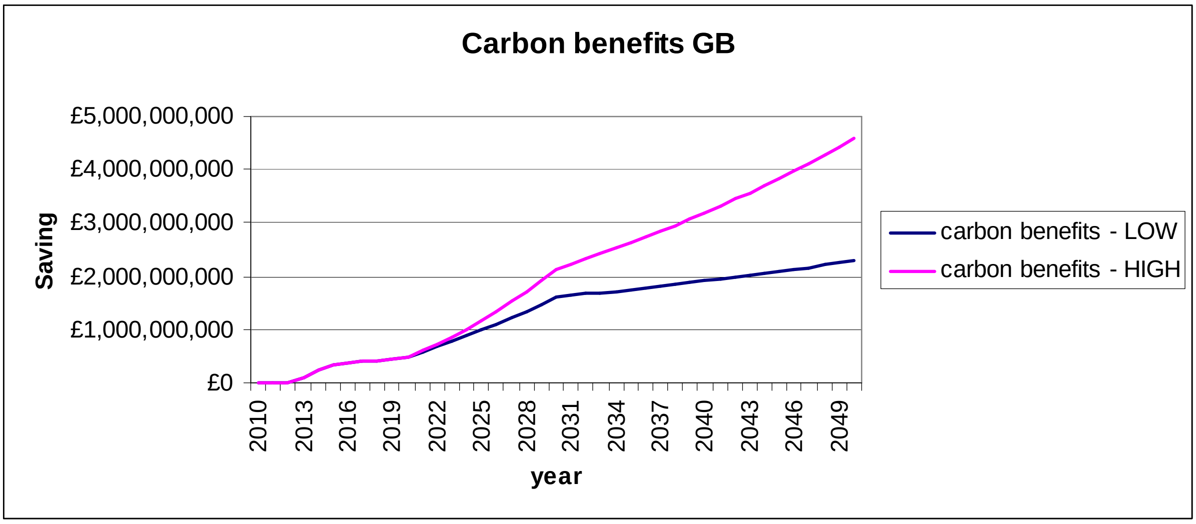


This will results in monetary carbon savings ranking from £1.1m for 5% penetration up to £2.2m for 10% in 2050 from the Bracknell primary substation. Please see figure below.



2.4 Carbon savings for GB up to 2050

The results for TVV project are also projected to the GB following a large scale roll-out. For this projects a scaling ratio of 2076 (25m GB customers vs 12.040 Bracknell customers) has been used. This results in the following national carbon savings.



3 ADDITIONAL BENEFITS

The TVV project will provide additional benefits, not yet quantified at moment:

3.1 Carbon benefits by enabling low carbon technologies: EVs

The TVV project will demonstrate solutions to enable future low carbon technologies, such as electric vehicles and heat pumps. Currently, combustion vehicles produce on average 164 gCO2/km (well-to-wheel) with expectations that this will go down to 115 gCO2/km in 2030[5], whilst EVs currently produce on average 69 gCO2/km with the expectations that this will go down to 47 gCO2/km in 2030.

With an annual national mileage 467 billion km and 30 million cars in 2010 with an increase of 2.5 million per 10 years, the carbon benefit of increased EV penetration will be substantial.

3.2 Carbon benefits by enabling low carbon technologies: GSHPs

Another low carbon technology that will be enabled by solutions demonstrated in this project are Ground Source Heat Pumps. Replacing gas or oil fired boilers for space heating by ground source heat pumps can provide a significant carbon saving due to the power ratio of GSHPs. This ratio, which on average is 4:1, means that for an average household, requiring 20 kW of heating power (previously provided by gas or oil), only 5 kW electric power will be needed by using GSHP technology. The

[5] BERR & DfT Investigation into the Scope for the Transport Sector to Switch to Electric Vehicles and Plug-in Hybrid Vehciles, Oct 2008

carbon benefit of this technology can be further increased by combining heat pumps with heat storage. This combination will allow for demand response with the aim avoid drawing power from the grid during peak hours, when the most pollution plants are running.

3.3 Carbon benefits by actively promoting low carbon technologies

As part of the Learning and Dissemination of the TVV project, SSE will run a promotional campaign for the installation of PVs, GSHPs and CERT funded insulation installations in target customer properties – both private and Council (with particular emphasis on the fuel poor). This will include the establishment of a Council supported Energy Advisory Centre.