The Economics of Low Carbon Cities

A Mini-Stern Review for the Sheffield City Region

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Our research themes are Smart Infrastructure, Energy Systems and the Circular Economy. Our activities are focused on the needs of business in both the demonstration of innovation and the associated skills development.

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The Economics of a Low Carbon Sheffield City Region

Today

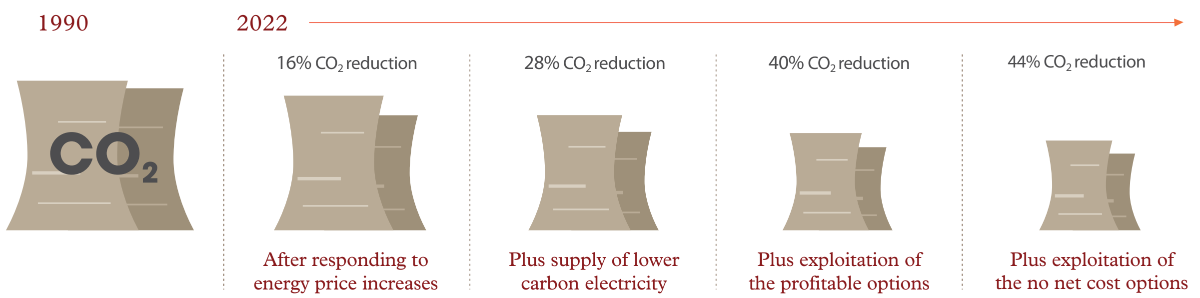
13% of city-scale GVA leaves the local economy every year through payment of the energy bill. This is forecast to grow significantly by 2022.

Tomorrow

1.4% of GVA could be profitably invested, every year for ten years, to exploit commercially attractive energy efficiency and low carbon opportunities.

- **Energy** – reductions in the energy bill equalling 2% of GVA
- **Financial viability** – five years for measures to pay for themselves
- **Employment** – more jobs and skills in low carbon goods and services
- **Wider economic benefits** – energy security, increased competitiveness, extra GVA
- **Wider social benefits** – reductions in fuel poverty, improvements in health

Potential to reduce CO_2 emissions



The Economics of Low Carbon Cities: A Mini Stern Review for the Sheffield City Region

Executive Summary

What is the most effective and efficient way to decarbonise a city? There are hundreds of low carbon options available and, although they present a significant opportunity to reduce energy bills and carbon footprints, there is often a lack of reliable information on their performance. The higher levels of risk and uncertainty that emerge as a result of this lack of reliable information can be a major barrier to action, making it hard to develop a political, a business or a social case for investment in low carbon options.

> The Sheffield City Region is an area with a population of nearly 1.8 million, an economy worth £26 billion a year and an energy bill of £3.4 billion a year.

In an attempt to address this problem, this report reviews the cost and carbon effectiveness of a wide range of the low carbon options that could be applied at the local level in households, industry, commerce and transport. It then explores the scope for their deployment, the associated investment needs, financial returns and carbon savings, and the implications for the economy and employment.

It does this for the Sheffield City Region (SCR), an area with a population of 1.8 million, an economy worth £26 billion a year and an energy bill of £3.4 billion a year. Whilst highlighting the very significant and commercially viable opportunities for the decarbonisation of the Sheffield City Region – and the potential economic benefits associated with these – the report also recognises the scale of the challenge, the need for investment and the requirement for investment vehicles and delivery mechanisms that can exploit the potential for significant change.

Our Approach

Our approach has been to develop a robust model for assessing the costs and benefits of different levels of decarbonisation at the city region scale. We use UK Committee on Climate Change Data on the potential energy, cost and carbon savings from thousands of low carbon measures. We take into account changes in the economy and the wider energy infrastructure, but we focus primarily on the potential for the wider deployment of energy efficiency measures and small-scale renewables. We also assess the potential for their deployment and the rates at which they could be deployed at the local level.

We use realistic projections of the energy, cost and carbon savings emerging from different measures. Typical interest rates (8%) and energy prices are used and ambitious but realistic scenarios for the rate at which different technological and behavioural options are adopted. Projected savings are reduced to take into account implementation gaps. The scope for the adoption of different measures is adjusted to take into account hard to reach households and businesses.

The Potential for Carbon Reduction – Investments and Returns

We find that – compared to 1990 levels – the Sheffield City Region could reduce its carbon emissions by 2022 by:

- 11.6% through cost effective investments that would pay for themselves (on commercial terms) over their lifetime. This would require an investment of £3.70 billion, generating annual savings of £723 million, paying back the investment in 5.12 years but generating annual savings for the lifetime of the measures.
- 15.7% through cost neutral investments that could be paid for at no net cost to the Sheffield City Region economy if the benefits from cost effective measures were captured and re-invested in further low carbon measures. This would require an investment of £6.67 billion, generating annual savings of £929 million, paying back the investment in 7.2 years but generating annual savings for the lifetime of the measures.
- 16.5% with the exploitation of all of the realistic potential of the different measures. This would require an investment of £7.8 billion, generating annual savings of £1.02 billion, paying back the investment in 7.7 years but generating annual savings for the lifetime of the measures.

Impacts on Future Energy Bills

These figures are particularly significant in the context of projected energy price increases. We calculate that the 2011 SCR energy bill is £3.41 billion per year, but we forecast that this will grow to £4.59 billion by 2022 – a £1.18 billion increase in the SCR annual energy bill.

- With investment in all of the cost effective measures, this £1.18 billion increase in the annual energy bill could be cut by £723 million (61% of the projected increase).
- With investment in all of the cost neutral measures, it could be cut by £929 million (79% of the projected increase).
- With investment to exploit all of the realistic potential, it could be cut by £1.02 billion (86% of the projected increase).

The Sheffield City Region could therefore insulate itself against projected energy price increases to a very large extent through investments in energy efficiency and low carbon options.

The 2011 Sheffield City Region energy bill is £3.41 billion per year, but we forecast that this will grow to £4.59 billion by 2022.

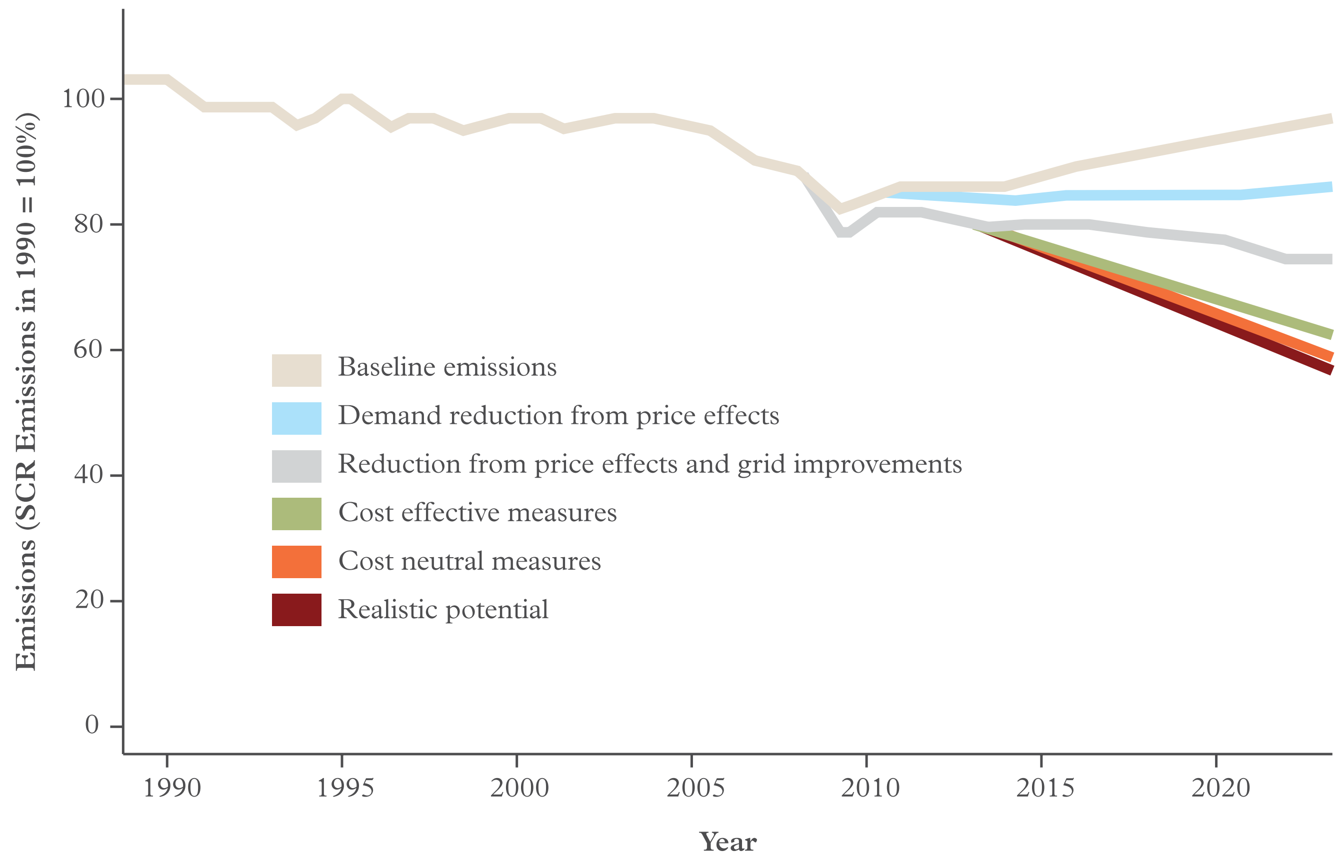
The Wider Context – Other Influences on SCR Carbon Emissions

To put these energy savings and carbon reduction figures into a wider context, we find that:

- With other things constant, background trends in economic growth combined with changes in the energy and carbon intensity of GDP will lead to a 6% decrease in SCR carbon emissions between 1990 and 2022.
- Higher energy price increases will impact on demand, and this will lead to a 10% drop in SCR carbon emissions compared to the 1990 baseline by 2022. The total effect of the background trends plus the response to higher energy price will be a 16% drop in SCR emissions between 1990 and 2022.
- The decarbonisation of the national electricity system will lead to a 12% drop in SCR carbon emissions by 2022. The total effect of background trends, the impacts of price increases and the decarbonisation of the national electricity supply system will be a 28% drop in SCR emissions between 1990 and 2022.
- The total effect of all of the above plus the exploitation of all of the cost effective low carbon options will be a 40% drop in SCR carbon emissions between 1990 and 2022.
- The total effect of all of the above plus the exploitation of the remaining cost neutral options will be a 44% drop in SCR emissions between 1990 and 2022.
- The total effect of all of the above plus the exploitation of all of the remaining realistic potential will be a 44% drop in SCR carbon emissions between 1990 and 2022.

The impacts of these price effects, grid decarbonisation and cost effective, cost neutral and realistic potential are shown in the Figure below.

Figure 1: Baselines and Analysis of Price Effects, Grid Decarbonisation and Cost Effective, Cost Neutral and Realistic Potential



Executive Summary

Wider Impacts on Employment and Economic Growth

We also calculate that the levels of investment required to realise these reductions in energy bills and carbon footprints could have wider economic benefits within the Sheffield City Region:

- Over the next ten years, the levels of investment needed to exploit all cost effective measures with employment generating capacity would lead (directly and indirectly) to the generation of 3,029 jobs and to growth in GVA of £147 million per year.
- Over the next ten years, the levels of investment needed to exploit the all of the cost neutral measures with employment generating capacity would lead (directly and indirectly) to a further 3,160 jobs and to GVA growth of £146 million per year.
- In total, therefore, we predict that the levels of investment needed to exploit all of the cost effective and cost neutral measures with employment generating capacity would lead to the generation of 6,189 jobs over the next ten years and to GVA growth of £293 million per year.

Low Carbon Investment: Supply and Demand

The analysis highlights that within the Sheffield City Region there is considerable potential to reduce energy use and carbon footprints through cost effective and cost neutral investments on commercial terms. However, the fact that these opportunities exist on this scale is obviously not enough to ensure that they are actually exploited. Incentives – no matter how strong they are – have to be matched with appropriate capacities if progress is to be made. These relate both to the capacity to supply appropriate levels of investment and to the capacity to stimulate and sustain demand for such investments.

To stimulate the supply of the very significant levels of investment that are needed, we need to think about innovative financing mechanisms, based on new forms of cost recovery and benefit sharing and new ways of managing risk. And we need to develop new delivery vehicles that can stimulate and sustain demand for investment in low carbon options by overcoming the many potential barriers to change.

Conclusions and Recommendations

From a climate and carbon perspective, the analysis in this report suggests that the Sheffield City Region has to exploit all of the cost effective measures and all of the cost neutral measures identified if it is to reduce its carbon emissions by 44% by 2022.

Decarbonising on this scale and at this rate should be possible. The technological and behavioural options are readily available, the energy and financial savings associated with these are clear (even based on conservative assessments), the investment criteria are commercially realistic, and the deployment rates have been judged by the independent Committee for Climate Change to be challenging but still realistic.

The economic returns on investment could be very significant indeed. Many of the measures would pay for themselves in a relatively short period of time, they would generate significant levels of employment and economic growth in the process, and if done well there may be a wider range of indirect benefits (not least from being a first mover in this field). The political and business case for very large investments in the low carbon economy is very strong indeed.

However, the transition depends on political and social capital as well as financial capital. The levels of ambition, investment and activity needed to exploit the available potential are very significant indeed. Enormous levels of investment are required, along with major new initiatives with widespread and sustained influence in the domestic, commercial and industrial sectors.

And, of course, we need to think about some major innovations, particularly in stimulating the supply of and the demand for major investment resources. We need to think about innovative financing mechanisms, based on new forms of cost recovery and benefit sharing and new ways of managing risk. And we need to develop new delivery mechanisms that can stimulate and sustain demand for investment in low carbon options by overcoming the many potential barriers to change.

Whilst this report provides some vital insights, we should recognise that economics is not the only discipline that has something useful to say on the transition to a low carbon economy/society. A wider analysis should also consider the social and political acceptability of the different options, as well as issues relating to the social equity and broader sustainability of the different pathways towards a low carbon economy and society. We also need to think about `future proofing' investments to consider their compatibility with the more demanding targets for carbon reduction and with the different levels of climate change that are likely to come after 2022.

Table 1: Cost, Benefits and Carbon by Local Authority (from exploiting the cost-effective options)

	Energy bill in 2011	Level of investment that could be secured	Potential cut in annual energy bill	Jobs created	Carbon saved by 2022 (1990 baseline)
Barnsley	£418 million	£410 million	£88 million	357	36%
Bassetlaw	£267 million	£260 million	£53 million	221	50%
Bolsover	£247 million	£160 million	£29 million	124	28%
Chesterfield	£159 million	£223 million	£43 million	187	36%
Derbyshire Dales	£195 million	£206 million	£38 million	109	39%
Doncaster	£647 million	£599 million	£120 million	509	36%
North East Derbyshire	£175 million	£178 million	£35 million	132	31%
Rotherham	£475 million	£530 million	£101 million	435	45%
Sheffield	£827 million	£1124 million	£219 million	955	43%
SCR	£3.4 billion	£3.7 billion	£723 million	3,029	40%

What is the most effective and efficient way to decarbonise the Sheffield City Region? There are hundreds of low carbon options available and, although they present a significant opportunity to reduce energy bills and carbon footprints, there is often a lack of reliable information on their performance. The higher levels of risk and uncertainty that emerge as a result can be a major barrier to action, making it hard to develop a political, a business or a social case for investment in low carbon options.

In an attempt to address this problem, this paper reviews the cost and carbon effectiveness of a wide range of the low carbon options that could be applied at the local level in households, industry, commerce and transport. It then explores the scope for their deployment in the Sheffield City Region (SCR). On this basis, we identify least cost pathways towards different levels of decarbonisation within the Sheffield City Region, and we examine the investment needs and payback periods associated with different levels of decarbonisation. We also consider the wider economic implications of such transitions – with a particular emphasis on the opportunities for job creation in the low carbon and environmental goods and services sector. It also explores the wider implications of these investments for employment and economic growth.

Whilst highlighting the very significant and commercially viable opportunities for the decarbonisation of the Sheffield City Region – and the potential economic benefits associated with these – we also recognise the scale of the challenge, the need for investment and the requirement for policy innovations and delivery mechanisms that can create the potential for significant change.

The low carbon and environmental goods and services sector is estimated to be worth £3.2 trillion a year, and to be growing steadily through the recession (BIS, 2010).

There are some pressing reasons why we need to better understand how to decarbonise a city or a city region. Cities could be particularly exposed to the impacts of climate change (UN HABITAT, 2009) and as a result we might hope that cities would play a leading role in helping to avoid climate change. There is certainly evidence that many cities are doing just this (Bulkely and Betsil, 2005) – and a number of local authorities within the Sheffield City Region have set ambitious targets for carbon reduction. But climate change is a collective action problem on a global scale, and in some instances the case for action on environmental grounds alone is not strong enough.

Fortunately, there are other drivers that might motivate cities to address issues of climate change – some of which appeal more to self interest than to collective concern. Incentives to invest in energy efficiency and energy security are going up: energy prices are high and are forecast to increase and possibly to become more volatile in years to come (IEA, 2009). Policy pressures are intensifying: in some settings, national governments have adopted ambitious carbon targets that seem likely to tighten further over time. And economic development opportunities are becoming more prominent: the low carbon and environmental goods and services sector has been estimated to be worth £3.2 trillion a year, to employ 28 million people worldwide and to be growing steadily through the recession (BIS, 2010).

These trends could have major social and economic implications for all – through their impacts on growth, competitiveness, employment, social welfare, fuel poverty and so on – but their effects are likely to be felt more acutely in cities. Globally, more than half of all economic output is generated in cities, and more than half of all people live in cities, but in urbanised countries these figures increase to around 80% (UN HABITAT, 2004; UNWUP, 2009). Further, it has been estimated that between 40 and 70% of all anthropogenic greenhouse gas (GHG) emissions are produced in cities, and that at least 70% of emissions can be attributed to the consumption that takes place within cities (UN HABITAT, 2011). Cities seem to be as exposed to attempts to reduce energy use and carbon footprints as they are vulnerable to the effects of climate change itself.

This paper considers how the Sheffield City Region could most efficiently and effectively exploit the wide range of technological and behavioural opportunities to reduce its energy bill and carbon footprint. It considers how much it would cost to reach different levels of decarbonisation through the least cost route. Evidence is presented on the economics of decarbonising the domestic, commercial, industrial and transport sectors as well as the city region as a whole.

At the national level in the UK, information on the performance of a wide range of different low carbon options has been collated by the independent Committee on Climate Change (CCC). The CCC was established as part of the 2008 Climate Change Act, legislation that led the UK to become the first country in the world to set legally binding carbon reduction targets. The CCC has subsequently recommended, and the UK Government has adopted, legally binding targets of a 34% reduction on 1990 levels of greenhouse gas emissions by 2022 and a 50% reduction by 2027.

To inform the setting of these targets, the CCC modelled three key aspects of the transition to a low carbon economy/society:

- the scope to decarbonise national energy systems, for example through the incorporation of large scale renewables or new nuclear facilities;
- the potential to deploy smaller scale renewables such as solar PV or micro-wind turbines; and
- the potential for demand-side reductions through a range of technological and behavioural changes.

Throughout the research presented in this paper, we have collaborated closely with the secretariat of the CCC to downscale the national level data to make it relevant at the local level. Given our interest in measures that can be adopted at the local level, we focus only on demand side measures and small scale renewables, whilst taking account of changes in national energy infrastructure and the forecast decarbonisation of electricity supply.

Thereafter, we need to generate data on a range of variables, as set out in Table 1.

To collect or generate data on each of these variables, the methodology follows a number of stages:

1. Identifying a list of the applicable low carbon measures

The CCC data includes a list of the energy efficiency measures and small scale renewables that could be adopted in the domestic, commercial, industrial and transport sectors. To a large degree, we base our analysis on that list of measures. However, as the transport sector analysis only considers private road transport options, we expand it to consider a limited number public transport options. A full list of the measures included in the analysis is presented in Table 2. We do not claim that this list of measures is complete – indeed expanding it to include a wider range of (particularly behavioural) measures should be seen as a key priority – but it is the most detailed and extensive list that we have found that is underpinned by broadly comparable data sets.

Table 1: List of Variables

Baseline trends	Financial savings per measure
Range of applicable low carbon measures	Carbon savings per measure
Capital cost of each measure	Scope for deployment in the Sheffield City Region
Operational costs of each measure	Rate of deployment in the Sheffield City Region
Hidden and missing costs of each measure	Total costs and carbon savings
Energy savings per measure	Cost and carbon savings for different levels of investment, decarbonisation

Table 2: Lists of the Low Carbon Measures Considered

Domestic	Mini wind turbines (5kW) with FiT; Photovoltaic generation with FiT' Biomass boilers with RHI; Electronic products; ICT products; Integrated digital TVs; Reduced standby consumption; Reduce heating for washing machines; A++ rated cold appliances; A-rated ovens; Biomass district heating with RHI; Efficient lighting; A-rated condensing boiler; Insulate primary pipework; Glazing – old double to new double; Uninsulated cylinder to high performance; Glazing – single to new; Insulated doors; Reduce household heating by 1^0C; Induction hobs; Loft insulation 0 – 270mm; Cavity wall insulation for pre-76 houses; Improve airtightness; DIY floor insulation (suspended timber floors); Loft insulation (increase from 25 to 270mm); Loft insulation (increase from 50 to 270mm; cavity wall insulation for houses built between 1976 and 1983); A+ rated wet appliances; Loft insulation (increase from 75 to 270mm); Cavity wall insulation for houses built post-83; Turn unnecessary lighting off; Installed floor insulation (suspended timber floors); Loft insulation (increase from 100 - 270mm); Loft insulation (increase from 150 to 270mm); Room thermostat to control heating; Paper type solid wall insulation; Modestly insulated cylinder to high performance; Thermostatic radiator valves; Air source heat pump with RHI; Micro wind turbines (1kW) with FiT; Hot water cylinder thermostat; Solar water heating with RHI.
Commercial	Photocopiers – energy management; Printers – energy management; Monitors – energy management; Computers – energy management; Fax machine switch off; Vending machines – energy management; Most energy efficient monitor PC only; Most energy efficient monitor; Lights – turn off lights for an extra hour; Lights – sunrise-sunset timers; Lights – basic timer; Heating – more efficient air conditioning; Lights – light detectors; Stairwell timer; Compressed air; Presence detector; Heating – programmable thermostats; Heating – optimising start times; Heating – reducing room temperature; Biomass boilers with RHI; Most energy efficient fridge-freezer; Heating – TRVs fully installed; Most energy efficient flat roof insulation; Heating – most energy efficient boiler; Biomass district heating with RHI; Lights – metal halide floodlights; Lights – IRC tungsten-halogen – spots; Most energy efficient pitched roof insulation; Most energy efficient cavity wall insulation; Air source heat pump with RHI; Most energy efficient freezer; Most energy efficient fridge; Ground source heat pump with RHI; Lights – most energy efficient replacement 26mm; Motor – 4 pole motor – EFF1 replace 4 pole; Lights – HF ballast; Most energy efficient external wall insulation; Solar thermal (inc RHI)most energy efficient double glazing; Lights – most energy efficient replacement tungsten; Variable speed drives; Most energy efficient double glazing (replace old double).
Industrial*	Burners; Drying and separation; Refrigeration and air conditioning; Lighting; Compressed air; Heat recovery with RHI; Design; Low temperature heating; Renewable heat with RHI; Building energy management; Space heating; New food and drink plant; High temperature heating; Fabrication and machining; Operation and maintenance; Controls; Energy management; Process improvement; Ventilation; Information technology; Motors and drives; insulation.
Transport	Park and ride; Express bus network; Bus priority and quality enhancements; Smarter choices; Cycling; Demand management; Mild hybrid; Plug-in hybrid; Full hybrid; Biofuels; Micro hybrid; Electric; New railway stations; Rail electrification.

* *Industrial measures are based on the grouping of thousands of different measures into broader categories to aid analysis and presentation.*

2. Evaluating the cost and carbon performance of each applicable measure

Based on the CCC data set, we extract data on the costs of adopting one unit of each measure and the energy (and hence the financial and carbon) savings that can be expected over the lifetime of that measure. The costs we consider include the capital costs, running costs and any hidden or missing costs (i.e. the costs of searching for or adopting the measure). We take into account incentives designed to encourage take up of small scale renewable or energy efficiency measures, such as Feed-in Tariffs. Future energy costs are based on DECC energy price forecasts through to 2022 (see Appendix A). Savings are based on CCC evaluations of the energy saved or generated in different contexts over the lifetime of each measure. Conservative estimates of energy savings are used throughout and these are adjusted to take account of rebound effects (i.e. the degree to which consumption goes up as efficiency improves). Future carbon savings are based on projected falls in the carbon intensity of electricity in the period to 2022 (again see Appendix A). Carbon savings from demand reductions are based on the attribution of a share of national carbon emissions to the relevant form of final consumption at the local level (AEA, 2010).

3. Understanding the potential for the deployment of different measures within the SCR

We then relate this list of measures to the scope for their deployment at the city scale. Ideally, this process would use observed data to take into account the size, composition and energy efficiency of the domestic, industrial, commercial and transport sectors in each particular locality.

For the domestic sector, such data is available and hence we have a very detailed and highly realistic picture of the scope for saving energy and fitting small-scale renewables in households at the local level.

For industry, local level data is available on both the scale and the sectoral composition of the economy. However, no local or firm level data is available on levels of energy efficiency or up take of low carbon options. Our data therefore reflects the size and sectoral composition of industry within the Sheffield City Region, taking into account 21 key industrial sectors, but more data is needed on the level of uptake of energy efficient and low carbon options in the area. In the absence of this, we assume here that each sector of local industry is as energy efficient and hence has the same potential to adopt low carbon measures as the same sector at the national level.

For the commercial sector, we adjust for scale of the sector to reflect capacities at the local level, using levels of floor space as the key indicator. Whilst we are able to identify the scope for decarbonisation in the public and private sectors, no further data is available on the sectoral composition or energy efficiency of the commercial sector at the local level. As with industry, we assume that the commercial sector is on average as energy efficient, and that it has the same potential to adopt low carbon measures, as the commercial sector at the national level.

For transport, the national data set developed by the CCC is limited to private road transport. For this sector, we take into account the number of vehicles registered at the local level, the fuel efficiency of the vehicle stock and the average number of miles travelled to develop a detailed picture of private road transport at the local level. However, we supplement the national data set with local data on public transport and demand management options. The options themselves and the carbon savings associated with them were identified in a recent report by Arup (Arup, 2009), with the cost benefit data being developed on the basis of further research on similar transport options in other contexts. A summary of the sources of data for this stage of the analysis is included in Table 3.

4. Understanding background trends, developing baselines and scenarios for deployment

The analysis focuses on the adoption of low carbon measures at rates over and above three key elements:

Background trends – the UK economy is forecast to grow and we take account of this by factoring projected economic growth into the calculation of the baseline, based on the most recent HM Treasury forecasts (again see Appendix A for details). It is also expected to steadily (autonomously) decarbonise at a slow rate as a result of structural and technological changes – for example as we de-industrialise and adopt more efficient new technologies. We account for this by extrapolating from past trends in decarbonisation within the Sheffield City Region, controlling for the impact of price changes as these are addressed separately.

The impact of future price increases – energy price increases (themselves reflecting carbon price increases) generally lead to reductions in demand and we account for these through the application of medium term price elasticities of demand for the different sectors (see Appendix A for details), applied to the price increases expected within DECC's energy price forecasts.

The future decarbonisation of energy supply – the UK has been, and plans to continue, investing in the replacement of its energy infrastructure with less carbon intensive alternatives. DECC forecasts carbon intensities for future energy supply through to 2022.

We therefore identify a baseline that reflects the impact of these background trends (but not future initiatives) in the period to 2022.

To consider the potential for the adoption of extra low carbon measures above this baseline, we then follow the CCC by assuming take up rates of low carbon measures that are based on a realistic proportion of the technical potential of each measure being exploited by 2022. These deployment rates take into account the impact of policies such as the EU Emissions Trading Scheme (ETS), the UK Carbon Reduction Commitment (CRC) and the UK Feed-in Tariffs (FiTs) for small-scale renewables. We also incorporate an evaluation of the impacts of the UK Renewable Heat Incentive (RHI), based on provisional incentive rates included in consultation documents (DECC, 2010). We assume that current and prospective rates of FiT and RHI stay in place through to 2022. The analysis does not account for the impact of the Green Deal or the Green Investment Bank – although these schemes could provide finance for some of the investments mentioned.

Table 3: Data Sources

Domestic: CCC data downscaled and compositionally adjusted using the Housing Energy Efficiency Database.
Transport: CCC data on vehicle stock and vehicle usage downscaled and compositionally adjusted using UK Department for Transport data, supplemented with behavioural measures identified by Arup and cost data on these measures drawn from related projects.
Commercial: CCC data downscaled using Office of National Statistics data on commercial floor space.
Industry: CCC data downscaled and compositionally adjusted using SIC data on the sectoral make up of the SCR economy from the Regional Econometric Model.

5. Identifying investment needs, financial returns and carbon savings for different levels of decarbonisation

Having worked out that each measure could be applied a particular number of times within the Sheffield City Region, we calculate aggregated investment needs, payback periods and carbon savings under different conditions. We do this for both a social case and a business case for investment. In each case, there are two key issues in the analysis – the first relates to the selected discount/interest rate, and the second to the forecast energy prices.

Discount/interest rates – for the social case, we adopt the standard (i.e. HM Treasury Green Book recommended) discount rate of 3.5%. In terms of the business case analysis, for the main forecasts we adopt a commercially realistic interest rate of 8%. To turn a nominal interest rate into a real interest rate, we also have to adjust for inflation, and we assume a 3% inflation rate when generating business case projections.

Energy price forecasts – DECC produce energy price forecasts – including price forecasts at 'central', 'high' and 'high' levels (see Appendix A). Current prices are some way above those in DECC's 'high' price forecasts. Basing the main part of the analysis on the 'high' forecast ensures that the estimates of financial returns are quite conservative.

Of course, interest rates, energy prices and inflation rates can go up and down and this will affect financial returns. To account for this, we also conduct some sensitivity tests based on a more and less favourable scenarios. The more favourable scenario has the same interest rate as the central forecast (as interest rates are unlikely to drop below current rates) but is based on higher forecast energy prices – meaning that returns on energy saving investments would also be higher. The less favourable scenario has a higher interest rate (11%), but lower energy prices, meaning that returns on energy saving investments would be lower.

A summary of all of these aspects is included in Table 4.

As we want to examine the extent to which there is a commercially realistic business case for investment in low carbon options, in the main part of the analysis below we present the results of the analysis based on the central business case. However, we consider the implications of moving to a more or less favourable business case in a sensitivity analysis.

Table 4: The Different Scenarios

Scenario	Discount/interest rate	Inflation rate	Energy price
Social case	3.5%	0%	High, no tax
Central business case	8%	3%	High, with tax
More favourable business case	8%	3%	Very high, with tax
Less favourable business case	11%	3%	Central, with tax

6. Developing league tables and MAC curves

Having completed calculations of the costs and benefits of each option on the basis above, for the central business case we then prioritise options according to the extent that they pay for themselves over their lifetime (i.e. by their Net Present Value). This enables the identification of league tables of the most cost effective measures for the domestic, industrial, commercial and transport sectors and for the city region as a whole. These are presented both as league tables of the most cost and carbon effective measures, and as Marginal Abatement Cost (MAC) curves. for the domestic, commercial, industrial and transport sectors (see Appendices D-G).

We then identify the different levels of decarbonisation that could be achieved with different levels of investment, with a distinction drawn between three levels of investment:

The cost effective level – this includes all of the measures that would more than pay for themselves over their lifetime.

The cost neutral level – this includes all of the measures that could be afforded if the benefits from the cost effective measures were captured and reinvested in further low carbon options.

The realistic technical potential level – this includes all of the measures that could realistically be adopted, regardless of their cost effectiveness.

7. Calculating employment and wider effects on GVA

The final stage of the analysis focuses the effects that investments in decarbonising the Sheffield City Region would have on employment and the wider SCR economy. To do this, we take the forecast levels of investment required to exploit those cost effective and cost neutral opportunities with employment generating potential under the central business case scenario. We assume even levels of investment per year over the period from 2012 to 2022, and assumptions about the amount of the investment retained within the SCR are made taking into account the strength of the supplier base and the level of competition from outside the SCR in particular sectors, based on a recently completed study of the low carbon goods and services sector within the SCR (see Quantum Strategy and Technology, 2010). Only those measures with employment generating potential are examined – some behavioural measures (i.e. adjusting thermostats) with no employment generating potential are not assessed. Thereafter, groups of measures are clustered together to create cross-cutting categories that could be assessed based on the insights from the recent work on the size, capacities, and employment intensity of the low carbon goods and services sector. The direct employment effects of major levels of investment in low carbon options are then forecast based on an expansion of current levels of employment per unit of GVA within the SCR low carbon goods and services sector, and direct economic effects are forecast based on an expansion of current levels of GVA per employee. Wider economic effects were then calculated using standard multipliers proposed by English Partnerships (see Appendix C for details).

At the energy prices and interest rates encountered by households and businesses, how much would it cost to cut energy bills and carbon footprints and how quickly would investments be repaid? How many jobs could we create in the process of cutting energy bills and lowering carbon footprints? And to what extent is it possible to insulate the local economy from future energy price hikes?

The potential for carbon reduction – investments and returns

The results of the central business case analysis show that, compared to 1990, the Sheffield City Region could reduce its carbon emissions by 2022 by:

- 11.6% through cost effective investments that would pay for themselves (on commercial terms) over their lifetime. This would require an investment of £3.70 billion. This would generate an annual savings of £723 million, paying back the investment in 5.12 years but generating annual savings for the lifetime of the measures.
- 15.7% through cost neutral investments that could be paid for at no net cost to the Sheffield City Region economy if the benefits from cost effective measures were captured and re-invested in further low carbon measures. This would require an investment of £6.67 billion, generating annual savings of £929 million, paying back the investment in 7.2 years but generating annual savings for the lifetime of the measures.
- 16.5% if all of the realistic potential of the different measures was exploited. This would require an investment of £7.8 billion. This would generate an annual savings of £1.02 billion, paying back the investment in 7.7 years but generating annual savings for the lifetime of the measures.

Impacts on future energy bills

These figures are particularly significant in the context of projected energy price increases. We calculate that the 2011 SCR energy bill is £3.41 billion per year, but we forecast that this will grow to £4.59 billion by 2022 – a £1.18 billion increase in the SCR annual energy bill.

- With investment in all of the cost effective measures, this £1.18 billion increase in the annual energy bill could be cut by £723 million (61% of the projected increase).
- With investment in all of the cost neutral measures, it could be cut by £929 million (79% of the projected increase).
- With investment to exploit all of the realistic potential, it could be cut by £1.02 billion (86% of the projected increase).

The Sheffield City Region could therefore insulate itself against projected energy price increases to a very large extent through investments in energy efficiency and low carbon options.

Table 5: Main Results

SCR sector	Capital cost in 2012	Annual cost saving in 2022	Annual carbon saving in 2022	Payback	SCR carbon cut in 2022 (above trend, 1990 base)
	£bn	£bn	KTCO2	yrs	%
			Cost effective measures		
Domestic	£0.80	£0.24	560.68	3.36	3.58%
Transport	£0.62	£0.10	151.26	6.50	0.96%
Commercial	£1.18	£0.21	558.95	5.66	3.57%
Industry	£1.11	£0.18	541.66	6.04	3.46%
Total	**£3.70**	**£0.72**	**1813**	**5.12**	**11.56%**
			Cost neutral measures		
Domestic	£1.74	£0.30	697.50	5.77	4.45%
Transport	£1.50	£0.17	394.64	8.57	2.52%
Commercial	£1.79	£0.25	641.10	7.20	4.09%
Industry	£1.65	£0.21	719.67	8.04	4.59%
Total	**£6.67**	**£0.93**	**2452.90**	**7.18**	**15.65%**
			Realistic technical potential		
Domestic	£1.74	£0.30	697.50	5.77	4.45%
Transport	£2.64	£0.27	525.29	9.94	3.35%
Commercial	£1.79	£0.25	641.10	7.20	4.09%
Industry	£1.65	£0.21	719.67	8.04	4.59%
Total	**£7.82**	**£1.02**	**2583.56**	**7.66**	**16.48%**

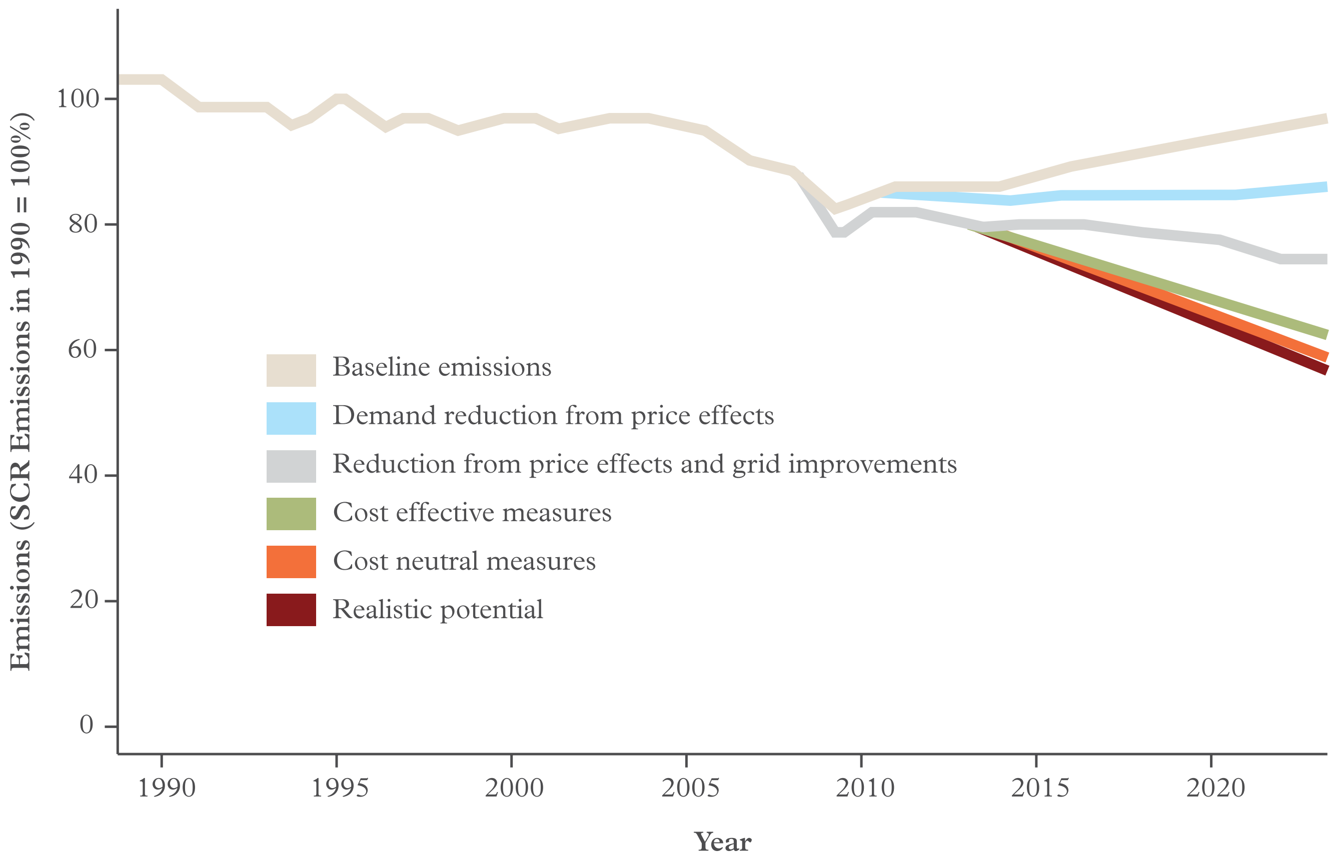
The wider context – other influences on SCR carbon emissions

It is critically important to note that these figures relate to the impacts of investments that are over and above a continuation of background trends, the ongoing impacts of current policies, the impacts of future increases on energy prices and the impact of a continuing decarbonisation of national energy supply. The combined impacts of all of these factors are reflected in Figure 1.

As is shown in Figure 1, we forecast that:

- With other things constant, background trends in economic growth combined with changes in the energy and carbon intensity of GDP will lead to a 6% decrease in SCR carbon emissions between 1990 and 2022.
- Higher energy price increases will impact on demand, and this will lead to a 10% drop in SCR carbon emissions compared to the 1990 baseline by 2022. The total effect of the background trends plus the response to higher energy price will be a 16% drop in SCR emissions between 1990 and 2022.
- The decarbonisation of the national electricity system will lead to a 12% drop in SCR carbon emissions by 2022. The total effect of background trends, the impacts of price increases and the decarbonisation of the national electricity supply system will be a 28% drop in SCR emissions between 1990 and 2022.

Figure 1: Baselines and Analysis of Price Effects, Grid Decarbonisation and Cost Effective, Cost Neutral and Realistic Potential



—The total effect of all of the above plus the exploitation of all of the cost effective low carbon options will be a 40% drop in SCR carbon emissions between 1990 and 2022.
—The total effect of all of the above plus the exploitation of the remaining cost neutral options will be a 44% drop in SCR emissions between 1990 and 2022.
—The total effect of all of the above plus the exploitation of all of the remaining realistic potential will be a 44% drop in SCR carbon emissions between 1990 and 2022.

Sensitivity analysis

Based on a sensitivity analysis, these results appear to be very robust. When compared to scenarios that, in terms of returns on investment, are either more (the same interest rate, higher energy prices) or less (higher interest rates, lower energy prices) favourable, there is little change in the results. Wider analysis suggests returns on investment are more sensitive to changes in energy prices than interest rates, but the broader conclusion is that they are not that sensitive to changes in either of these key variables.

Wider impacts on employment and economic growth

In terms of the wider economic implications of the different levels of investment, we estimate that implementation of the cost effective and cost neutral measures in the domestic, non-domestic, industrial and transport sectors will result in the creation of a total of about 6,287 additional jobs/annum and additional GVA of £297 million/annum in Sheffield City Region (SCR) over the 10 year period (or £3 billion in total).

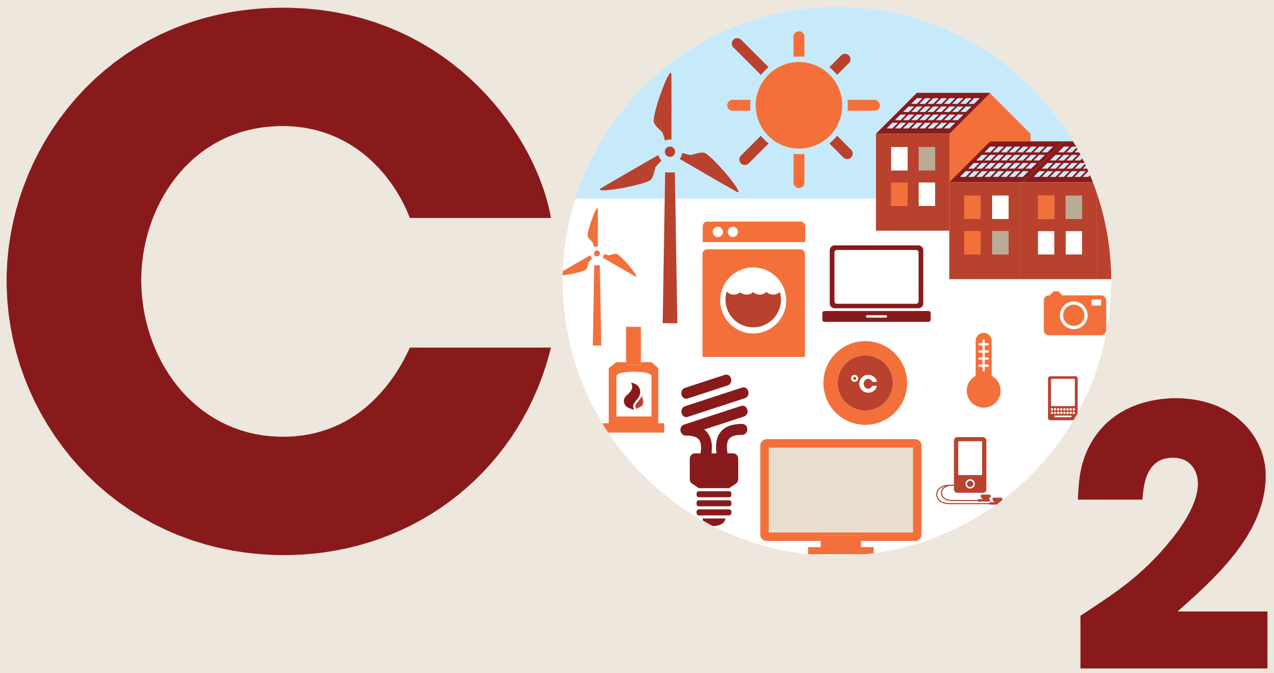
These totals include the direct impacts of the required levels of investment in employment and GVA and indirect effects based on supply chain and income (or consumption) multipliers. A summary of the estimates by sector is provided in Table 6.

Table 6: Summary of the Economic Benefits

Sector	Measures	Total investment to 2022 (£000)	SCR direct jobs p.a.	SCR direct GVA p.a. (£000)	SCR total jobs p.a.	SCR total GVA p.a. (£000)
Domestic	Cost effective	735,164	498	23,324	684	31,986
	Cost neutral	940,120	774	34,058	1,195	52,619
	Sub-total	**1,675,284**	**1,273**	**57,382**	**1,878**	**84,605**
Commercial	Cost effective	866,761	617	27,505	950	42,320
	Cost neutral	851,435	689	29,847	1,011	43,817
	Sub-total	**1,718,196**	**1,306**	**57,352**	**1,961**	**86,137**
Industrial	Cost effective	138,551	66	4,235	66	6,353
	Cost neutral	327,125	173	12,808	260	19,212
	RH Measures	631,471	465	20,299	695	30,239
	Sub-total	**1,097,147**	**705**	**37,342**	**1,054**	**55,804**
Transport	**Sub-total**	**n/a**	**886**	**44,130**	**1,330**	**66,195**
Total	Cost effective	1,740,477	2,067	99,194	3,029	146,855
	Cost neutral	2,750,151	2,103	97,012	3,160	145,887
	All measures	**4,490,627**	**4,170**	**196,206**	**6,189**	**292,741**

Sector Focus

The Domestic Sector



Main Findings
The Domestic Sector

Cost effective opportunities

- There are £796 million worth of cost-effective, energy efficient and low carbon investment opportunities available in the domestic sector in the Sheffield City Region.
- Exploiting these would generate annual savings of £237 million a year.
- At commercial rates, these investments would pay for themselves in under 3.4 years, whilst generating annual savings for the lifetime of the measures.
- If exploited, these investments would reduce Sheffield City Region carbon emissions by 3.6% by 2022, compared to 1990.

Cost neutral opportunities

- There are £1.7 billion of cost-neutral, energy efficient and low carbon investment opportunities available in the domestic sector in the Sheffield City Region.
- Exploiting these would generate annual savings of £301 million a year.
- At commercial rates, these investments would pay for themselves in 5.8 years, whilst generating annual savings for the lifetime of the measures.
- These investments would reduce Sheffield City Region carbon emissions by 4.5% by 2022, compared to 1990.

Table 7: League Table of the Most Cost Effective Measures for the Domestic Sector

	Central business case	£/TCO2
1	Mini wind turbines (5kW) with FiT	-457
2	Biomass boilers with RHI	-257
3	Electronic products	-245
4	Information and communication technology products	-244
5	Integrated digital TVs	-228
6	Reduced standby consumption	-228
7	Reduce heating for washing machines	-209
8	A++ rated cold appliances	-180
9	A rated ovens	-175
10	Efficient lighting	-153
11	A-rated condensing boiler	-145
12	Insulate primary pipework	-132
13	Biomass district heating with RHI	-126
14	Glazing – old double to new double	-123
15	Uninsulated cylinder to high performance	-122
16	Glazing – single to new	-120
17	Insulated doors	-118
18	Reduce household heating by 1°C	-111
19	Induction hobs	-110
20	Loft insulation 0 - 270mm	-79
21	Pre '76 cavity wall insulation	-73
22	Improve airtightness	-71

FiT = Feed in Tarriff. RHI = Renewable Heat Incentive. Correct as at 1/1/2012

Cost effective

Cost neutral

Discussion

There are numerous opportunities for reducing the energy use and carbon footprints of households within the Sheffield City Region. This could be done through investments in the fabric of the built environment (i.e. through loft and wall insulation, double glazing), through investments in more energy efficient appliances (computers, TVs, fridges, freezers etc) or through changes in behaviour (turning off appliances, turning down thermostats etc). The league tables of the most cost and carbon effective measures are included in Table 7.

23	DIY floor insulation (susp. timber floors)	-70
24	Loft insulation 25 - 270mm	-69
25	Loft insulation 50 - 270mm	-59
26	Ground source heat pumps with RHI	-58
27	76-83 cavity wall insulation	-56
28	A+ rated wet appliances	-54
29	Loft insulation 75 - 270mm	-52
30	Post '83 cavity wall insulation	-30
31	Turn unnecessary lighting off	-28
32	Installed floor insulation (susp. timber frames)	-25
33	Loft insulation 100 - 270mm	-8
34	Glazing (to best practice)	-4

35	Solid wall insulation	9
36	Loft insulation 125 - 270mm	11
37	Loft insulation 150 - 270mm	59
38	Room thermostat to control heating	59
39	Paper type solid wall insulation	76
40	Modestly insulated cylinder to high performance	90
41	Thermostatic radiator valves	135
42	Photovoltaic generation with FiT	180
43	Air source heat pump with RHI	337
44	Micro wind turbines (1kW) with FiT	639
45	Hot water cylinder 'stat	671
46	Solar water heating with RHI	866

Table 8: League Table of the Most Carbon Effective Measures for the Domestic Sector

	Central business case	KTCO2
1	Reduce household heating by 1°C	115.92
2	Biomass boilers with RHI	100.98
3	Solid wall insulation	84.02
4	Biomass district heating with RHI	52.31
5	Ground source heat pump with RHI	50.60
6	Electronic products	48.75
7	Pre '76 cavity wall insulation	37.94
8	Information and communication technology products	31.98
9	Air source heat pump with RHI	30.12
10	Efficient lighting	28.00
11	A+ rated wet appliances	9.78
12	DIY floor insulation (susp. timber floors)	8.48
13	Mini wind turbines (5kW) with fit	7.31
14	Reduce heating for washing machines	7.10
15	Photovoltaic generation with fit	7.03
16	Solar water heating with RHI	7.01
17	Glazing – single to new	6.47
18	Uninsulated cylinder to high performance	6.28
19	Reduced standby consumption	5.99
20	Improved airtightness	5.65
21	Glazing – old double to new double	5.59
22	Loft insulation 100 - 270mm	5.51

FiT = Feed in Tarriff. RHI = Renewable Heat Incentive. Correct as at 1/1/2012

The analysis shows that bigger domestic wind turbines (with FiTs) are the most cost effective measures, but the aggregated carbon saving potential from this measure is relatively small across the Sheffield City Region. Biomass boilers (with RHI) are the next most cost effective measure, and they are also an option with one of the largest potential carbon savings at the SCR scale. Other options that are cost effective but that have relatively small carbon savings relate to the adoption of more efficient appliances. Solar PV (with FiTs) has a relatively small carbon saving potential at the SCR scale, but reducing household heating levels by one degree has a very significant level of cost-effective carbon saving potential, as does the wider deployment of energy efficient lighting and investments in loft insulation cavity wall for the oldest and least well insulated houses. One of the biggest aggregate carbon saving available for any domestic sector measure relates to solid wall insulation – investments in this measure are cost neutral over their life time.

In terms of the wider employment and economic effects, domestic measures represent 30% of the total jobs and GVA that could be created within the SCR through investments in cost effective and cost neutral low carbon measures. Within this sector the measures which result in the most jobs/GVA are loft and cavity wall insulation, solid wall insulation, PV generation, mini wind turbine and renewable heat such as heat pumps, biomass boilers and solar thermal.

Cost effective
Cost neutral

23	Glazing (to best practice)	5.37
24	Loft insulation 0 - 270mm	4.33
25	Loft insulation 75 - 270mm	3.75
26	Modestly insulated cylinder to high performance	3.63
27	76-83 cavity wall insulation	3.26
28	Loft insulation 50 - 270mm	2.55
29	Post '83 cavity wall insulation	2.35
30	Room thermostat to control heating	2.29
31	Turn unnecessary lighting off	1.83
32	Thermostatic radiator valves	1.21
33	Insulate primary pipework	0.94
34	Paper type solid wall insulation	0.72

35	Integrated digital TVs	0.65
36	Micro wind turbines (1kW) with fit	0.62
37	A++ rated cold appliances	0.59
38	Loft insulation 25 - 270mm	0.44
39	Hot water cylinder 'stat	0.18
40	A rated ovens	0.00
41	A rated condensing boiler	0.00
42	Insulated doors	0.00
43	Induction hobs	0.00
44	Installed floor insulation (susp. timber frames)	0.00
45	Loft insulation 125 - 270mm	0.00
46	Loft insulation 150 - 270mm	0.00

For those investments with employment creating potential:

- Total capital expenditure for the selected measures over the 10 years is £1.7 billion (44% for cost effective measures and 56% for cost neutral measures);
- Total average number of jobs/year created is about 1,900 (36% for cost effective measures and 64% for cost neutral measures). This total comprises 1,270 direct jobs and 630 indirect jobs based on composite supply chain and income (or consumption) multipliers;
- Total average annual GVA is about £85 million (38% for cost effective measures and 62% for cost neutral measures). This equates to a cumulative total of £850 billion over the 10 year period.

A breakdown of the jobs per year for the cost effective measures is given in Figure 2.

This shows that microgeneration technologies (PV generation, biomass and mini wind) account for 75% of the total jobs for cost effective measures and insulation measures account for 19% of the total. Other measures include efficient lighting and energy efficient (A+ and A++ rated) appliances.

A breakdown of the jobs per year for the cost neutral measures is given in Figure 3.

Solid wall insulation accounts for 41% of the total jobs for cost neutral measures and renewable heat technologies (air source and ground source heat pumps and solar thermal) account for 55% of the total. Other measures include heating controls and micro wind.

We estimate that around 250 direct additional jobs and £17.5m GVA/annum could be created in SCR associated with the delivery of whole house survey by energy advisors (375 jobs and £26m GVA/annum if indirect jobs are included).

Figure 2: Breakdown of Total Jobs for Cost Effective Domestic Measures

(Total jobs/annum – 684)

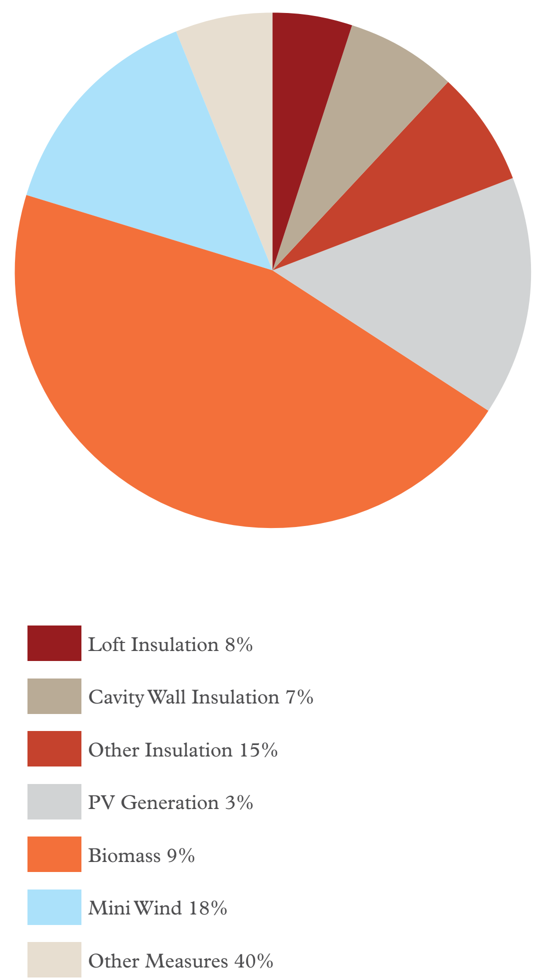
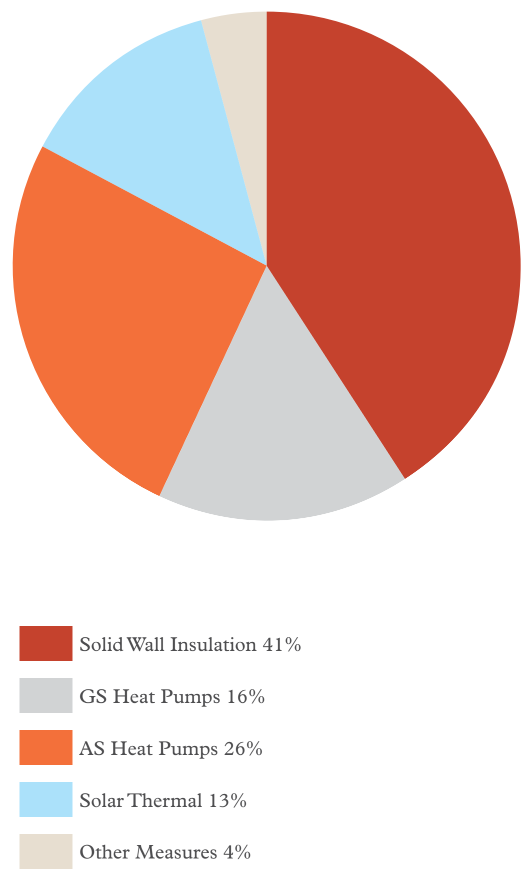


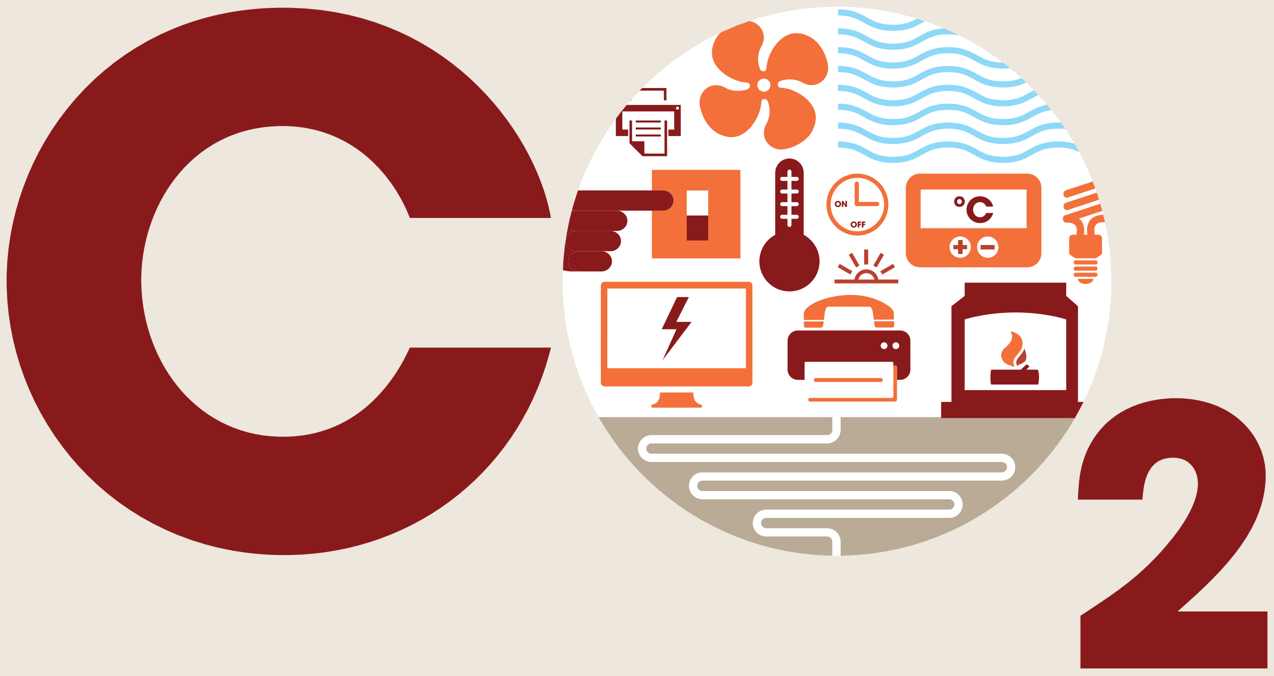
Figure 3: Breakdown of Total Jobs for Cost Neutral Domestic Measures

(Total jobs/annum – 1,195)



Sector Focus

The Commercial Sector



Main Findings
The Commercial Sector

Cost effective opportunities

- There are £1.2 billion of cost-effective, energy efficient and low carbon investment opportunities available in the commercial sector within the Sheffield City Region.
- Exploiting these would generate annual savings of £208 million a year.
- These investments would pay for themselves in 5.7 years, whilst generating annual savings for the lifetime of the measures.
- If exploited, these investments would reduce Sheffield City Region carbon emissions by 3.6% by 2022, compared to 1990.

Cost neutral opportunities

- There are £1.8 billion of cost-effective, energy efficient and low carbon investment opportunities available in the commercial sector within the Sheffield City Region.
- Exploiting these would generate annual savings of £248 million a year.
- Collectively, these investments would pay for themselves in 7.2 years, whilst generating annual savings for the lifetime of the measures.
- Collectively, these investments would reduce Sheffield City Region carbon emissions by 4.1% by 2022, compared to 1990.

Table 9: League Table of the Most Cost Effective Measures for the Commercial Sector

	Central business case	£/TCO2
1	Vending machines – energy management	-233.67
2	Office equipment – fax machine switch off	-233.67
3	Photocopiers – energy management	-233.67
4	Computers – energy management	-233.67
5	Monitors – energy management	-233.67
6	Printers – energy management	-233.67
7	Office equipment – most energy efficient monitor PC only	-209.41
8	Biomass boilers with RHI	-206.64
9	Lights – turn off lights for an extra hour	-194.08
10	Lights – sunrise-sunset timers	-193.90
11	Lights – basic timer	-193.78
12	Heating – more efficient air conditioning	-193.73
13	Office equipment – most energy efficient monitor	-192.18
14	Lights – light detectors	-188.92
15	Stairwell timer	-180.65
16	Heating – programmable thermostats high	-159.50
17	Heating – optimising start times	-158.88
18	Heating – reducing room temperature	-158.32
19	Most energy efficient fridge	-156.83
20	Heating – thermostatic radiator valves fully installed	-140.77
21	Compressed air	-136.45

FiT = Feed in Tarriff. RHI = Renewable Heat Incentive. Correct as at 1/1/2012

Cost effective

Cost neutral

Discussion

Again, there are numerous energy efficient and low carbon options available to the commercial sector, including many forms of more energy efficient appliance (computer monitors, photocopiers etc), various different types of energy saving equipment (light detectors, thermostats etc) and some behavioural measures (turning lights off for an extra hour). A range of small scale-renewables could also be adopted and there are various ways in which buildings could be better insulated. The league tables of the most cost and carbon effective measures are included below.

22	Most energy efficient freezer	-108.99
23	Presence detector	-104.92
24	Biomass district heating with RHI	-82.01
25	Most energy efficient fridge-freezer	-67.84
26	Most energy efficient flat roof insulation	-60.54
27	Heating – most energy efficient boiler	-60.22
28	Ground source heat pumps with RHI	-13.14
29	Most energy efficient cavity wall insulation	-10.54
30	Most energy efficient pitched roof insulation	-10.27
31	Air source heat pumps with RHI	-5.55
32	Most energy efficient external wall insulation	10.36
33	Lights – metal halide floods	19.92
34	Lights – IRC tungsten-halogen – spots	23.05
35	Lights – most energy efficient replacement 26mm	154.45
36	Motor – 4 Pole motor – EFF1 replace 4 Pole	192.51
37	Lights – high frequency ballast	194.73
38	Solar water heating with RHI	496.42
39	Lights – most energy efficient replacement tungsten	521.57
40	Variable speed drives	687.98
41	Most energy efficient double glazing	691.07
42	Most energy efficient double glazing (replace double)	2918.71

Table 10: League Table of the Most Carbon Effective Measures for the Commercial Sector

Central business case		KTCO2
1	Air source heat pumps with RHI	84.87
2	Heating – most energy efficient boiler	74.49
3	Heating – programmable thermostats high	72.58
4	Biomass boilers with RHI	50.93
5	Biomass district heating with RHI	44.63
6	Heating – reducing room temperature	44.10
7	Ground source heat pumps with RHI	43.09
8	Most energy efficient double glazing	26.68
9	Heating – optimising start times	24.86
10	Lights – basic timer	19.87
11	Heating – more efficient air conditioning	17.18
12	Solar water heating with RHI	13.73
13	Heating – thermostatic radiator valves fully installed	13.29
14	Lights – most energy efficient replacement 26mm	12.86
15	Lights – turn off lights for an extra hour	10.81
16	Monitors – energy management	9.59
17	Lights – high frequency ballast	8.58
18	Most energy efficient external wall insulation	8.25
19	Most energy efficient flat roof insulation	7.99

FiT = Feed in Tarriff. RHI = Renewable Heat Incentive. Correct as at 1/1/2012

The analysis shows that the most cost effective measures all involve replacing office equipment with more energy efficient alternatives. However, at the SCR scale, these measures would not lead to very significant amounts of carbon reduction. Some of the biggest carbon savings from cost effective measures come from the installation of biomass boilers, biomass district heating schemes and air source heat pumps (all taking into account the effect of RHIs). Thereafter, the biggest carbon savings from cost effective measures come from installing programmable thermostats, more energy efficient boilers, reducing room temperature and optimising start and stop times on heating systems.

Commercial measures (i.e. in public and private sector buildings) represent about 32% of the total jobs and 30% of GVA that could be generated through cost effective and cost neutral investments in low carbon measures. Within this sector, the measures which result in the most jobs/GVA are more efficient boilers and air-conditioning, heating and lighting controls, renewable heat and the most energy efficient double glazing.

Cost effective

Cost neutral

20	Presence detector	5.79
21	Most energy efficient cavity wall insulation	5.78
22	Most energy efficient pitched roof insulation	5.42
23	Office equipment – most energy efficient monitor PC only	4.72
24	Computers – energy management	4.09
25	Stairwell timer	3.67
26	Variable speed drives	3.67
27	Lights – most energy efficient replacement tungsten	3.05
28	Lights – IRC tungsten-halogen – spots	2.51
29	Most energy efficient freezer	2.40
30	Lights – sunrise-sunset timers	2.11
31	Lights – light detectors	2.09
32	Most energy efficient double glazing (replace double)	1.62
33	Compressed air	1.47
34	Printers – energy management	1.07
35	Lights – metal halide floods	1.02
36	Most energy efficient fridge	0.79
37	Photocopiers – energy management	0.59
38	Office equipment – fax machine switch off	0.31
39	Vending machines energy management	0.23
40	Motor – 4 Pole motor – EFF1 replace 4 Pole	0.18
41	Most energy efficient fridge-freezer	0.08
42	Office equipment – most energy efficient monitor	0.04

— Total capital expenditure for the selected measures over the 10 years is £1.7 billion (50% for cost effective measures and 50% for cost neutral measures);

— Total average number of jobs/year created is about 1,961 (48% for cost effective measures and 52% for cost neutral measures). This total comprises 1,306 direct jobs and 655 indirect jobs based on composite supply chain and income (or consumption) multipliers; and

— Total average annual GVA is about £86 million (50% for cost effective measures and 50% for cost neutral measures). This equates to a cumulative total of £860 million over the 10-year period.

A breakdown of the jobs per year for the cost effective measures is given in Figure 4.

Air source heat pumps account for 40% of the total jobs for cost effective measures, followed by biomass installations with 18%, energy efficient boilers with 15% and insulation measures with 9% of the total. Other measures include insulation, efficient air-conditioning and compressed air.

A breakdown of the jobs per year for the cost neutral measures is given in Figure 5.

Insulation measures account for 47% of the total jobs for cost neutral measures, followed by ground source heat pumps with 22%.

Figure 4: Breakdown of Total Jobs for Cost Effective Commercial Measures

(Total jobs/annum – 950)

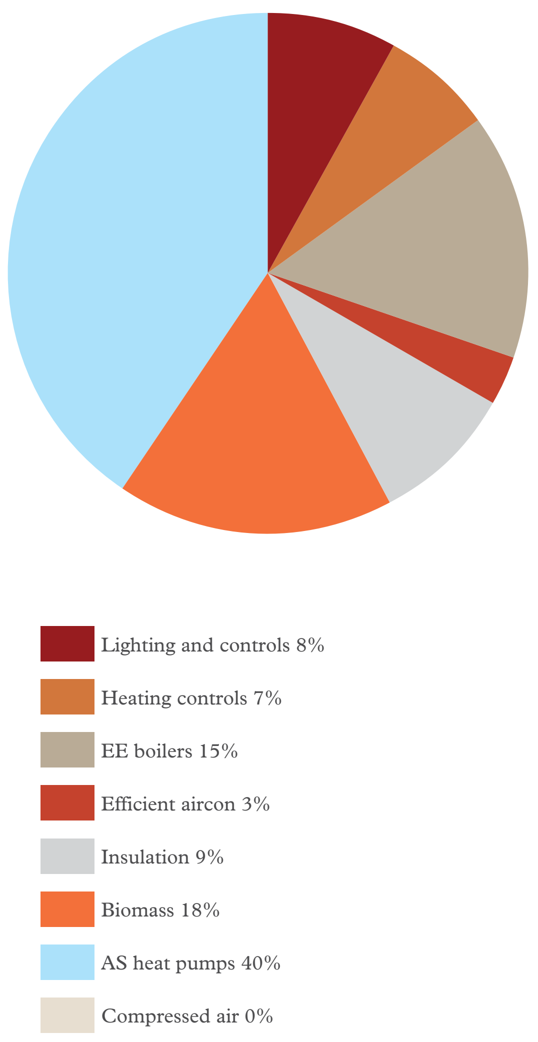
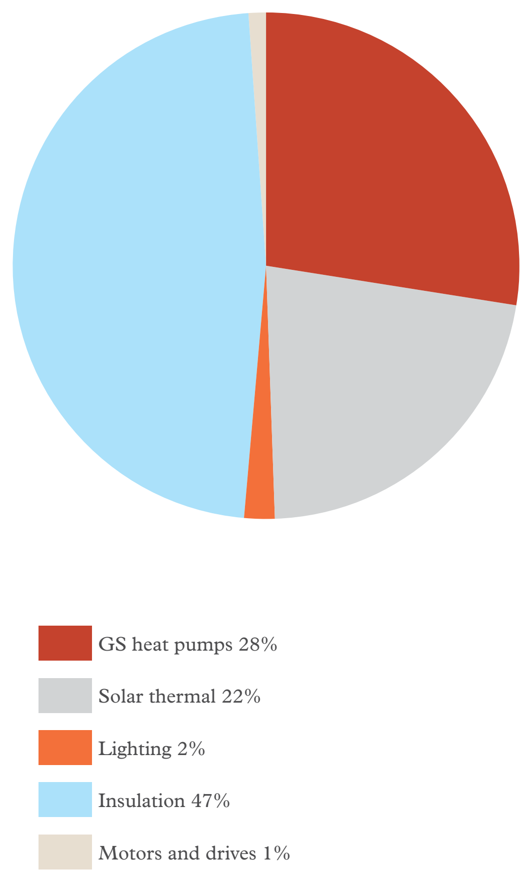


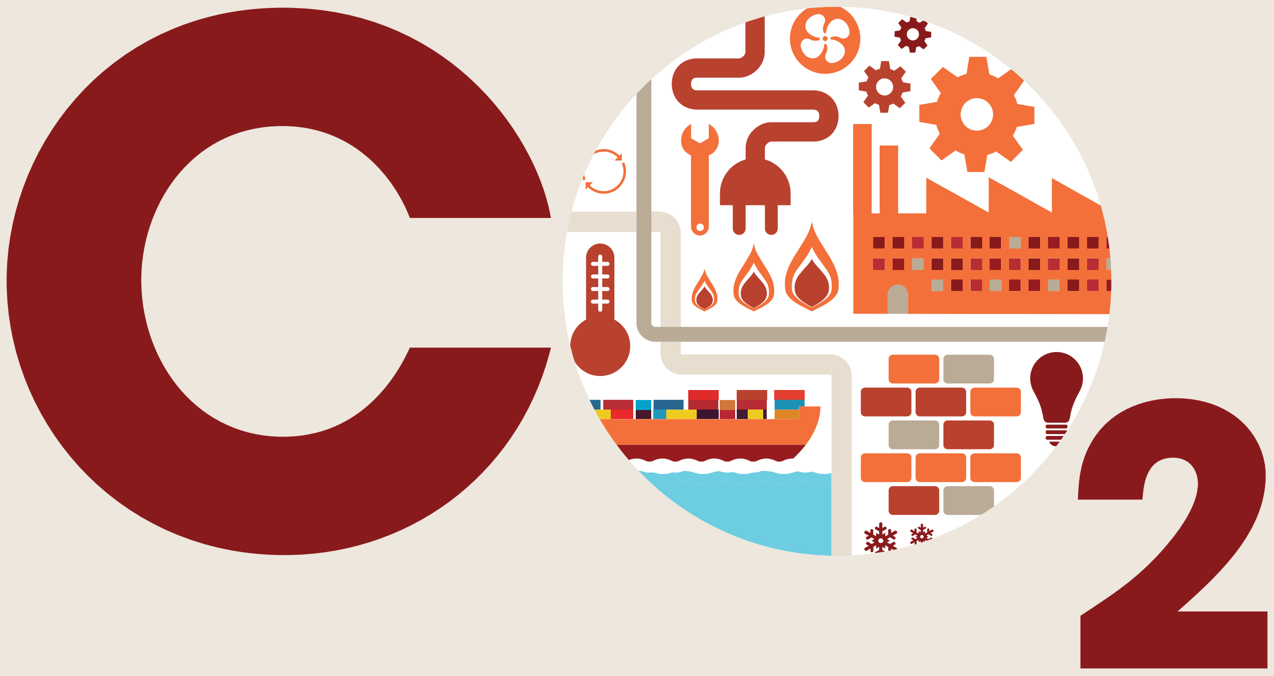
Figure 5: Breakdown of Total Jobs for Cost Neutral Commercial Measures

(Total jobs/annum – 1,011)



Sector Focus

The Industrial Sector



Main Findings
The Industrial Sector

Cost effective opportunities

- There are £1.1 billion of cost effective, energy efficient and low carbon investment opportunities available in industry in the Sheffield City Region.
- Exploiting these would generate annual savings of £183 million a year.
- At commercial rates, these investments would pay for themselves in 6 years, whilst generating annual savings for the lifetime of the measures.
- If exploited, these investments would reduce Sheffield City Region carbon emissions by 3.5% by 2022, compared to 1990.

Cost neutral opportunities

- There are £1.65 billion of cost neutral, energy efficient and low carbon investment opportunities available in industry in the Sheffield City Region.
- Exploiting these would generate annual savings of £205 million a year.
- Collectively, these investments would pay for themselves in 8.04 years, whilst generating annual savings for the lifetime of the measures.
- Collectively, these investments would reduce Sheffield City Region carbon emissions by 4.6% by 2022, compared to 1990.

Discussion

There are thousands of energy efficient and low carbon measures that could be adopted in different sectors of industry and that have been analysed in this research. For simplicity, we have clustered these together in a smaller number of categories of measures which includes more energy efficient burners, motors and drives, fabrication and machining, refrigeration and air conditionings, lighting, heat recovery, ventilation and so on. The league tables of the most cost and carbon effective measures are included below.

Table 11: League Table of the Most Cost Effective Measures for the Industrial Sector *

	Central business case	£/TCO2
1	Burners	-764.09
2	Refrigeration and air-conditioning	-244.32
3	Compressed air	-225.06
4	Lighting	-195.72
5	Fabrication and machining	-160.79
6	Design	-147.42
7	Operation and maintenance	-132.85
8	Low temperature heating	-131.98
9	Building energy management	-126.07
10	New food and drink plant	-118.9
11	Drying and separation	-117.01
12	Space heating	-115.39
13	Controls	-100.1
14	Renewable heat	-91.03
15	High temperature heating	-90.56
16	Energy management	-84.6
17	Heat recovery	-47.87
18	Process improvement	-44.7
19	Others	48.88
20	Ventilation	176.41
21	Information technology	476.82
22	Motors and drives	540
23	Insulation	815.69

Cost effective
Cost neutral
Realistic technical potential

Table 12: League Table of the Most Carbon Effective Measures for the Industrial Sector *

	Central business case	KTCO2
1	Renewable heat	274.60
2	High temperature heating	86.75
3	Process improvement	67.37
4	Motors and drives	60.83
5	Others	39.85
6	Controls	31.62
7	Drying and separation	28.00
8	Low temperature heating	24.96
9	Operation and maintenance	24.57
10	Heat recovery	18.24
11	Energy management	13.87
12	Space heating	10.12
13	Fabrication and machining	8.24
14	Refrigeration and air-conditioning	6.47
15	Ventilation	5.83
16	Building energy management	4.54
17	Insulation	3.81
18	Compressed air	3.76
19	Design	2.20
20	New food and drink plant	1.40
21	Burners	1.24
22	Lighting	1.10
23	Information technology	0.33

* *Industrial measures are based on the grouping of thousands of different measures into broader categories to aid analysis and presentation. Average carbon effectiveness figures are presented for all measures within each category.*

The analysis shows more energy efficient burners are highly cost effective, but as the scope for their deployment in the SCR is low their aggregated potential to reduce carbon is also low. Thereafter, a number of measures are cost effective, but as (on average) they are not highly cost effective the incentives for their adoption are not necessarily high. The cost effective measure that stands out as having by far the highest potential to reduce carbon from industry is renewable heat.

In terms of their wider economic impact, industrial measures represent around 17% of the total jobs and 19% of total GVA that could be generated through cost effective and cost neutral investments in low carbon measures. The measures which result in the most jobs/GVA are associated with motors and drives, high temperature heating, heat recovery, drying and separation, process improvements and renewable heat.

- Total capital expenditure for the measures with employment creating potential over the 10 years is about £1.1 billion (13% for cost effective, 30% for cost neutral and 57% for renewable heat measures);
- Total average number of jobs/year created is about 1,054 (10% for cost effective, 25% for cost neutral and 65% for renewable heat measures). This total comprises 705 direct jobs and 349 indirect jobs based on composite supply chain and income (or consumption) multipliers; and
- Total average annual GVA is about £56 million (11% for cost effective, 34% for cost neutral and 55% for renewable heat measures). This equates to a cumulative total of £560 million over the 10-year period.

A breakdown of the jobs per year for the cost effective measures is given in Figure 6.

Process improvement accounts for 28% of the total jobs for cost effective measures, followed by high temperature heating with 22% and heat recovery with 11% of the total. Other measures include burners, space heating, motors and drives and insulation.

A breakdown of the jobs per year for the cost neutral measures is given in the Figure 7.

Process improvements makes up over 90% of the total jobs. Other measures include fabrication and machining, low temperature heating, compressed air and insulation.

It should be noted that the categories of measures are the same as for the cost effective measures since they have been combined across a wide range of industry sectors, i.e. measures can be cost effective in some sectors and cost neutral in others.

A breakdown of the jobs per year for the renewable heat measures is given in Figure 8 which shows that biomass accounts for 62% of the total jobs, followed by air source heat pumps with 23% and ground source heat pumps with 15%.

Figure 6: Breakdown of Total Jobs for Cost Effective Industrial Measures

(Total jobs/annum – 66)

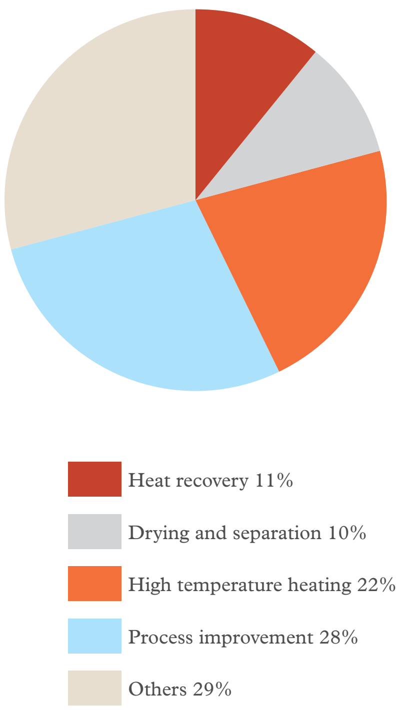


Figure 7: Breakdown of Total Jobs for Cost Neutral Industrial Measures

(Total jobs/annum – 260)

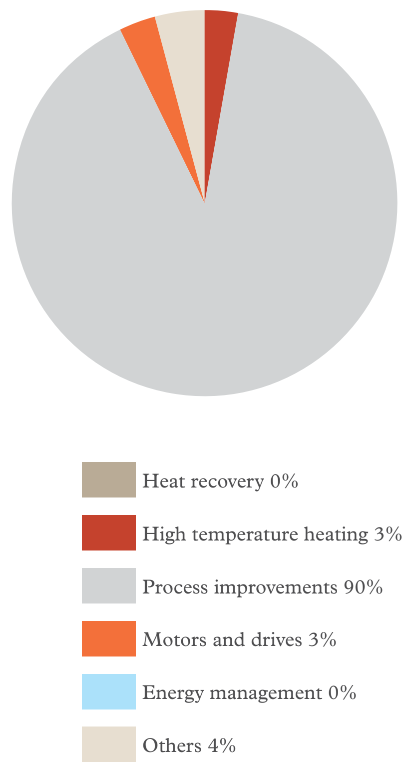
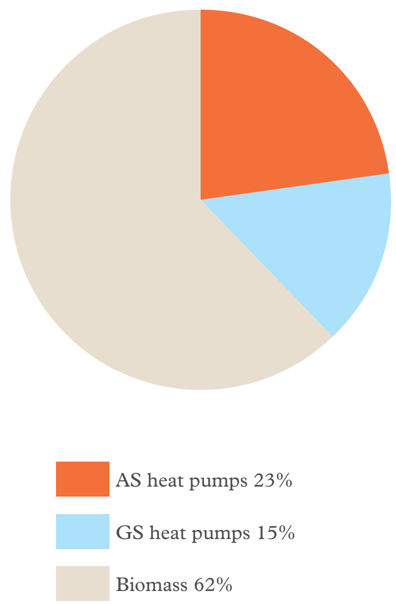


Figure 8: Breakdown of Total Jobs for Renewable Heat Industrial Measures

(Total jobs/annum – 695)



Sector Focus

The Transport Sector

Main Findings
The Transport Sector

Cost effective opportunities

- There are £621 million of cost effective, energy efficient and low carbon investment opportunities available in the transport sector in the Sheffield City Region.
- Exploiting these would generate annual savings of £96 million a year.
- These investments would pay for themselves in 6.5 years, whilst generating annual savings for the lifetime of the measures.
- These investments would reduce Sheffield City Region carbon emissions by 1.0% by 2022, compared to 1990.

Cost neutral opportunities

- There are £1.50 billion of cost neutral, energy efficient and low carbon investment opportunities available in the transport sector in the Sheffield City Region.
- Exploiting these would generate annual savings of £175 million a year.
- Collectively, these investments would pay for themselves in 8.6 years, whilst generating annual savings for the lifetime of the measures.
- Collectively, these investments would reduce Sheffield City Region carbon emissions by 2.5% by 2022, compared to 1990.

Discussion

The list of low carbon measures available in the transport sector is less extensive than the lists for the other sectors. Clearly there are other measures that could be included. Nonetheless, there are significant opportunities for reducing the energy use and carbon footprints of transport within the Sheffield City Region. These include investments in park and ride schemes, smarter choices, cycling and demand management as well as investments in more fuel efficient and hybrid vehicles. League tables of the most cost and carbon effective measures are included in Tables 13 and 14.

Analysis

The analysis shows that park and ride schemes are the most cost effective low carbon transport option but that in aggregate across the SCR they do not have the highest level of transport related carbon saving potential. Express bus networks are also very cost effective over their life time, and they have significant carbon saving potential across the SCR, as do smarter choices and demand management. However, the carbon savings available through the widespread adoption of hybrid and electric vehicles are by far the most significant.

Table 13: League Table of the Most Cost Effective Measures for the Transport Sector

	Central business case	£/TCO2
1	Park and ride schemes	-370.03
2	Express bus/coach network	-370.03
3	Bus priority and quality enhancements	-316.54
4	Smarter choices	-315.17
5	Cycling	-261.97
6	Demand management	-53.45
7	Plug-in hybrid vehicles	-39.63
8	Mild hybrid vehicles	-39.54
9	Full hybrid vehicles	15.90
10	Biofuels	53.11
11	Micro hybrid vehicles	277.43
12	Electric vehicles	365.14
13	New railway stations	1429.09
14	Rail electrification	1448.29

In terms of their employment creating potential, transport measures represent 21% of the total jobs and 23% of GVA that could be generated through cost effective and cost neutral investments in low carbon measures. The measures which result in the most jobs/GVA are concerned with modal shift from cars to public transport.

- —Total number of jobs/year created is about 1,330. This total comprises 886 direct jobs and 444 indirect jobs based on composite supply chain and income (or consumption) multipliers;
- —About 69% of the jobs would be created in the rail transport sector, 24% in the bus sector and 7% in the cycling industry; and
- —Total average annual GVA is about £66 million. This equates to a cumulative total of £660 million over the 10-year period.

These are mainly associated with modal shift from cars to more sustainable forms of transport such as buses, rail, and cycling, which would lead to a significant reduction in carbon emissions according to a report by Arup for LCR (Arup, 2009).

A report by Ekosgen on employment in sustainable transport (Ekosgen, 2010) shows that a shift from cars to rail, bus and cycle transport would also lead to an increase in jobs due to their higher job densities per km traveled. It concludes that between 1993 and 2010 an increase in rail, bus and cycle use could generate 130,000 jobs nationally, which would more than offset the 43,000 jobs lost in the motor industry through reduced car use. If this is true, then modal shift would have a significant impact on jobs and GVA in SCR since the job gains are most likely to be local whilst many the job losses are likely to occur outside SCR due to the location of the car industry.

Some of the cost effective and cost neutral measures are associated with the introduction of hybrid and electric vehicles. These changes are unlikely to have a significant impact on jobs in SCR since we are not aware of any major car, light vehicle or truck manufacturers in the region. There is a major bus manufacturer in Leeds, Optaire, which supplies hybrid and electric drive trains but the MAC data here does not include buses.

There may be some job creation potential in the supply of components for hybrid and electric vehicles (e.g. electric motors and batteries) but we are not aware of any suppliers in SCR, which could benefit from the opportunities. The establishment of an electric vehicle charging infrastructure in SCR will lead to some job creation. However, the potential is not likely to be very significant since the current suppliers of these systems are based outside SCR and hence the opportunities are mainly associated with local installation.

The introduction of biodiesel and bioethanol has already and will continue to create jobs but the main impact of this in the wider region will be in the Sheffield and Humber region where the large biofuel plants and refineries are located.

Table 14: League Table of the Most Carbon Effective Measures for the Transport Sector

Cost effective
Cost neutral
Realistic technical potential

	Central business case	KTCO2
1	Biofuels	127.63
2	Full hybrid vehicles	100.16
3	Micro hybrid vehicles	95.45
4	Plug-in hybrid vehicles	66.71
5	Electric vehicles	47.05
6	Mild hybrid vehicles	42.67
7	Demand management	18.90
8	Smarter choices	10.36
9	Bus priority and quality enhancements	8.21
10	Rail electrification	3.18
11	Cycling	2.14
12	Express bus/coach network	1.30
13	Park and ride schemes	0.96
14	New railway stations	0.56

Low Carbon Investment: Supply and Demand

The analysis has highlighted that within the Sheffield City Region there is very considerable potential to reduce energy use and carbon footprints through cost effective and cost neutral investments on commercial terms. However, the fact that these opportunities exist on this scale is obviously not enough to ensure that they are actually exploited. Incentives – no matter how strong they are – have to be matched with appropriate capacities if progress is to be made. These relate both to the capacity to supply appropriate levels of investment, and to the capacity to stimulate and sustain demand for such investments.

Supply side factors: unlocking the supply of investment resources

The most obvious capacity that is needed is a capacity to raise, invest and secure returns on the very significant sums that are highlighted as being required within the report. We forecast that to exploit the cost effective opportunities alone, a total investment of £3.7 billion is needed. When spread over ten years, this equates to an investment of less than 1.4% of SCR GVA per year. Potentially, some of this level of investment could come from the Green Deal or the Green Investment Bank, but these investment opportunities are forecast to be profitable on commercial terms – particularly for investors with slightly longer time horizons than most UK investors (i.e. pension funds and other large institutional investors). The potential to attract very substantial levels of private sector investment should also therefore be explored.

The potential for investment depends in part on the mechanisms for cost recovery and the arrangements for benefit sharing that could be put in place. Public and private sector expertise on cost recovery has advanced rapidly in the UK in recent years, both through the development of the Green Deal and through experiments with different forms of Energy Service Company (ESCO). These mechanisms offer an opportunity to collect returns on investment either through energy companies on a pay as you save basis, or through longer term energy service contracts. Benefit sharing arrangements are also key as there needs to be a strong enough incentive for both the source and the recipient of the investment to participate. Such arrangements can easily be tailored to reflect the levels of risk and return associated with different low carbon options.

The potential for investment also depends in part on the development of innovative financing mechanisms, such as revolving or self-replenishing funds. Potentially, a much smaller level of initial investment could enable the exploitation of the most cost effective measures first, with the investment fund then replenishing itself before moving on to less cost effective measures. The detailed analysis of the capital and operational costs and benefit streams of the wide range of low carbon options that have been investigated in this report could be used to underpin the more detailed cash-flow analysis that is needed to investigate this issue further. Different cost recovery and benefit sharing arrangements could easily be explored in such an investigation.

The potential for investment also depends on capacities for identifying and managing risk. The energy and hence financial savings forecast in this report are based on detailed evaluations of different energy saving or low carbon measures in different contexts carried out for the CCC. The results of these evaluations are then interpreted conservatively to generate the data that has underpinned this research. The results have also been subjected to a sensitivity test to see how susceptible they are to changes in key factors such as energy prices or interest rates. To this extent this analysis represents the most detailed and robust assessment of the economics of decarbonising a city or city region that we know of. But there are still risks of course – and the actual potential of many of the cost effective low carbon measures identified will need to be evaluated before investment in particular measures can be recommended.

Demand side factors: unlocking demand for investment resources

As well as raising sufficient investment funds, there is also a need to consider the extent to which different actors in the domestic, commercial, industrial or transport sectors may want to access these funds and participate in any related schemes. A long list of issues could restrict their involvement (see BIS, 2009, 2010; DEFRA, 2010a and 2010b; Carbon Trust, 2010; Federation of Small Businesses, 2010).

Short-termism can be a key barrier to change. Even where there are demonstrable returns on investments in the medium to long term, some actors appear to overlook them because of more pressing priorities in the short term. High levels of risk aversity can also mean that some actors are sceptical about the presence or the relevance of purported opportunities in their particular context. Perceived risks can be higher where there is a lack of honest brokers who are sufficiently trusted and who have the expertise and experience needed to make a compelling case for investment, or a lack of learning networks through which information can flow and capacities can be built.

There can also be significant opportunity costs where the perceived risks of diverting scarce resources (including time and attention) from priority areas and channelling them towards what can be seen as peripheral issues can prevent the exploitation of apparent opportunities. Under these conditions, decision makers tend to over-estimate the costs and under-estimate the benefits. There are often also organisational barriers to investment, and these in turn often relate to split incentives where the costs of investment fall on one party (i.e. a landlord or a finance department) whilst the benefits accrue to another (i.e. a tenant or another department or subsidiary). On occasion there can also be regulatory barriers that prevent change – for example in the regulated utilities companies can be legally prevented from investing in various low carbon options.

Furthermore, there are commonly significant issues to do with embedded or locked-in forms of behaviour. Habits and routines emerge gradually over many years, and they can be incredibly resistant to change, particularly in large, complex organisations. Technological lock-in can also be a major factor as some decisions – such as investments in major infrastructure or capital projects – have long life times and the windows of opportunity within which changes can be made do not arise very regularly. And in smaller organisations the fixed costs (and the hassle costs) of searching for and accessing information on particular options can fall on one person who often lacks the time and the specialist expertise needed to take a good decision. Finally, instead of being available in the form of relatively `big wins', efficiency issues often present themselves as a large number of small and fragmented opportunities. This amplifies the significance of many of the other barriers to change mentioned above.

Unless all of these factors can be overcome, it is quite possible that opportunities to improve energy use and carbon footprints will be overlooked even if investment resources are made available. We need to think then not only about raising investment, but also about stimulating demand through an appropriate delivery vehicle that has the capacity to address all of the barriers to change presented above, whether in the domestic, commercial, industrial or transport sectors.

The potential to attract very substantial levels of private sector investment should be explored.

Conclusions and Recommendations

From a climate and carbon perspective, the analysis in this report suggests that the Sheffield City Region has to exploit all of the cost effective measures and virtually all of the cost neutral measures identified above if it is to reduce its carbon emissions by 40% by 2022.

Decarbonising on this scale and at this rate should be possible. The technological and behavioural options are readily available, the energy and financial savings associated with these are clear (even based on conservative assessments), the investment criteria are commercially realistic, and the deployment rates have been judged by the independent Committee for Climate Change to be challenging but still realistic.

The economic returns on investment could be very significant indeed. Many of the measures would pay for themselves in a relatively short period of time, they would generate significant levels of employment and economic growth in the process, and if done well there may be a wider range of indirect benefits (not least from being a first mover in this field). The political and business case for very large investments in the low carbon economy is very strong indeed.

However, the transition depends on political and social capital as well as financial capital. The levels of ambition, investment and activity needed to exploit the available potential are very significant indeed. Enormous levels of investment are required, and major new initiatives are needed with widespread and sustained influence in the domestic, commercial and industrial sectors.

And of course we need to think about some major innovations, particularly in stimulating the supply of and the demand for major investment resources. We need to think about innovative financing mechanisms, based on new forms of cost recovery and benefit sharing and new ways of managing risk. And we need to develop new delivery mechanisms that can stimulate and sustain demand for investment in low carbon options by overcoming the many potential barriers to change.

Of course the list of low carbon measures included in the analysis here may not be complete. Identifying and evaluating other low carbon measures and including them in an analysis that allows their performance to be compared with the wider range of options is critically important if the SCR is to adopt a least cost pathway towards the low carbon economy/society.

And fundamentally, we should recognise that economics is not the only discipline that has something useful to say on the transition to a low carbon economy/society. A wider analysis should also consider the social and political acceptability of the different options, as well as issues relating to the social equity and broader sustainability of the different pathways towards a low carbon economy and society. We also need to think about `future proofing' investments to consider their compatibility with the more demanding targets for carbon reduction and with the different levels of climate change that are likely to come after 2022.

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Appendix A: Background Data

DECC (2010) projections of energy prices by year: Low price scenario

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ELECTRICITY retail: domestic	p/kWh	9.33	9.49	10.02	9.76	10.33	10.69	11.02	11.40	11.88	12.20	12.58	12.72	13.20
ELECTRICITY – retail: commercial	p/kWh	7.63	7.66	7.99	8.17	8.56	8.90	9.26	9.62	10.15	10.57	10.98	11.34	11.83
ELECTRICITY – retail: industrial	p/kWh	7.00	7.03	7.33	7.50	7.85	8.17	8.49	8.83	9.32	9.70	10.08	10.40	10.86
ELECTRICITY – Variable element: domestic	p/kWh	5.07	5.01	5.19	5.18	5.26	5.25	5.28	5.31	5.34	5.39	5.42	5.50	5.61
ELECTRICITY – Variable element: commercial	p/kWh	4.62	4.56	4.72	4.71	4.78	4.76	4.79	4.81	4.83	4.88	4.90	4.97	5.07
ELECTRICITY – Variable element: industrial	p/kWh	4.33	4.28	4.43	4.42	4.48	4.47	4.50	4.52	4.54	4.58	4.61	4.67	4.76
GAS – retail: domestic	p/kWh	2.81	2.88	2.98	3.11	3.31	3.39	3.44	3.55	3.67	3.77	3.97	3.82	3.86
GAS – retail: commercial	p/kWh	1.89	1.90	1.93	1.96	2.01	2.07	2.14	2.24	2.36	2.52	2.70	2.72	2.74
GAS – retail: industrial	p/kWh	1.73	1.74	1.76	1.79	1.83	1.89	1.96	2.04	2.15	2.30	2.47	2.48	2.50
GAS – Variable element: domestic	p/kWh	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.36	1.37	1.38
GAS – Variable element: commercial	p/kWh	1.17	1.17	1.18	1.18	1.19	1.19	1.20	1.20	1.20	1.21	1.21	1.22	1.22
GAS – Variable element: industrial	p/kWh	1.17	1.17	1.18	1.18	1.19	1.19	1.20	1.20	1.20	1.21	1.21	1.22	1.22
COAL – retail: domestic	p/kWh	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55	2.55
COAL – retail: commercial	p/kWh	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
COAL – retail: industrial	p/kWh	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
COAL – Variable element: domestic	p/kWh	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19
COAL – Variable element: commercial	p/kWh	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
COAL – Variable element: industrial	p/kWh	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
BURNING OIL – retail: domestic	p/litre	30.23	30.23	31.02	31.80	32.59	33.37	34.16	34.16	34.16	34.16	34.16	34.16	34.16
GAS OIL – retail: commercial	p/litre	34.64	34.64	35.45	36.25	37.05	37.85	38.65	38.65	38.65	38.65	38.65	38.65	38.65
GAS OIL – retail: industrial	p/litre	31.93	31.93	32.73	33.53	34.33	35.13	35.94	35.94	35.94	35.94	35.94	35.94	35.94
BURNING OIL – Variable element: domestic	p/litre	25.79	25.79	26.54	27.29	28.03	28.78	29.53	29.53	29.53	29.53	29.53	29.53	29.53
GAS OIL – Variable element: commercial	p/litre	22.80	22.80	23.60	24.40	25.20	26.01	26.81	26.81	26.81	26.81	26.81	26.81	26.81

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
GAS OIL – Variable element: industrial	p/litre	19.08	19.08	19.88	20.68	21.49	22.29	23.09	23.09	23.09	23.09	23.09	23.09	23.09
ROAD TRANSPORT – retail: petrol	p/litre	100.6	103.0	106.8	109.4	111.4	112.6	113.6	113.6	113.5	113.5	113.5	113.5	113.4
ROAD TRANSPORT – retail: DERV	p/litre	103.7	106.1	110.0	112.7	114.9	116.2	117.3	117.2	117.2	117.2	117.1	117.1	117.1
ROAD TRANSPORT – Variable element: petrol	p/litre	27.37	27.39	28.22	29.05	29.88	30.72	31.55	31.56	31.57	31.58	31.60	31.61	31.62
ROAD TRANSPORT – Variable element: DERV	p/litre	28.71	28.71	29.64	30.57	31.50	32.43	33.37	33.37	33.37	33.37	33.37	33.37	33.37
AVIATION – retail: Aviation fuel	p/litre	23.96	23.96	24.98	26.00	27.03	28.05	29.07	29.07	29.07	29.07	29.07	29.07	29.07
AVIATION – Variable element: Aviation fuel	p/litre	23.26	23.26	24.28	25.30	26.33	27.35	28.37	28.37	28.37	28.37	28.37	28.37	28.37

Note: Retail = taxes included; Variable element = without taxes

DECC (2010) projections of energy prices by year: Central price scenario

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ELECTRICITY – retail: domestic	p/kWh	11.63	11.99	12.54	12.35	12.92	13.31	13.64	14.02	14.48	14.76	15.10	15.31	15.77
ELECTRICITY – retail: commercial	p/kWh	10.01	10.25	10.61	10.87	11.24	11.62	11.97	12.35	12.85	13.24	13.60	14.03	14.50
ELECTRICITY – retail: industrial	p/kWh	9.19	9.41	9.73	9.97	10.32	10.66	10.99	11.33	11.79	12.15	12.48	12.87	13.30
ELECTRICITY – Variable element: domestic	p/kWh	7.37	7.56	7.82	7.93	8.04	8.14	8.23	8.33	8.40	8.53	8.62	8.74	8.83
ELECTRICITY – Variable element: commercial	p/kWh	6.80	6.97	7.20	7.30	7.39	7.49	7.57	7.65	7.71	7.83	7.91	8.02	8.10
ELECTRICITY – Variable element: industrial	p/kWh	6.36	6.52	6.74	6.83	6.92	7.01	7.08	7.16	7.22	7.33	7.41	7.51	7.59
GAS – retail: domestic	p/kWh	3.75	3.89	4.01	4.16	4.38	4.48	4.55	4.68	4.81	4.93	5.14	5.02	5.08
GAS – retail: commercial	p/kWh	2.90	2.99	3.04	3.09	3.17	3.25	3.34	3.46	3.59	3.76	3.97	4.01	4.05
GAS – retail: industrial	p/kWh	2.64	2.73	2.77	2.82	2.89	2.96	3.05	3.15	3.28	3.43	3.62	3.66	3.70

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
GAS – Variable element: domestic	p/kWh	2.16	2.24	2.27	2.31	2.34	2.37	2.40	2.44	2.47	2.50	2.53	2.57	2.60
GAS – Variable element: commercial	p/kWh	2.06	2.14	2.17	2.19	2.22	2.25	2.27	2.30	2.33	2.35	2.38	2.41	2.44
GAS – Variable element: industrial	p/kWh	2.06	2.14	2.17	2.19	2.22	2.25	2.27	2.30	2.33	2.35	2.38	2.41	2.44
COAL – retail: domestic	p/kWh	3.12	3.07	3.01	2.95	2.89	2.84	2.84	2.84	2.84	2.84	2.84	2.84	2.84
COAL – retail: commercial	p/kWh	1.46	1.40	1.35	1.29	1.24	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18
COAL – retail: industrial	p/kWh	1.24	1.19	1.13	1.08	1.02	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
COAL – Variable element: domestic	p/kWh	2.73	2.68	2.62	2.57	2.51	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
COAL – Variable element: commercial	p/kWh	1.22	1.16	1.11	1.05	1.00	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
COAL – Variable element: industrial	p/kWh	1.12	1.06	1.01	0.96	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
BURNING OIL – retail: domestic	p/litre	38.08	38.48	38.87	39.26	39.65	40.05	40.44	40.83	41.23	41.62	42.01	42.40	42.80
GAS OIL – retail: commercial	p/litre	42.67	43.07	43.47	43.87	44.27	44.67	45.07	45.47	45.87	46.28	46.68	47.08	47.48
GAS OIL – retail: industrial	p/litre	39.95	40.35	40.75	41.15	41.55	41.95	42.35	42.76	43.16	43.56	43.96	44.36	44.76
BURNING OIL – Variable element: domestic	p/litre	33.27	33.64	34.02	34.39	34.77	35.14	35.51	35.89	36.26	36.64	37.01	37.38	37.76
GAS OIL – Variable element: commercial	p/litre	30.82	31.22	31.62	32.02	32.42	32.82	33.22	33.63	34.03	34.43	34.83	35.23	35.63
GAS OIL – Variable element: industrial	p/litre	27.10	27.50	27.90	28.30	28.70	29.11	29.51	29.91	30.31	30.71	31.11	31.51	31.91
ROAD TRANSPORT – retail: petrol	p/litre	110.2	113.1	116.5	118.5	120.1	120.8	121.3	121.8	122.2	122.7	123.1	123.6	124.1
ROAD TRANSPORT – retail: DERV	p/litre	114.7	117.7	121.1	123.2	124.8	125.6	126.1	126.6	127.1	127.6	128.2	128.7	129.2
ROAD TRANSPORT – Variable element: petrol	p/litre	35.58	36.01	36.43	36.85	37.27	37.70	38.12	38.54	38.96	39.39	39.81	40.23	40.65
ROAD TRANSPORT – Variable element: DERV	p/litre	38.02	38.49	38.96	39.42	39.89	40.35	40.82	41.28	41.75	42.22	42.68	43.15	43.61
AVIATION – retail: Aviation fuel	p/litre	34.18	34.69	35.20	35.71	36.23	36.74	37.25	37.76	38.27	38.78	39.29	39.80	40.31
AVIATION – Variable element: Aviation fuel	p/litre	33.48	33.99	34.50	35.01	35.53	36.04	36.55	37.06	37.57	38.08	38.59	39.10	39.61

Note: Retail = taxes included; Variable element = without taxes

DECC (2010) projections of energy prices by year: High price scenario

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ELECTRICITY – retail: domestic	p/kWh	12.73	13.17	13.90	13.89	14.59	15.08	15.45	16.00	16.34	16.55	16.94	17.46	17.98
ELECTRICITY – retail: commercial	p/kWh	11.16	11.48	12.02	12.46	12.98	13.45	13.86	14.40	14.78	15.08	15.51	16.26	16.79
ELECTRICITY – retail: industrial	p/kWh	10.24	10.53	11.03	11.44	11.91	12.34	12.72	13.21	13.56	13.84	14.23	14.92	15.41
ELECTRICITY – Variable element: domestic	p/kWh	8.45	8.72	9.17	9.46	9.75	9.99	10.19	10.56	10.58	10.72	10.97	11.39	11.48
ELECTRICITY – Variable element: commercial	p/kWh	7.81	8.06	8.47	8.75	9.01	9.23	9.42	9.75	9.77	9.89	10.13	10.52	10.60
ELECTRICITY – Variable element: industrial	p/kWh	7.30	7.53	7.92	8.18	8.42	8.63	8.80	9.12	9.14	9.25	9.47	9.84	9.92
GAS – retail: domestic	p/kWh	4.17	4.33	4.52	4.74	5.04	5.21	5.34	5.54	5.74	5.92	6.20	6.05	6.08
GAS – retail: commercial	p/kWh	3.35	3.46	3.59	3.72	3.87	4.02	4.19	4.38	4.59	4.83	5.10	5.12	5.13
GAS – retail: industrial	p/kWh	3.05	3.16	3.27	3.39	3.53	3.67	3.82	3.99	4.18	4.41	4.66	4.67	4.68
GAS – Variable element: domestic	p/kWh	2.56	2.66	2.76	2.86	2.97	3.07	3.17	3.27	3.37	3.47	3.57	3.57	3.58
GAS – Variable element: commercial	p/kWh	2.46	2.56	2.65	2.75	2.84	2.94	3.04	3.13	3.23	3.32	3.42	3.42	3.42
GAS – Variable element: industrial	p/kWh	2.46	2.56	2.65	2.75	2.84	2.94	3.04	3.13	3.23	3.32	3.42	3.42	3.42
COAL – retail: domestic	p/kWh	3.22	3.18	3.14	3.11	3.07	3.03	3.03	3.03	3.03	3.03	3.03	3.03	3.03
COAL – retail: commercial	p/kWh	1.55	1.51	1.48	1.44	1.40	1.37	1.37	1.37	1.37	1.37	1.37	1.37	1.37
COAL – retail: industrial	p/kWh	1.33	1.30	1.26	1.22	1.19	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
COAL – Variable element: domestic	p/kWh	2.83	2.79	2.75	2.72	2.68	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
COAL – Variable element: commercial	p/kWh	1.31	1.27	1.24	1.20	1.16	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13
COAL – Variable element: industrial	p/kWh	1.21	1.17	1.14	1.10	1.06	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
BURNING OIL – retail: domestic	p/litre	43.58	44.76	46.33	47.90	49.08	50.65	51.83	53.40	54.97	56.15	57.72	57.72	57.72
GAS OIL – retail: commercial	p/litre	48.28	49.48	51.09	52.69	53.90	55.50	56.70	58.31	59.91	61.11	62.72	62.72	62.72
GAS OIL – retail: industrial	p/litre	45.56	46.77	48.37	49.97	51.18	52.78	53.99	55.59	57.19	58.40	60.00	60.00	60.00
BURNING OIL – Variable element: domestic	p/litre	38.51	39.63	41.12	42.62	43.74	45.24	46.36	47.86	49.35	50.47	51.97	51.97	51.97
GAS OIL – Variable element: commercial	p/litre	36.43	37.64	39.24	40.84	42.05	43.65	44.86	46.46	48.06	49.27	50.87	50.87	50.87
GAS OIL – Variable element: industrial	p/litre	32.72	33.92	35.52	37.13	38.33	39.93	41.14	42.74	44.35	45.55	47.15	47.15	47.15

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ROAD TRANSPORT – retail: petrol	p/litre	116.8	121.0	125.6	128.9	131.8	133.8	135.5	137.2	139.0	140.7	142.4	142.4	142.4
ROAD TRANSPORT – retail: DERV	p/litre	122.2	126.7	131.5	135.1	138.1	140.4	142.3	144.3	146.3	148.2	150.2	150.2	150.1
ROAD TRANSPORT – Variable element: petrol	p/litre	41.18	42.69	44.19	45.70	47.20	48.71	50.21	51.72	53.22	54.73	56.23	56.24	56.25
ROAD TRANSPORT – Variable element: DERV	p/litre	44.37	46.07	47.76	49.46	51.15	52.84	54.54	56.23	57.92	59.62	61.31	61.31	61.31
AVIATION – retail: Aviation fuel	p/litre	44.52	39.29	41.34	42.87	44.91	46.96	48.49	50.54	52.07	54.11	56.16	57.69	59.74
AVIATION – Variable element: Aviation fuel	p/litre	43.82	38.59	40.63	42.17	44.21	46.25	47.79	49.83	51.36	53.41	55.45	56.99	59.03

Note: Retail = taxes included; Variable element = without taxes

DECC (2010) projections of energy prices by year: High price scenario

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
ELECTRICITY – retail: domestic	p/kWh	14.18	14.88	15.91	16.16	17.12	17.77	18.37	18.66	18.51	18.60	18.72	19.02	19.64
ELECTRICITY – retail: commercial	p/kWh	12.66	13.26	14.10	14.82	15.60	16.25	16.88	17.15	17.03	17.21	17.35	17.87	18.51
ELECTRICITY – retail: industrial	p/kWh	11.62	12.16	12.94	13.60	14.31	14.91	15.49	15.74	15.63	15.80	15.92	16.40	16.99
ELECTRICITY – Variable element: domestic	p/kWh	9.81	10.37	11.13	11.72	12.31	12.77	13.28	13.42	12.99	13.08	13.11	13.24	13.40
ELECTRICITY – Variable element: commercial	p/kWh	9.09	9.62	10.32	10.87	11.42	11.85	12.33	12.45	12.04	12.12	12.14	12.26	12.41
ELECTRICITY – Variable element: industrial	p/kWh	8.49	8.98	9.64	10.15	10.67	11.07	11.51	11.63	11.25	11.33	11.35	11.46	11.60
GAS – retail: domestic	p/kWh	4.69	4.97	5.27	5.60	6.01	6.29	6.54	6.64	6.73	6.82	6.99	6.83	6.87
GAS – retail: commercial	p/kWh	3.91	4.14	4.39	4.64	4.91	5.19	5.48	5.55	5.66	5.79	5.95	5.96	5.98
GAS – retail: industrial	p/kWh	3.56	3.78	4.00	4.24	4.48	4.73	5.00	5.07	5.16	5.28	5.43	5.44	5.45
GAS – Variable element: domestic	p/kWh	3.06	3.27	3.48	3.69	3.90	4.11	4.32	4.32	4.33	4.34	4.34	4.35	4.36

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
GAS – Variable element: commercial	p/kWh	2.96	3.17	3.37	3.57	3.78	3.98	4.19	4.19	4.19	4.19	4.19	4.19	4.20
GAS – Variable element: industrial	p/kWh	2.96	3.17	3.37	3.57	3.78	3.98	4.19	4.19	4.19	4.19	4.19	4.19	4.20
COAL – retail: domestic	p/kWh	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31	3.31
COAL – retail: commercial	p/kWh	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64	1.64
COAL – retail: industrial	p/kWh	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42
COAL – Variable element: domestic	p/kWh	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92	2.92
COAL – Variable element: commercial	p/kWh	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
COAL – Variable element: industrial	p/kWh	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
BURNING OIL – retail: domestic	p/litre	51.04	54.18	57.33	60.08	63.22	66.36	69.50	69.50	69.50	69.50	69.50	69.50	69.50
GAS OIL – retail: commercial	p/litre	55.90	59.11	62.32	65.13	68.33	71.54	74.75	74.75	74.75	74.75	74.75	74.75	74.75
GAS OIL – retail: industrial	p/litre	53.18	56.39	59.60	62.41	65.62	68.82	72.03	72.03	72.03	72.03	72.03	72.03	72.03
BURNING OIL – Variable element: domestic	p/litre	45.61	48.60	51.60	54.21	57.21	60.20	63.19	63.19	63.19	63.19	63.19	63.19	63.19
GAS OIL – Variable element: commercial	p/litre	44.05	47.26	50.47	53.28	56.49	59.70	62.90	62.90	62.90	62.90	62.90	62.90	62.90
GAS OIL – Variable element: industrial	p/litre	40.34	43.54	46.75	49.56	52.77	55.98	59.19	59.19	59.19	59.19	59.19	59.19	59.19
ROAD TRANSPORT – retail: petrol	p/litre	126.1	132.3	138.9	144.3	149.2	153.2	157.0	157.0	156.9	156.9	156.9	156.9	156.9
ROAD TRANSPORT – retail: DERV	p/litre	132.8	139.6	146.7	152.6	158.0	162.6	166.9	166.9	166.8	166.8	166.8	166.7	166.7
ROAD TRANSPORT – Variable element: petrol	p/litre	49.07	52.31	55.55	58.78	62.02	65.26	68.50	68.51	68.52	68.53	68.55	68.56	68.57
ROAD TRANSPORT – Variable element: DERV	p/litre	53.33	56.99	60.65	64.31	67.97	71.63	75.28	75.28	75.28	75.28	75.28	75.28	75.28
AVIATION – retail: Aviation fuel	p/litre	44.52	46.96	51.05	55.14	59.22	62.80	66.89	70.98	75.07	75.07	75.07	75.07	75.07
AVIATION – Variable element: Aviation fuel	p/litre	43.82	46.25	50.34	54.43	58.52	62.10	66.19	70.28	74.36	74.36	74.36	74.36	74.36

Note: Retail = taxes included; Variable element = without taxes

DECC (2011) projections of carbon emissions factors by year

Carbon emissions factor (kgCO2/kWh)

Year	Electricity	Gas	Oil	Solid fuel	Space heating	Water heating	Petrol	Diesel
Source	DECC	DECC	DECC	CCC	Derived	Derived	DECC	DECC
Units	kgCO2/kWh	kgCO2/kWh	kgCO2/kWh	kgCO2/kWh	kgCO2/kWh	kgCO2/kWh	kgCO2/litre	kgCO2/litre
2012	0.48	0.185	0.245	0.329	0.202	0.219	2.238	2.525
2013	0.46	0.185	0.245	0.329	0.202	0.219	2.226	2.511
2014	0.46	0.185	0.245	0.329	0.202	0.220	2.223	2.508
2015	0.46	0.185	0.245	0.329	0.202	0.220	2.199	2.481
2016	0.43	0.185	0.245	0.329	0.202	0.220	2.176	2.454
2017	0.41	0.185	0.245	0.329	0.202	0.221	2.152	2.428
2018	0.41	0.185	0.245	0.329	0.202	0.221	2.128	2.401
2019	0.39	0.185	0.245	0.329	0.203	0.222	2.104	2.374
2020	0.37	0.185	0.245	0.329	0.203	0.222	2.081	2.347
2021	0.33	0.185	0.245	0.329	0.203	0.223	2.081	2.347
2022	0.31	0.185	0.245	0.329	0.203	0.223	2.081	2.347

Sources: DECC = Dept. of Energy and Climate Change, CCC = Committee on Climate Change

Appendix B: Baseline Data Analysis

Baseline Scenario for Sheffield City Region

In order to support the analysis of the different climate change mitigation measures for the Sheffield City Region, baseline scenarios from 1990-2022 were constructed. These baseline scenarios provide an indication of the emissions level, energy use and financial cost to consumers associated with a continuation of historical trends in energy use at the local level and existing policies at the national level. The baselines are based on the published emissions and energy use data for each energy-using sector in the Local Authorities (LAs) from 2005-2008. These published 2005-2008 energy use and emissions figures are not altered in the baseline scenario. Each backcast from 2005 to 1990, and each projection from 2008-2022 was then calculated individually for each sector in each local authority. This approach was limited by the data available at local authority level and in the absence of any LA specific data a secondary method was applied – projecting the local authority data using regional or national datasets.

Backcasts to 1990

Backcasts to 1990 were made for each local authority using local (when available) or national emissions and energy use data. Where data were unavailable at the local level, national datasets were used. As a result, many of the local authorities follow the same historical trend as the nationally published data for a particular sector.

Projections to 2022

The projections to 2022 were made by analysing the relationship between the energy use and explanatory variables for different sectors, such as number of consumers and any historical data on the energy use per consumer. This varied by sector, energy type and data available. Specific local data projections were used if available, such as household number projections by local authority published by the Department for Communities and Local Government (DCLG), or road traffic forecasts from the Department for Transport (DfT). The emissions and costs associated with this energy use were calculated accordingly based on the emissions and costs associated the fuel type, conversion factors published by the Department of Environment and Rural Affairs (Defra) and forecast prices provided by the Department for Energy and Climate Change (DECC).

Projected Scenarios

Three projected scenarios for 2008-2022 were calculated for the local authorities within the Sheffield City Region. They are all based on the method described in the section above, but vary as follows:

1. Future trends assuming no change to the electricity grid or demand reduction due to price increases.
2. Future trends incorporating projected shifts in demand due to price rises (assuming medium term price elasticities for different fuel types)
3. Future trends incorporating projected improvements to the electricity grid and changes to demand due to price effects.

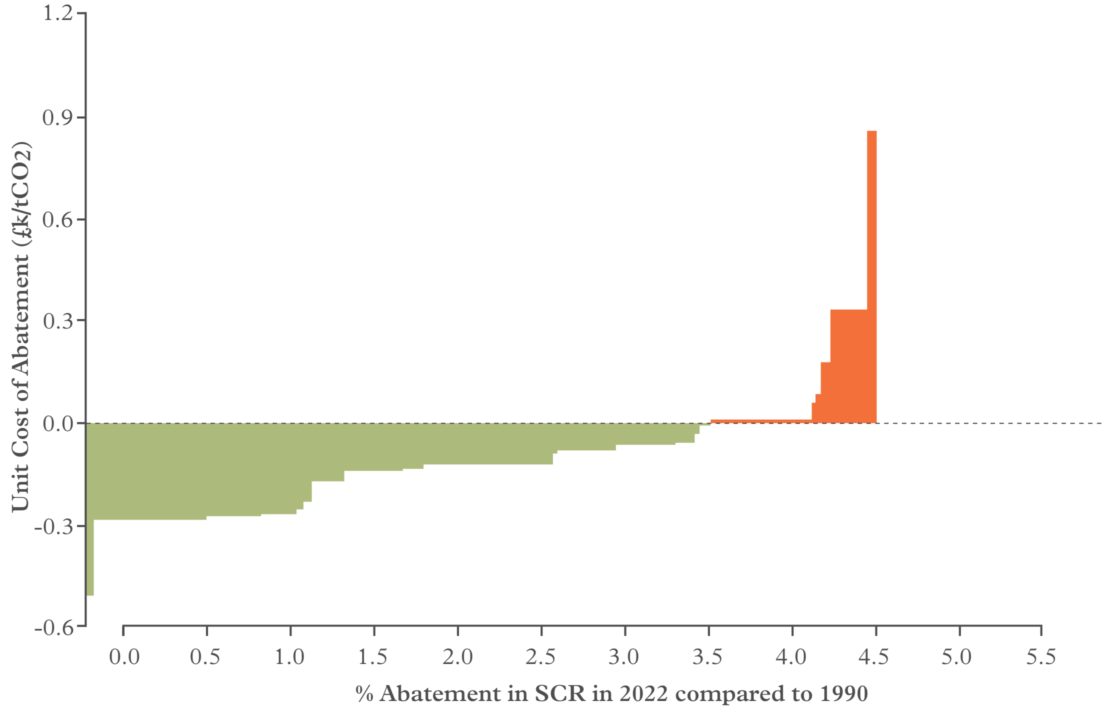
These three scenarios demonstrate the independent contribution of each of the three variables of the baseline – the underlying background trends in energy use and emissions; the improvements to the national grid and the price effects.

Appendix C: Employment and Wider Economic Effects

1. To evaluate job and wealth creating potential, we use the lists of measures included in the wider analysis for domestic and commercial buildings, transport and renewable heat and on the broader categories of measures selected for industry.
2. Calculations on costs, benefits and up-take are based on the central business case scenario – 8% interest rates, and DECC 'high' energy price forecasts.
3. For each measure, total capital expenditure data over the 10 year period to 2022 is generated in the wider analysis for the domestic, commercial and industrial sectors and for the renewable heat technologies. We translate this into an average annual expenditure over the period. Clearly, the actual spend profile will vary from year-to-year but there is no data on which to base a realistic analysis by year.
4. In the transport sector, the economic benefits are based on assessing the impacts of modal change from cars to public transport and cycling using vehicle kilometres figures used in the wider analysis and on data in an Arup report for SCR(Arup, 2009). This has been translated into jobs using ratios derived from a report by Ekosgen on employment in sustainable transport (Ekosgen, 2010).
5. The number of direct annual jobs for the domestic, commercial and industrial sectors has been calculated using average job/turnover ratios - based on ABI and ABS data from the Office of National Statistics - for various measures e.g. installation, wholesale/retail, manufacturing and consultancy/technical services depending on the sector and measure.
6. The annual GVA has been calculated using average GVA/employee data for the relevant job categories based on ABI and ABS data from the Office of National Statistics.
7. Assumptions are made about the proportions of the jobs and GVA that will be retained within the Sheffield City Region (SCR) taking account of the strengths of the local supplier base and competition from outside SCR. For most of the installation work, this is assumed to be 80% since there is a strong base of installers for energy efficiency and renewable energy measures – however, some leakage of the work to companies outside SCR is likely. The proportion has been reduced to 70% for PV generation and 60% for biomass district heating based on competition from outside SCR. In the industrial sector, a range of proportions have been used depending on local manufacturing strengths.
8. Finally, composite multipliers have been used to calculate indirect jobs based on supply chain and income (or induced) effects. The multipliers are based on the third edition of the Additionality Guide: a standard approach to assessing the additional impact of interventions produced by English Partnerships. Three levels of regional composite multipliers are suggested:
   - Low – limited local supply linkages and induced or income effects: 1.3;
   - Medium – average linkages – the majority of interventions will be in this category: 1.5;
   - High - strong local supply linkages and induced or income effects: 1.7.

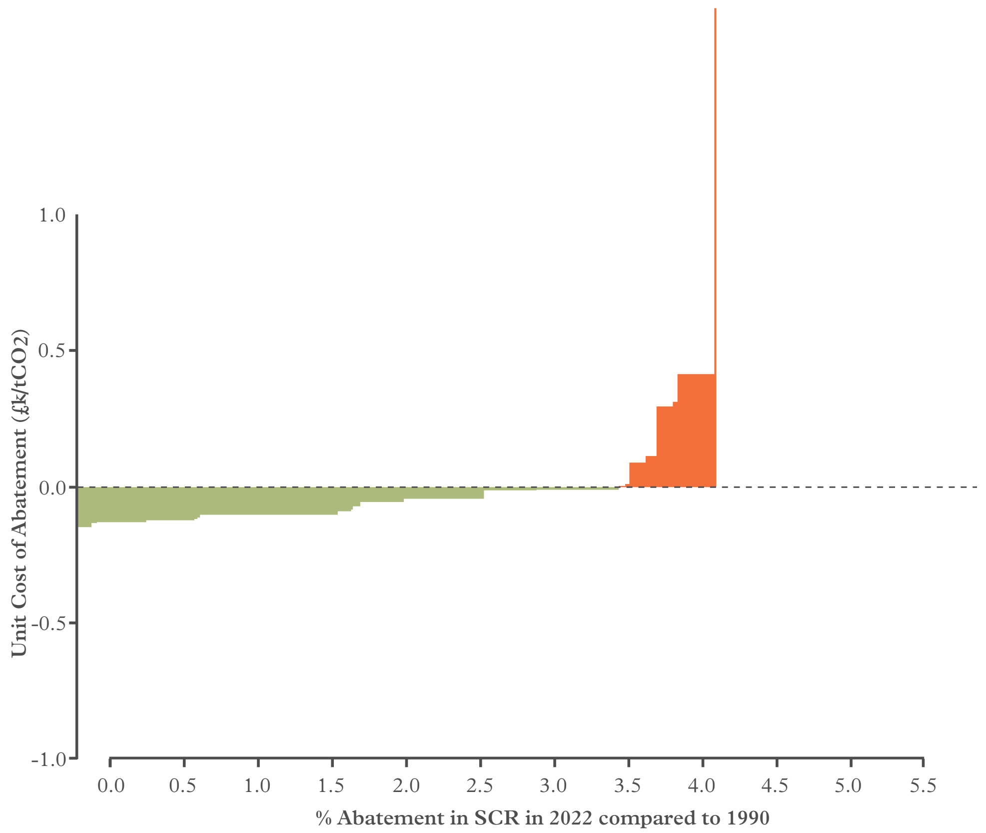
Appendix D:

Domestic Sector : Marginal Abatement Cost (MAC) Curve



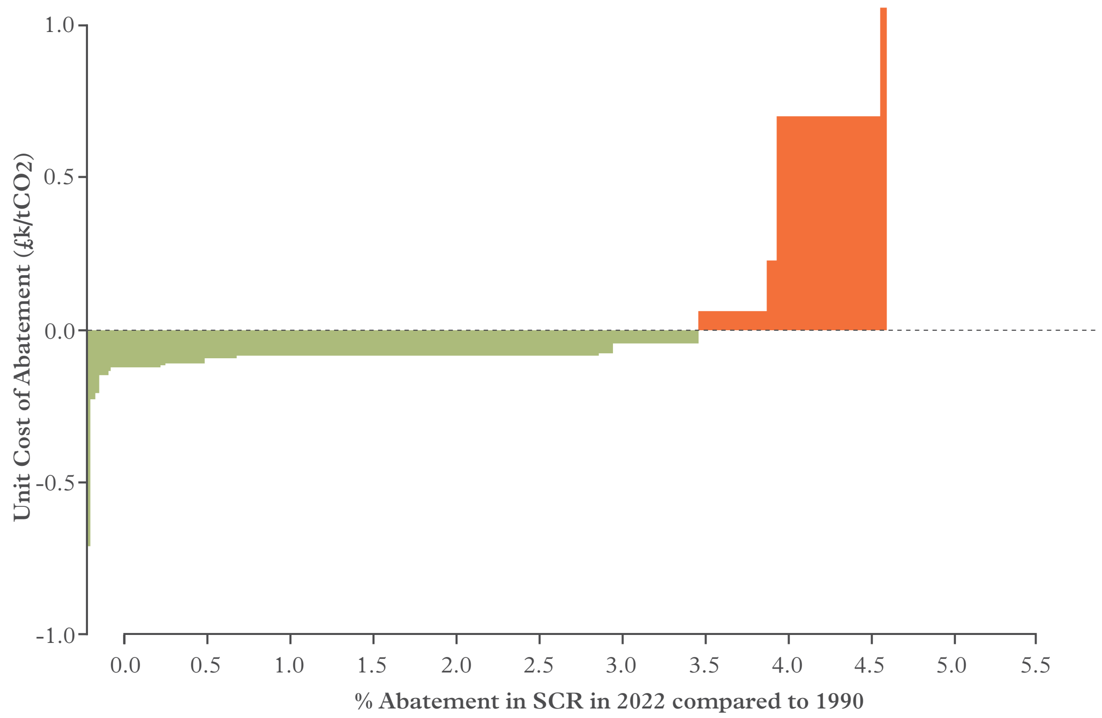
Appendix E:

Commercial Sector: Marginal Abatement Cost (MAC) Curve



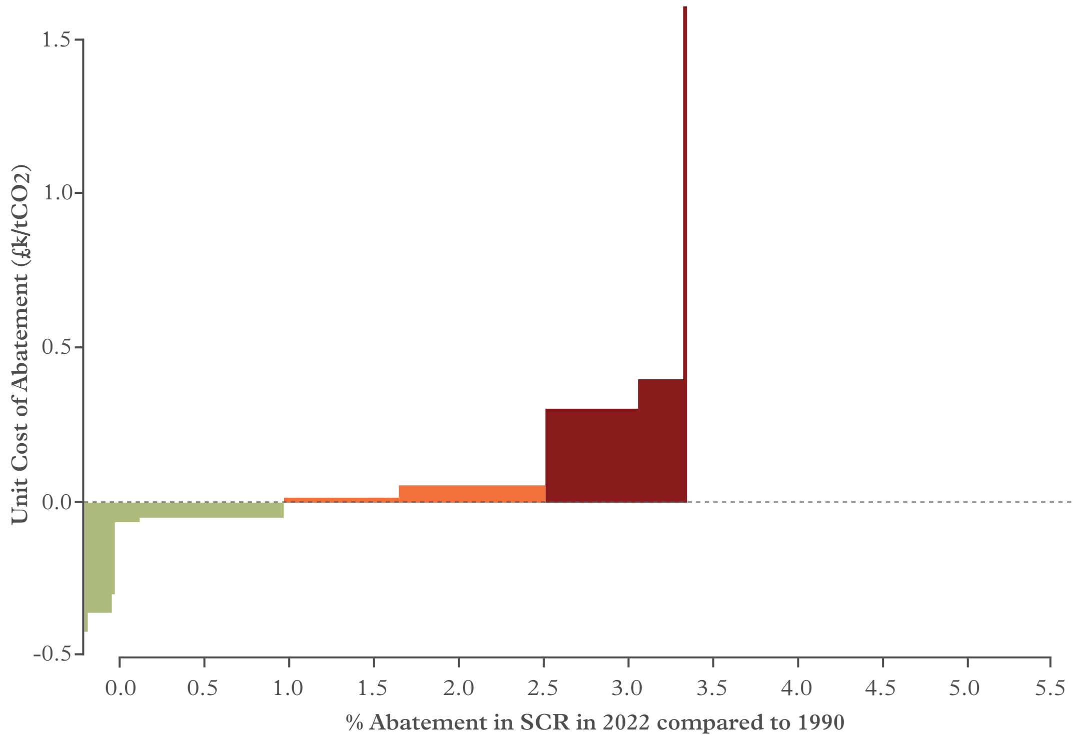
Appendix F:

Industrial Sector : Marginal Abatement Cost (MAC) Curve



Appendix G:

Transport Sector: Marginal Abatement Cost (MAC) Curve



Appendix H: Overall List of the Most Cost Effective Measures

Cost effective
Cost neutral
Realistic technical potential

Central business case			£/TCO2
1	Industry	Burners	-764.09
2	Domestic	Mini wind turbines (5kW) with FiT	-457.39
3	Transport	Park and ride	-370.03
4	Transport	Express bus/coach network	-370.03
5	Transport	Bus priority and quality enhancements	-316.54
6	Transport	Smarter choices	-315.17
7	Transport	Cycling	-261.97
8	Domestic	Biomass boilers with RHI	-256.68
9	Domestic	Electronic products	-244.68
10	Industry	Refrigeration and air conditioning	-244.32
11	Domestic	Information and communicaton technology products	-244.28
12	Commercial	Vending machines energy management	-233.67
13	Commercial	Office equipment – fax machine switch off	-233.67
14	Commercial	Photocopiers – energy management	-233.67
15	Commercial	Computers – energy management	-233.67
16	Commercial	Monitors – energy management	-233.67
17	Commercial	Printers – energy management	-233.67
18	Domestic	Integrated digital TVs	-228.08
19	Domestic	Reduced standby consumption	-228.04
20	Industry	Compressed air	-225.06
21	Commercial	Office equipment – most energy efficient monitor PC only	-209.41
22	Domestic	Reduced heating for washing machines	-208.79
23	Commercial	Biomass boilers with RHI	-206.64
24	Industry	Lighting	-195.72
25	Commercial	Lights – turn off lights for an extra hour	-194.08
26	Commercial	Lights – sunrise-sunset timers	-193.90
27	Commercial	Lights – basic timer	-193.78
28	Commercial	Heating – more efficient air conditioning	-193.73
29	Commercial	Office equipment – most energy efficient monitor	-192.18
30	Commercial	Lights – light detectors	-188.62
31	Commercial	Stairwell timer	-180.65
32	Domestic	A++ rated cold appliances	-180.33
33	Domestic	A rated ovens	-175.41
34	Industry	Fabrication and machining	-160.79
35	Commercial	Heating – programmable thermostats high	-159.50
36	Commercial	Heating – optmising start times	-158.88
37	Commercial	Heating – reducing room temperature	-158.32
38	Commercial	Most energy efficient fridge	-156.83
39	Domestic	Efficient lighting	-152.82
40	Industry	Design	-147.42
41	Domestic	A-rated condensing boiler	-145.33
42	Commercial	Heating – thermostatic radio valves fully installed	-140.77
43	Commercial	Compressed air	-136.45
44	Industry	Operation and maintenance	-132.85
45	Domestic	Insulate primary pipework	-132.31
46	Industry	Low temperature heating	-131.98
47	Domestic	Biomass district heating with RHI	-126.18
48	Industry	Building energy management	-126.07
49	Domestic	Glazing – old double to new double	-122.87
50	Domestic	Uninsulated cylinder to high performance	-121.96
51	Domestic	Glazing - single to new	-120.39
52	Industry	New food and drink plant	-118.90
53	Domestic	Insulated doors	-117.88
54	Industry	Drying and separation	-117.01
55	Industry	Space heating	-115.39
56	Domestic	Reduce household heating by 1°C	-110.55
57	Domestic	Induction hobs	-109.79
58	Commercial	Most energy efficient freezer	-108.99
59	Commercial	Presence detector	-104.92
60	Industry	Controls	-100.10
61	Industry	Renewable heat	-91.03
62	Industry	High temperature heating	-90.56
63	Industry	Energy management	-84.60

Cost effective
Cost neutral
Realistic technical potential

64	Commercial	Biomass district heating with RHI	-82.01
65	Domestic	Loft insulation 0 - 270mm	-79.42
66	Domestic	Pre '76 cavity wall insulation	-73.25
67	Domestic	Improved airtightness	-71.34
68	Domestic	DIY floor insulation (susp. timber floors)	-70.10
69	Domestic	Loft insulation 25 - 270mm	-68.85
70	Commercial	Most energy efficient fridge-freezer	-67.84
71	Commercial	Most energy efficient flat roof insulation	-60.54
72	Commercial	Heating – most energy efficient boiler	-60.22
73	Domestic	Loft insulation 50 - 270mm	-58.66
74	Domestic	Ground source heat pumps with RHI	-58.47
75	Domestic	76-83 Cavity wall insulation	-56.15
76	Domestic	A+ rated wet appliances	-54.24
77	Transport	Demand management	-53.45
78	Domestic	Loft insulation 75 - 270mm	-52.29
79	Industry	Heat recovery	-44.87
80	Industry	Process Improvement	-44.70
81	Transport	Plug-in hybrid vehicles	-39.63
82	Transport	Mild hybrid vehicles	-39.54
83	Domestic	Post '83 cavity wall insulation	-30.19
84	Domestic	Turn unnecessary lighting off	-28.26
85	Domestic	Installed floor insulation (susp. timber frames)	-25.38
86	Commercial	Ground source heat pump with RHI	-13.14
87	Commercial	Most energy efficient cavity wall insulation	-10.54
88	Commercial	Most energy efficient pitched roof insulation	-10.27
89	Domestic	Loft insulation 100 - 270mm	-8.18
90	Commercial	Air source heat pump with RHI	-5.55
91	Domestic	Glazing (to best practice)	-3.54
92	Domestic	Solid wall insulation	8.62
93	Commercial	Most energy efficient external wall insulation	10.36
94	Domestic	Loft insulation 125 - 270mm	11.42
95	Transport	Full hybrid vehicles	15.90

96	Commercial	Lights – metal halide floods	19.92
97	Commercial	Lights – IRC tungsten–halogen – spots	23.05
98	Industry	Others	48.88
99	Transport	Biofuels	53.11
100	Domestic	Loft insulation 150 - 270mm	58.91
101	Domestic	Room thermostat to control heating	59.10
102	Domestic	Paper type solid wall insulation	75.82
103	Domestic	Modestly insulated cylinder to high performance	89.77
104	Domestic	Thermostatic radiator valves	135.25
105	Commercial	Lights– most energy efficient replacement 26mm	154.45
106	Industry	Ventilation	176.41
107	Domestic	Photovoltaic generation with FiT	180.21
108	Commercial	Motor – 4 Pole motor – EFF1 replace 4 Pole	192.51
109	Commercial	Lights – HF ballast	194.73
110	Transport	Micro hybrid vehicles	277.43
111	Domestic	Air source heat pump with RHI	336.68
112	Transport	Electric vehicles	365.14
113	Industry	Information technology	476.82
114	Commercial	Solar water heating with RHI	496.42
115	Commercial	Lights – most energy efficient replacement tungsten	521.57
116	Industry	Motors and drives	540
117	Domestic	Micro wind turbines (1kW) with FiT	639.41
118	Domestic	Hot water cylinder 'stat	670.95
119	Commercial	Variable speed drives	687.98
120	Commercial	Most energy efficient double glazing	691.07
121	Industry	Insulation	815.69
122	Domestic	Solar water heating with RHI	865.99
123	Transport	New railway stations	1429.09
124	Transport	Rail electrification	1448.29
125	Commercial	Most energy efficient double glazing (replace double)	2918.71

Appendix I: Overall List of the Most Carbon Effective Measures

Cost effective
Cost neutral
Realistic technical potential

Central business case			KTCO2
1	Industry	Renewable heat	274.60
2	Transport	Biofuels	127.63
3	Domestic	Reduce household heating by 1°C	115.92
4	Domestic	Biomass boilers with RHI	100.98
5	Transport	Full hybrid vehicles	100.16
6	Transport	Micro hybrid vehicles	95.45
7	Industry	High temperature heating	86.75
8	Commercial	Air source heat pump with RHI	84.87
9	Domestic	Solid wall insulation	84.02
10	Commercial	Heating – most energy efficient boiler	74.49
11	Commercial	P Heating – programmable thermostats high	72.58
12	Industry	Process improvement	67.37
13	Transport	Plug-in hybrid vehicles	66.71
14	Industry	Motors and drives	60.88
15	Domestic	Biomass district heating with RHI	52.31
16	Commercial	Biomass boilers with RHI	50.93
17	Domestic	Ground source heat pump with RHI	50.60
18	Domestic	Electronic products	48.75
19	Transport	Electric vehicles	47.05
20	Commercial	Biomass district heating with RHI	44.63
21	Commercial	Heating – reducing room temperature	44.10
22	Commercial	Ground source heat pump with RHI	43.09
23	Transport	Mild hybrid vehicles	42.67
24	Industry	Others	39.85
25	Domestic	Pre-'76 cavity wall insulation	37.94
26	Domestic	Information and communication technology products	31.98
27	Industry	Controls	31.62
28	Domestic	Air source heat pump with RHI	30.12
29	Industry	Drying and separation	28.00
30	Domestic	Efficient lighting	28.00
31	Commercial	Most energy efficient double glazing	26.68
32	Industry	Low temperatire heating	24.96
33	Commercial	Heating – optimising start times	24.86
34	Industry	Operation and maintenance	24.57
35	Commercial	Lights – basic timer	19.87
36	Transport	Demand management	18.90
37	Industry	Heat recovery	18.24
38	Commercial	Heating – more efficient air conditioning	17.18
39	Industry	Energy management	13.87
40	Commercial	Solar water heating with RHI	13.73
41	Commercial	Heating – thermostatic radio valves fully installed	13.29
42	Commercial	Lights – most energy efficient replacement 26mm	12.86
43	Commercial	Lights – turn off lights for an extra hour	10.81
44	Transport	Smarter choices	10.36
45	Industry	Space heating	10.12
46	Domestic	A+ rated wet appliances	9.78
47	Commercial	Monitors – energy management	9.59
48	Commercial	Lights – HF ballast	8.58
49	Domestic	Diy floor insulation (susp. timber floors)	8.48
50	Commercial	Most energy efficient external wall insulation	8.25
51	Industry	Fabrication and machining	8.24
52	Transport	Bus priority and quality enhancements	8.21
53	Commercial	Most energy efficient flat roof insulation	7.99
54	Domestic	Mini wind turbines (5kW) with FiT	7.31
55	Domestic	Reduce heating for washing machines	7.10
56	Domestic	Photovoltaic generation with FiT	7.03
57	Domestic	Solar watre heating with RHI	7.01
58	Domestic	Glazing – single to new	6.47
59	Industry	Refrigeration and airconditioning	6.47
60	Domestic	Uninsulated cylinder to high performance	6.28
61	Domestic	Reduced standby consumption	5.99
62	Industry	Ventilation	5.83

Cost effective
Cost neutral
Realistic technical potential

63	Commercial	Presence detector	5.79
64	Commercial	Most energy efficient cavity wall insulation	5.78
65	Domestic	Improved airtightness	5.65
66	Domestic	Glazing – old double to new double	5.59
67	Domestic	Loft insulation 100 - 270mm	5.51
68	Commercial	Most energy efficient pitched roof insulation	5.42
69	Domestic	Glazing (to best practice)	5.37
70	Commercial	Office equipment – most energy efficient monitor PC only	4.72
71	Industry	Building energy management	4.54
72	Domestic	Loft insulation 0 - 270mm	4.33
73	Commercial	Computers – energy management	4.09
74	Industry	Insulation	3.81
75	Industry	Compressed air	3.76
76	Domestic	Loft insulation 75 - 270mm	3.75
77	Commercial	Stairwell timer	3.67
78	Commercial	Variable speed drives	3.67
79	Domestic	Modestly insulated cylinder to high performance	3.63
80	Domestic	76-83 cavity wall insulation	3.26
81	Transport	Rail electrification	3.18
82	Commercial	Lights– most energy efficient replacement tungsten	3.05
83	Domestic	Loft insulation 50 - 270mm	2.55
84	Commercial	Lights – IRC tungsten-halogen – spots	2.51
85	Commercial	Most energy efficient freezer	2.40
86	Domestic	Post '83 cavity wall insulation	2.35
87	Domestic	Room thermostat to control heating	2.29
88	Industry	Design	2.20
89	Transport	Cycling	2.14
90	Commercial	Lights – sunrise-sunset timers	2.11
91	Commercial	Lights – light detectors	2.09
92	Domestic	Turn unnecessary lighting off	1.83
93	Commercial	Most energy efficient double glazing (replace double)	1.62
94	Commercial	Compressed air	1.47

Cost effective
Cost neutral
Realistic technical potential

95	Industry	New food and drink plant	1.40
96	Transport	Express bus/coach network	1.30
97	Industry	Burners	1.24
98	Domestic	Thermostatic radiator valves	1.21
99	Industry	Lighting	1.10
100	Commercial	Printers – energy management	1.07
101	Commercial	Lights - metal halide floods	1.02
102	Transport	Park and ride	0.96
103	Domestic	Insulate primary pipework	0.94
104	Commercial	Most energy efficient fridge	0.79
105	Domestic	Paper type solid wall insulation	0.72
106	Domestic	Integrated digital TVs	0.65
107	Domestic	Micro wind turbines (1kW) with FiT	0.62
108	Commercial	Photocopiers – energy management	0.59
109	Domestic	A++ rated cold appliances	0.59
110	Transport	New railway stations	0.56
111	Domestic	Loft insulation 25 - 270mm	0.44
112	Industry	Information technology	0.33
113	Commercial	Office equipment fax machine switch off	0.31
114	Commercial	Vending machines energy management	0.23
115	Commercial	Motor – 4 Pole motor – EFF1 replace 4 Pole	0.18
116	Domestic	Hot water cylinder 'stat	0.18
117	Commercial	Most energy efficient fridge-freezer	0.08
118	Commercial	Office equipment – most energy efficient monitor	0.04
119	Domestic	A rated ovens	0.00
120	Domestic	A rated condensing boiler	0.00
121	Domestic	Insulated doors	0.00
122	Domestic	Induction hobs	0.00
123	Domestic	Installed floor insulation (susp. timber frames)	0.00

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