Pathways to 40% Carbon Reductions by 2020:

The impact of Feed-in Tariffs and the Renewable Heat Incentive on the economic performance of eligible technologies

REPORT
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Abbreviations/Terms of Reference

AD	Anaerobic digestion
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DECC	Department of Energy & Climate Change
GSHP	Ground Source Heat Pumps
NPV	Net Present Value
PV	Photovoltaic

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1 Introduction

1.1 Background

In 2009, Carbon Descent was commissioned by Friends of the Earth to deliver evidence-based scenarios for the reduction of carbon dioxide emissions by 40% (relative to 2006 emissions) by 2020 across a representative range of local authorities in England.

Carbon Descent's in-house software tool, VantagePoint, was used to model carbon-reduction scenarios for the county of Hampshire (excluding Southampton and Portsmouth), the London Borough of Tower Hamlets, and the unitary authority of Middlesbrough. Carbon-reduction measures relating to the three sectors of housing, decentralised energy supply and transport were modelled as separate scenarios. Selected measures from these individual scenarios were then taken to form a combined scenario for each authority covering the energy system at the local level.

The resulting report, *Pathways to 40% Carbon Reductions by 2020*[i], demonstrated that each of the three local authorities can meet the 40% reduction target by 2020 through action and investment across the three identified policy areas. The different characteristics of each authority meant that different measures are appropriate in each case, and the economic performance of the three scenarios varied correspondingly. Domestic microgeneration technologies were generally found to perform negatively in economic terms out to 2030, as measured by net present values (NPVs). The relatively large application of domestic microgeneration for Hampshire was a major cause of Hampshire's negative overall NPV in 2030, which contrasted with positive NPVs for Tower Hamlets and Middlesbrough (whose scenarios used less or no domestic microgeneration, respectively). The report indicated, however, that the advent of Feed-in Tariffs (FITs) in 2010 and the Renewable Heat Incentive (RHI) in 2011 could significantly change the economic performance of domestic microgenerators and other eligible technologies.

1.2 Objectives of this work

This study updates the previous report by assessing the impact of FITs and the RHI on the NPV of any eligible technology considered in the original modelling work**Error! Bookmark not defined.**[ii]. Across all three combined scenarios these technologies are domestic solar photovoltaic (PV) systems, domestic solar thermal (water heating) systems, domestic ground-source heat pumps (GSHPs), and biomass CHP. The methodology and assumptions applied for each technology are described in the following sections, before updated NPV results for each scenario and associated conclusions are presented.

2 Methodology and Assumptions

2.1 Net present value

As in the previous report, net present value (NPV) has been calculated in this study to demonstrate the financial viability of each installed technology over time. NPV takes into account the time value of money. It is calculated as follows:

$$\sum_{t=1}^{T} \frac{C(t)}{(1+d)^t}$$

Where *t* is the time in years, *C(t)* is the cash flow in year *t, T* is the year for which the NPV is being calculated and *d* is the discount rate. For the purpose of this work (and consistency with the original study) the discount rate has been assumed to be 3%. If a technology has a positive NPV, it contributes value and could be considered economically viable.

2.2 General assumptions

- All domestic microgeneration installations are assumed to be retrofits (rather than being installed on new-build dwellings), in accordance with the original study.
- The first year of the project is 2008, during which time initial installations are made. Installations made in any year begin to bring in revenue in the following year, and hence the earliest possible year for generator operation is 2009. Installations in any of the three installation periods considered in the original report (2009–2013, 2013–2016, and 2016–2020), are spread evenly within those periods. No further installations are made in the final period to 2030, although reinvestment costs are required for existing installations in some cases, as specified in the following sections.
- FIT payments begin in 2010, while RHI payments begin in 2011. The payments received by any generators installed earlier than these points are described specifically for each technology, in the following sections.

2.3 Technology-specific assumptions

2.3.1 Solar photovoltaic systems

- PV systems have a rated capacity of 2.5 kW_e.
- All PV systems receive Feed-in Tariff as outlined by DECC[iii]. Thus all electricity generated receives the 'generation tariff', which starts at 41.3 p/kWh for generators beginning operation in 2010, and 'degresses' for technologies installed in later years. It is assumed that 50% of PV-generated electricity is used by the household, saving 13 p/kWh, while 50% is exported and receives the 'export tariff' of 3 p/kWh. This export proportion follows a range of recent publications including DECC's *Feed-in Tariffs* document[iii,iv,v].
- PV systems generating from the start of 2009 are assumed to join the FIT scheme in 2010 and subsequently receive the FIT transfer tariff of 9 p/kWh instead of the generation tariffs outlined above. This transfer tariff was designed to provide similar revenue to previously existing support such as ROCs, and hence the small number of 2009 generators are assumed to receive 9 p/kWh in 2009 from those previous revenue options.
- The feed-in tariff lifetime for solar PV is 25 years, and hence all generators continue to receive their tariffs out to 2030.
- The assumed capital cost of PV systems for 2009, 2015 and 2020 were taken from the quantitative analysis provided to DECC by Element Energy and Pöyry[vi], which underlies the current design of Feed-

in Tariffs. Capital costs for interim years were linearly interpolated between the costs for 2009, 2015, and 2020.

- The assumed maintenance costs and electricity yield for each 2.5 kW system are £110/year and 850 kWh/kW_p respectively. The assumed lifetime of each PV system is 25 years, an extension from the 20 years assumed in the original *Pathways* work, and hence no system requires reinvestment out to 2030. These values are also based on the Element Energy/Pöyry report[vi].

2.3.2 Solar thermal (hot water) systems

- All solar thermal systems are assumed to have specifications based on NERA's recent report for DECC, *Design of the Renewable Heat Incentive*[vii]. In particular, this involves a starting capital cost of £4160, a 'size' of 2.6 kW, and an output of 1.8 MWh/yr. Percentage reductions in capital cost over the years to 2020 were based on estimates for 2010, 2015, and 2020 made by NERA and AEA[viii], work that preceded the previously-mentioned NERA report.
- All solar thermal systems receive RHI payments for 20 years. RHI payments begin in 2011, and any generators installed before 2011 are assumed to be eligible for the RHI from 2011 onwards. The proposed tariff of 18 p/kWh for 2011 was taken from the recent consultation document published by DECC[ix]. It was assumed here that the tariffs will be degressed for future installations, similar to FITs for solar PV. The percentage reductions for capital costs were used here as a proxy for this rate of degression, resulting in a degression to 15 p/kWh for systems installed in 2020.
- In addition to the RHI payment, heat provided by the solar thermal systems is assumed to save money for the household by reducing the use of an assumed gas boiler. The financial saving of this displacement is based on a boiler efficiency of 76% (the average efficiency of central heating systems reported by Utley and Shorrock[x]) and a price of gas of 4 p/kWh (approximated from DECC[xi]).
- Running costs were assumed equal to the original study, at approximately £79 per year per system.
- System lifetimes are assumed to be 25 years, again an extension from the original Pathways report, and hence no reinvestment costs are required out to 2030.

2.3.3 Ground-source heat pumps

- In contrast to the previously specified solar thermal systems, the characteristics (such as capital costs, system size and so on) of GSHPs outlined in NERA's *Design of the Renewable Heat Incentive*[vii] have a wide range. As a result, specifications and costs used in the original *Pathways* report[i] were used in this study, which are generally within the NERA range. Percentage capital cost reductions were estimated by NERA and AEA[viii] and these were applied to reduce capital costs over time, in a similar manner to solar thermal.
- DECC's Consultation on the Renewable Heat Incentive[ix] proposes that for small and medium scale heat generators, the amount of heat generated should be estimated or 'deemed' rather than metered. This is to encourage low energy consumption and discourage wasting heat. On the basis of the original *Pathways* report[i] it has been assumed here that GSHPs are installed on detached houses. The base case (3-bedroom) detached dwelling of cavity-wall construction outlined by DECC[ix] (Annex 2) has been assumed here, giving a deemed heat load of 15,744 kWh/yr. This is thus the assumed generation eligible for a RHI payment for each GSHP.
- DECC's proposed starting RHI payment for GSHPs (of less than 45 kW) is 7 p/kWh[ix], and that was assumed here. Similar to solar thermal, it was further assumed that the tariffs will be degressed for future installations. The percentage reductions for capital costs were again used as a proxy for this rate of degression, resulting in a tariff degression to 6 p/kWh for systems installed in 2020.
- The heat provided by a GSHP is assumed to displace a gas-boiler based alternative similar to that described above for solar thermal systems.

- Reinvestment costs were not included as the majority of installations would not require re-investment within the analysis period (beyond the operation and maintenance costs).

2.3.4 Biomass CHP

- For the purposes of this study, the original category of 'biomass CHP' has been split in two, to consider both anaerobic-digestion (AD) based systems and solid-biomass systems. AD systems are eligible for feed-in tariffs but other forms of biomass CHP are not, while the RHI Consultation proposes that both be eligible for (differing) RHI payments.
- The installed capacities of biomass CHP modelled in the original work[i] were based upon resource estimates made using the 2007 Biomass Strategy[xii]. This Strategy was used to split biomass CHP capacities into AD and solid biomass proportions. 13% of the original installed capacities were assumed here to be AD-based CHP, since this is the proportion of wet biomass resource estimated in the Biomass Strategy. The remaining 87% of installed capacity is assumed here to be solid-biomass based CHP, the proportion of solid biomass resource estimated in the Biomass Strategy.
- Unlike solar thermal and GSHP systems, assumed costs and system specifications were not available from the documents[vii,viii] underpinning the RHI Consultation[ix]. As a result the original capital, running and reinvestment costs per unit of installed capacity, as well as quantities of electricity and heat generation, were assumed to apply for this study. The exception to this was the fuel cost for AD-based CHP, which was assumed here to be zero. This is arguably conservative because fuel costs for such systems can in fact be a source of revenue rather than a cost, and will vary depending on the exact fuel source, the level of landfill tax (where applicable), and other factors.
- AD CHP is assumed to receive FITs for 20 years, in accordance with DECC[iii]. Also following DECC[iii], the generation tariff is assumed to be 11.5 p/kWh and is not degressed for future installations. It is assumed that all electricity is exported by the generator, thus receiving an additional 3 p/kWh. It has been assumed that the estimated heat generation would be the amount deemed to receive an RHI payment. This payment is 5.5 p/kWh and is assumed to last for 10 years – the proposed tariff details[ix] for 'biogas onsite combustion' for units size 45–200 kW. It has been assumed, in line with DECC's current position for FITs, that the RHI tariffs will not be degressed during the period considered within this study.
- Solid-biomass CHP systems are not eligible for FITs. As a result, electricity has been treated in the same way as the original report, receiving revenues through the sale of the electricity and via ROCs, LECS and the Emissions Trading Scheme. Similar to AD CHP, it is assumed that the estimated heat generation would be the amount deemed to receive RHI payments. This RHI payment has been taken as 6.5 p/kWh and to last for 15 years, the proposed tariff details[ix] for 45–500 kW solid biomass systems.
- In accordance with the original study[i], it is assumed that CHP systems require reinvestment after 20 years (at 50% of the initial capital cost).

3 Results

Tables 1 to 3, below, present updated NPVs for Hampshire, Tower Hamlets and Middlesbrough respectively. The updated NPVs are highlighted in **bold text** and reflect the estimated impact of FITs and the RHI on eligible technologies. This impact is significant, dramatically improving the NPVs of eligible technologies by 2030. The capital costs associated with the growth in the number of installations cause generally negative NPVs during the earlier periods (up to 2013, 2016, and 2020 respectively), but the estimated revenues introduced by FITs and the RHI work to improve the picture as time goes by, resulting in positive and often significant NPVs by 2030. The lack of reinvestment costs for the domestic microgenerators, an updated assumption from the previous work that has been specified in the previous section, aids the improvement process between 2020 and 2030.

Biomass CHP was originally found to provide a negative NPV for Hampshire and modest, positive NPVs for Tower Hamlets and Middlesbrough (where installed capacities are smaller). These values have all improved, most significantly for Hampshire which now has a positive NPV for biomass CHP of £90m in 2030.

The most dramatic changes from the original estimates can be seen for the domestic micro-generation technologies of solar PV, solar thermal and ground-source heat pumps. These changes are particularly striking in the case of Hampshire, the scenario that involves by far the greatest use of these technologies. With the exception of solar thermal, all technologies exhibit positive NPVs by 2030, particularly solar PV, which (for Hampshire) has a positive NPV of £302m in 2030.

For solar thermal systems, DECC have set the RHI tariffs to provide an internal rate of return (IRR) of 6% (as opposed to 12% for other technologies). This is the approximate IRR that individual solar thermal installations are estimated in this study to receive, and systems installed to provide hot water from 2011, for example, have positive NPVs from 2025 as a result. The NPV for the overall solar thermal category is negative (for both Hampshire and Tower Hamlets) in 2030, however, because of the continued capital costs of the projects out to 2020. Many of the later installations will not have received their full RHI payments (which have been proposed by DECC to last for 20 years) by 2030.

Overall, the estimated effect of FITs and RHI is to bring the Hampshire scenario from an originally negative NPV of -£1.1bn into a positive NPV of some £280m by 2030 – a huge change. In the cases of Tower Hamlets and Middlesbrough, overall NPVs have improved from their already positive positions within the original study[i], to values of approximately £780m and £35m respectively.

Technology	Units	2013	2016	2020	2030
CHP Biomass	**£k**	**-7,131**	**-480**	**24,912**	**93,309**
Heat from Large Gas CHP	£k	-5,146	-15,435	-105,038	-127,045
Heat from Gas CHP in Buildings	£k	-1,759	-623	7,816	59,059
PV Domestic	**£k**	**-135,408**	**-129,018**	**-46,177**	**302,430**
Solar Thermal Domestic	**£k**	**-92,776**	**-121,714**	**-124,308**	**-26,304**
Ground Source Heat Pump Domestic	**£k**	**-121,086**	**-152,666**	**-134,323**	**69,522**
Cavity Wall Insulation Domestic	£k	-3,206	-8,438	17,553	119,967
Loft Insulation Domestic	£k	-1,563	-5,288	-2,377	15,674
Double Glazing Domestic	£k	-231,072	-259,077	-255,623	-195,582
Solid Wall Insulation Domestic	£k	-29,355	-113,829	-180,179	-132,836
Demand reduction through eco-driving techniques - transport fuel	£k	7	33	145	496
Road transport efficiency improvements	£k	18	110	482	1,582
Replace road transport fuels with electricity	£k	17,770	45,383	84,521	103,160
Modal shift car to public transport	£k	2	14	64	216
Overall NPV	**£k**	**-610,705**	**-761,028**	**-712,532**	**283,647**

Table 1: Updated NPVs for Hampshire's combined scenario

Technology	Units	2013	2016	2020	2030
CHP Biomass	**£k**	**-2,803**	**-3,583**	**4,771**	**20,632**
Heat from CHP	£k	-1,557	3,587	-30,911	10,559
PV Domestic	**£k**	**-13,766**	**-11,025**	**1,969**	**28,464**
Solar Thermal Domestic	**£k**	**-223**	**-337**	**-398**	**-72**
Ground Source Heat Pump Domestic	**£k**	**-104**	**-138**	**-115**	**65**
Cavity Wall Insulation Domestic	£k	-350	-873	-734	1,401
Loft Insulation Domestic	£k	-13,866	-47,370	-77,863	-75,726
Double Glazing Domestic	£k	-53,139	-72,284	-64,990	-50,119
Solid Wall Insulation Domestic	£k	-1,830	-6,311	-13,079	-23,388
Energy Efficient Lighting Commercial	£k	5,347	51,903	256,956	857,136
Demand reduction through behavioural change - transport fuel	£k	3	8	18	37
Road transport efficiency improvements	£k	3	17	72	236
Replace road transport fuels with electricity	£k	1,195	3,051	5,681	6,934
Modal shift car to bus	£k	0	2	12	47
Overall NPV	**£k**	**-81,091**	**-83,353**	**81,390**	**776,205**

Table 2: Updated NPVs for Tower Hamlets' combined scenario

Technology	Units	2013	2016	2020	2030
CHP Biomass	**£k**	**0**	**-3,767**	**1,793**	**13,332**
CHP Buildings Gas	£k	-453	-1,232	388	8,695
Cavity Wall Insulation Domestic	£k	-557	-272	3,501	16,256
Loft Insulation Domestic	£k	-350	-47	744	7,714
Double Glazing Domestic	£k	-10,959	-17,527	-24,545	-18,865
Solid Wall Insulation Domestic	£k	0	298	-790	343
Fuel efficient driving	£k	1	3	6	13
Road transport efficiency improvements	£k	2	12	48	154
Replace road transport fuels with electricity	£k	1,360	3,474	6,213	7,517
Reduction in car km including walking & cycling	£k	0	0	0	0
Modal shift car to public transport	£k	0	1	6	19
Overall NPV	**£k**	**-10,955**	**-19,056**	**-12,637**	**35,177**

Table 3: Updated NPVs for Middlesbrough's combined scenario

4 Conclusions

Modelling work carried out by Carbon Descent in 2009[i] found that three representative local authorities, each with distinct characteristics, can meet a target of a 40% reduction in carbon emissions (relative to 2006 emissions) by 2020. These reductions can be achieved through comprehensive action and investment across three identified policy areas of housing, decentralised energy supply and transport. However, while the modelled scenarios demonstrated the technical feasibility of the carbon-reduction targets, the economic performance of the scenarios varied out to 2030. Tower Hamlets and Middlesbrough had positive NPVs by 2030, but Hampshire had a significant, negative NPV. It was noted in the report that Hampshire's negative NPV was due in large part to the relatively significant use of domestic microgenerators, whose economic performance could change with the advent of FITs and the RHI.

This study has updated the original modelling work by revising NPVs for technologies that are eligible for the recently introduced FITs, or that have been proposed to be eligible for the RHI that is due to begin in April 2011. These two policies are estimated to significantly improve the economic performance of the eligible technologies considered in this work. Solar thermal NPVs remained negative out to 2030 but have improved, while the NPVs of all other technologies (solar PV, ground-source heat pumps and biomass CHP) have become positive – sometimes significantly so – by 2030. It is worth noting that in many cases, technologies installed in the years approaching 2020 would still receive tariff payments beyond 2030, the final year considered in this work.

The improved economic performance (as measured by the NPV) of eligible technologies has improved the overall NPVs of all three scenarios. The scenarios for Tower Hamlets and Middlesbrough have improved NPVs of approximately £780m and £35m respectively by 2030, while the most significant positive change exhibited by the Hampshire scenario brings it from a previous NPV of -£1.1bn to a positive NPV of some £280m by 2030. These results suggest that technologies considered here that are eligible for FITs of the RHI can form a cost-effective part of the carbon-reduction strategies of local authorities.

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